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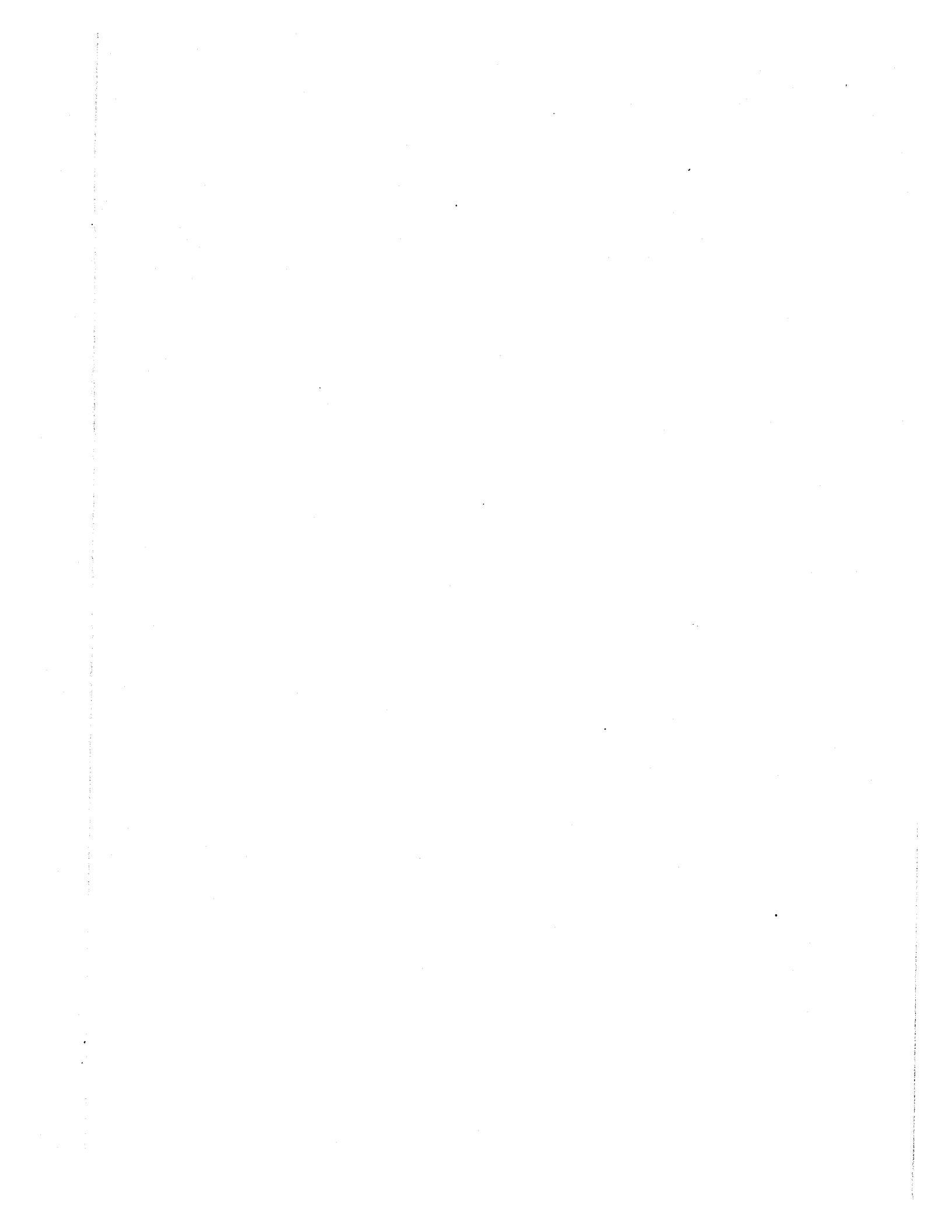
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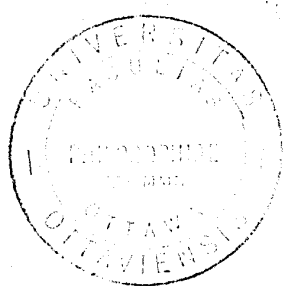


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UNIVERSITÉ D'OTTAWA -- ÉCOLE DES GRADUÉS

THE METAPHYSICAL FOUNDATIONS OF THE  
EPISTEMOLOGY  
OF ALBERT EINSTEIN

by  
John F. Kiley



A thesis submitted to the Faculty of Philosophy  
of the University of Ottawa in Partial  
Fulfillment of the requirements  
for the degree of  
Doctor of Philosophy

Ottawa, 1961



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## INTRODUCTION

In the world of those who, in modern times, engage in scientific investigations involving the formulation of theories, there are two poles about which all these thinkers are arranged. That is to say, there are fundamentally two great schools to which all scientific theoreticians belong and in which they function either as teacher or pupil. There is on the one hand, the school of Albert Einstein, relatively unpopulated yet immensely influential and, on the other, that of Bertrand Russell, heavily subscribed, powerfully amoebic and, therefore, just as immensely influential. Let us now proceed to characterize these two schools. The school of Einstein is, in the first place, metaphysically involved in a considerable number of what have been called, "extra-scientific problems" and which, for convenience, can be bracketed under the heading, "Realist Justifications". Striving for simplicity and unity it has not been able to find them and although it looks upon final unification as real goal, it considers it an immense task and, perhaps for this reason has an excellent record for making no permanently foolish announcements of its achievement. That is to say, the failure to find it actually has not been the cause of generating illusions about it much in the manner of those for whom wishing makes it so. Now, the reason why this school does not find simplicity is because it does not deliberately abstract from philosophical controversy in order

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to achieve it, realizing, perhaps for the most part instinctively, that the rules for scientific investigation are so completely bound up with the real world as to be unintelligible without reference to it. Thus it will not, indeed cannot, restrict itself to questions of formal logic and in this respect like Aristotle will insist on having its Posterior Analytics as well. For it cannot be satisfied with a greater communication and consensus which is purchased at the price of an impoverishment of understanding and justification. Thus, it will cry out against the "fateful fear of Metaphysics" of the Bertrand Russells who, by avoiding philosophical considerations, would turn physics into logic. In contrast, the school of Russell will argue that metaphysical considerations are unnecessary, for it is the rules that must be adhered to as all important and this can be done amidst diversity of interpretation for their validity, just as many different people lead decent lives from motives ranging all the way from the love of God to fear of the policeman. So, too, The Russelites would contend a unanimity of view can be achieved on the level of pragmatic understanding and by the test of consistency. This would save much time from controversy, which, at best, cannot raise itself above mere opinion and may become an end in itself like the futile hair-splitting of the scholastics. But this argument does not satisfy Einstein and perceiving this, the attempt is made to convince him "out of his own mouth".

For does not the combining of Space and Time into a four-dimensional continuum in which only the event has meaning, thus eliminating the concept of the material thing, show that matter is mind and mind is matter and formal consistency is the only "real" problem confronting the mathematical physicist? The quick and firm Einsteinian answer is that the concept of thing should be retained. For Einstein is just as sure that physics is not logic or mathematics as he is that concepts are not things. He is as sure that there is an enduring real behind sense appearances as he is unsure of the final structure of this reality which he had dedicated himself to reach.

Thus it is that one perceives in Einstein a positive yearning to reach and to know the real, that has, as a result, already disposed his epistemology to an inquiry into a deeper justification than it actually has. For in the last analysis Einstein cannot defend himself against the logicians of the type of Russell and Whitehead on this question of a real distinction between mind and matter nor can his epistemology have any other defense than the test of success, if the logicians prevail. For in such a logical reduction is removed the very ground for justifying such an epistemology in terms of an explanation which does not do violence to the strongly realist instincts of Einstein.

This thesis will attempt to supply the means of an Einsteinian defense by giving his epistemology a stable and

scientific ground within the real order by recourse to the metaphysical doctrines of St. Thomas Aquinas.<sup>1</sup> It will attempt to explain the necessity for certain epistemological procedures uniquely proper to Einstein by referring them to the dynamical activities and relationships of the most fundamental components of the real world for Thomistic metaphysics viz., matter and form, predicamental accidents, essence and existence.<sup>2</sup> It will for example, try to show the root

1. On this point G. Klubertanz, S.J., writes about "those who assert that all the special sciences are based on metaphysics. On the ground that metaphysics alone can formally treat of the most universal principles of knowledge, they maintain that all the sciences which use those principles are thereby based on metaphysics. This, however, is an overstatement. It is true that only metaphysics can discuss certain universal principles correctly. But that does not make the other sciences formally depend on metaphysics. Any particular science starts with a certain number of assumptions, and, as far as the internal necessities of that science are concerned, these assumptions can remain unproved assumptions. As long as a thinker works within that particular science, he need never go back beyond these assumptions. True enough, if the thinker wants to find the foundation of his science outside that science and continues his search far enough, he will ultimately come to metaphysics. But this search is precisely no longer within science." Introduction to Being, Appleton-Century Crofts, Inc., N. Y., 1952, p. 278.
2. The thesis is not attempting to do what Father Louis-Marie Regis warns against: "...to wish to construct a discourse on Thomistic method by taking science as a point of departure is to try to justify intellect by reason, the end by the means, the cause by the effect which amounts to seeking an absurd criterion by absurd means". L.M. REGIS, O.P. Epistemology, New York, Macmillan 1959, p. 465. See also "L'être dans le lit de Procuste", by Jacques CROTEAU, O.M.I., in Revue de l'Université d'Ottawa, 29 (1959), p. 181.

of the rule requiring sensible beginnings for all scientific theorising in the priority of existence over essence with especial attention to what is peculiar to Einstein's methodological procedure in the observance of this rule.

Einstein insists on sensible beginnings for scientific investigations. There is no logical path he contends from sensible things to the first concepts and axioms of a system of scientific deductive thought and experiences can do no more than suggest, but the origins are firmly rooted to the real world of sensible realities. There is no stronger credo in the whole Einsteinian epistemology.

At the same time there is lacking in Einstein's work any foundations for this methodological law other than an historico-pragmatic one. Now this cannot be spoken of as a foundation even in the loosest terminology but only as a common sense "rule of thumb" arrived at by inductions from the history of natural philosophy or "science" as it has come to be called. Einstein speaks of Greek, Mediaeval, "classical" i.e. Renaissance, and contemporary failures and lays them all at the door of Idealism of one form or another and then draws his lesson. Furthermore, the argument is weighty. But it is burdened with all the uncertainty of the inductive method in itself and can never raise itself above more than a mere probability or "statistical law". And yet a foundation needs to be found for this empiriological rule which can provide the stability and certitude necessary to

make it into a true law of scientific methodology and something which this powerful, modern scientific method should have, even though it has learned to content itself with less. Indeed, science has paid a high price for the abandonment of all metaphysics, however unavoidable it might have been, per accidens. At the present time, moreover, the very word, "metaphysics" has become so pejorative with many scientists that it constitutes a danger which Einstein, as will be seen has noticed and criticized. Indeed, in this very criticism lies the hope that the widespread contempt for metaphysics can be modified preparatory to a re-evaluation by modern thinkers of empiricistic beliefs in favor of a true metaphysics.

The thesis will take as its point of departure the position held by Einstein himself that there is an ontological reality behind the appearances of things, that something can be known about it and, furthermore, that such knowledge, when it is sufficiently elaborated will serve the physical investigation of nature in an explanatory way.<sup>3</sup> Indeed, as the eminent Pierre Duhem has pointed out regarding this type of investigation:

For such an inquiry to make sense or to be at all possible, we must first of all regard as certain the following affirmation:

3. See on this point, the article by Vincent E. SMITH, "Philosophy and Science: a Task for Higher Education" in Redman, St. John's University, 9 (1960), p. 14 ff.

Under the sensible appearances, which are revealed in our perceptions, there is a reality distinct from these appearances. This point granted, and without it the search for a physical explanation could not be conceived, it is impossible to recognize having reached such an explanation until we have answered this next question: What is the nature of the elements which constitute material reality? ...are they the elements which really go to make up material things or (do they) merely represent the universal properties perceived?

Now these two questions: Does there exist a material reality distinct from sensible appearances? and what is the nature of this reality? do not have their source in experimental method, which is acquainted only with sensible appearances and can discover nothing beyond them. The resolution of these questions transcends the methods used by physics; it is the object of metaphysics.<sup>4</sup>

It should be noted, at this time, that the thesis precludes entirely from the question of the validity of Relativity Theory, itself. The hypothesis that the universe is a curved space-time continuum, that it is finite but unbounded, that light energy considered in vacuo is a maximum and absolute signal, etc., is not the concern of this work, even indirectly. References which are made in the thesis to Relativity Theory are therefore purely illustrative and are in no sense an attempt to evaluate the theory metaphysically. The thesis does, in a general way, take cognizance of the almost universal acceptance of Relativity Theory by men of the highest scientific reputations as well as of the fruitfulness of the Theory in terms of its power of prediction

4. The Aim and Structure of Physical Theory, forward by Louis DE BROGLIE, translated by Philip P. WIENER, Princeton University Press, 1954, p.

and ability to unify previously disparate phenomena. All this it regards as positive signs of the scientific character of the Einsteinian epistemology. Indeed Einstein has related his discoveries in Relativity Theory to his own methodological approach, as will be seen. This is not to say that the writer regards Relativity Theory as proven or final, however.

The thesis will present in the first chapter the detailed features of the Einsteinian methodology drawing, whenever possible, from the primary sources of Einstein's own writings. It will also show here the actual workings of the methodology in the first major contribution of Albert Einstein, the Special Theory of Relativity. In the second chapter, a presentation and analysis of the metaphysical views of Einstein will be undertaken. Finally, in the third chapter, the attempt will be made to find a foundation for the Einsteinian methodology within the metaphysics of St. Thomas Aquinas.

The writer wishes to express his gratitude first to the Faculty of Philosophy of the University of Ottawa and in particular, to his mentor, the Rev. Dr. Jacques Croteau, O.M.I., for support in the choice of the thesis topic, for an appreciation of the "Epistemological Problem" as a result of lectures attended at the University and for valuable, painstaking criticism of the various parts of the thesis and for other assistances; to Dr. Jersy Wojciechowski for

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## CHAPTER I

## THE EPISTEMOLOGY OF ALBERT EINSTEIN

Section A. The Inductive Beginnings of  
Scientific Investigation

The famous use by Einstein of the elliptical non-Euclidean geometry of Reimann raised in its own way a point of extreme methodological interest and controversy, dealing with the question of the essence of geometry. Can geometry be called a physical science after the manner of, say, analytical mechanics, so that not only its validity but whole *raison d'être* has reference to the experiential world of real things?

There can not be found in the writings of Einstein any but relatively brief references to the essence of geometry, or pure geometry, as it is technically called. An analysis must be made of it, however, if Einstein's methodology is to be understood.

Does pure geometry, in the first place, satisfy the general requirement of a physical theory which Einstein lays down as "implying empirically testable assertions in general"?<sup>1</sup> Surely not, for in the first place, pure geometry

1. Albert Einstein, "Reply to Criticisms", Albert Einstein, *Philosopher-Scientist*, edited by Paul SCHLIPP, New York, Tudor, 1951, p. 629. This volume will hereinafter be referred to as AEPS.

asserts nothing about physical space at all. Its theorems are certain for the very reason that they are devoid of factual content. Historically speaking, as Einstein says, pure geometry (and here we will speak of the first, systematic geometry, viz, that of Euclid) had its origin, of course, in experience, and even in the practical affairs of surveying and astronomical researches of the Ancient Egyptians. In this sense, it implies something physical. The Greek geometers, however, removed the science from both physical origins with a systematic study of objects such as points, lines, planes, sections, triangles, etc., representing idealization of not only physical objects but of distances as well. Thus they abstracted from the extension of dots, rods and boards, at the same time assuming the length of the rods to exceed any finite bounds. Next they proceeded to set up what became, historically, the first example of the axiomatic presentation of a mathematical science. It is a known fact that the postulates or axioms on which Euclid based his system were not to be completed until the last years of the nineteenth century by Pasch, and thus some of the theorems were not logically deduced by Euclid at all. But it is this very fact which illustrates the critics' point about the nature of pure geometry, namely, its purely logical character. For it is the postulates, and the postulates alone, which contain all the "truth" that the system is to have. But, at the same time, it proposes its postulates

provisionally, that is, as assumptions. Thus, Euclid's geometry does not say that it is unconditionally true that the sum of the angles of any triangle equals two right angles but rather that any theorems which have been logically deduced from assumed postulates partake of the same assumption. The mark of the whole system is not its self-evident truth but its self-consistency. Thus, any appeal, whether explicit or implicit to intuitive feeling about geometrical figures, to the evidence itself, or, what is most important for this discussion, to the physical behavior of objects in space, is prohibited. One even notices such a lapse in Euclid wherein he makes use of ideas of motion and the translation of bodies based rather on experience than on the rules of logical deduction. David Hilbert corrected this later by making the proposition a postulate.

Now it is this very restriction of all mathematics and here, of geometry, to the strict process of deduction which imparts to it its character of certainty. In geometry therefore, what is proven is the strictly relational character of the theorems to the assumed axioms which logically implied them in the first place. In fact, except for the purely psychological progress that has been made, no new truths have been arrived at in the conclusion because these were already contained in full in the postulate. Thus, it is clear, truth of this conditional kind implies nothing about experience and insofar as it remains mathematical in

character, never can. Indeed, it is precisely because it is devoid of empirical content that such mathematical properties are certain.<sup>2</sup> Yet, it seemed nothing short of marvelous that a system so purely logical, so empty of physical content, could yet be considered as providing the structural picture of the world. Reichenbach refers to Kantianism as at least one attempt to explain this deep mystery, by making Euclidean geometry a category of the human mind:

As long as only one geometry, the Euclidean geometry, was known, the fact that this geometry could be used for a description of the physical world, represented a problem for the philosopher; and Kant's philosophy must be understood as an attempt to explain why a structured system derived from the human mind can account for observational relations. With the discovery of a plurality of geometries the situation changed completely. The human mind was shown to be capable of inventing all kinds of geometrical systems, and the question, which of the systems is suitable for the description of physical reality, was turned with an empirical question, i.e. its answer was ultimately left to empirical data!<sup>3</sup>

But given this very logical, empty character of Euclidean geometry, on what grounds could the assumption of it as a physical geometry be made? The answer of Einstein is that when anyone uses the concepts of points, straight lines, etc., in statements about objects in the physical world, this act transforms geometry into physics by charging purely

2. Cf., "Geometry & Empirical Science" by Carl G. HEMPEL in the World of Mathematics, Vol. 3, New York, Simon and Shuster, pp. 1635 ff.

3. H. REICHENBACH, "Philosophical Significance of Relativity," AEPS, p. 302.

mathematical ideas with physical meaning and content. It is then that the term, "point", serves to designate the location of a physical singularity, such as an atom or a planet; while the term, "straight line" is made to refer to the propagation of a ray of light through space. In this way, each geometrical concept acquires physical meaning and when this happens, every axiom and theorem becomes contaminated with the same sensible reference. Thus is transformed a system of pure geometry into one of physical geometry which, if true, may be said to describe the real world of bodies in space.<sup>4</sup>

4."One of Einstein's most fundamental contributions to scientific thought was his introduction of non-Euclidean geometry into the foundations of physics. Poincare had discussed the possibility of describing Nature by some non-Euclidean system; but he offered this suggestion only to dismiss it, for he believed that Euclidean geometry has an inherent simplicity which no other geometry possessed. In direct contradiction to this idea, Einstein greatly simplified the description of Nature by assuming a non-Euclidean space. (1) But, as he and others emphasized, this assumption is not of a geometric nature. For geometry, in its synthetic aspect, deals with undefined objects (called points, lines, planes, etc. cf. I, 1) and, in its analytic aspect, with arithmetically defined objects (triples of numbers, linear equations, etc., cf. I, 2). Einstein's assumption on the other hand, deals with physical objects such as cross-hairs in telescopes and the light rays observed by astronomers, etc. It amounts, in fact, to the hypothesis that certain physical objects behave like points and lines of a non-Euclidean rather than a Euclidean space. However, in formulating his hypothesis about the physical world, Einstein employed a geometric terminology. Indeed, his fundamental idea may be split into two parts: (1) That a light ray always follows the shortest path; and (2) That these shortest paths have the properties of lines in a non-Euclidean space. In this sense he geometrized certain basic parts of physics, particularly the theory of gravitation." Karl Menger, "Theory of Relativity and Geometry", AEPS, p. 464.

In order for any geometry to become the same as physical science, according to Einstein, it must never leave by way of abstraction, the sensible beginnings which are its inspiration. In this way, Euclidean geometry would be considered a physical theory describing the possible relations of rigid bodies in space.

If, however, one regard Euclidean geometry as the science of the possible mutual relations of practically rigid bodies in space, that is to say, treats it as a physical science, without abstracting from its original empirical content, the logical homogeneity of geometry and theoretical physics becomes complete.<sup>5</sup>

For Einstein, not only the circle was first discovered in the circular thing but also space, the concept, was achieved from its counterpart in experience, viz. the interval between solid objects.

5. A. Einstein, "Of The Method of Theoretical Physics," Essays in Science, New York, Philosophical Library, (no date), p. 14. This book is the authorized English translation from the volume, Mein Weltbild, by Albert EINSTEIN and contains only the scientific articles from this original German edition published by Querido VERLAG, Amsterdam, 1933. Essays in Science contains the following articles and subsequent quotations from such articles refer to this book: "Principles of Research"; "Inaugural Address to the Prussian Academy of Sciences"; "On Scientific Truth"; "On the Method of Theoretical Physics"; "Johannes Kepler"; "The Mechanics of Newton And Their Influence On The Development Of Theoretical Physics"; "Clerk Maxwell's Influence on the Evolution Of The Idea of Physical Reality"; "Neils Bohr"; "On The Theory Of Relativity"; "What Is The Theory Of Relativity"; "The Problem of Space, Ether, And The Field In Physics"; "Notes On the Origin Of The General Theory Of Relativity"; "Relativity And The Ether"; "Address At Columbia University".

Considered, then, from the point of view of sense experience, the development of the concept of space seems, after these brief indications, to conform to the following schema: solid body; spatial relations of solid bodies; interval; space. Looked at in this way, space appears as something real in the same sense as solid bodies.<sup>6</sup>

This space which appears as a real thing, was a commonplace among ordinary men even in the days of ancient Greece. In the physical science of Euclid, however, it was not included conceptually in the system. Instead, Euclid confined himself, according to Einstein, to concepts of the physical objects alone and the spaces between them. The concepts of the point, the plane, the straight line, length, etc., represented the idealization of these solid objects. On the other hand, spatial relations were viewed in terms of the contact, by way of intersection, of lines, planes or points lying on straight lines, etc. Space as a continuum does not appear in the conceptual apparatus of Euclid at all.

It is clear that the concept of space as a real thing already existed in the extra-scientific conceptual world. Euclid's mathematics, however, knew nothing of this concept as such; they confined themselves to the concepts of the object, and the spatial relations between objects. The point, the plane, the straight line, length, are solid objects idealized. All spatial relations are reduced to those of contact (the intersection of straight lines and planes, points lying on straight lines, etc.). Space as a continuum does not figure in the conceptual system at all. This concept was first introduced by Descartes.<sup>7</sup>

6. A. EINSTEIN, "The Problem of Space.....", p. 64.

7. Ibid.

The framing of this geometrical concept of space (a point which Euclid must have overlooked to have omitted the whole concept of space) seems especially related to the independence that an interval has to be filled by any body which can fit into the interval. Which again makes it plain that space is not necessary a priori.

If two bodies are of equal value for the filling of one such interval, they will also prove of equal value for the filling of other intervals. The interval is thus shown to be independent of the selection of any special body to fill it; the same is universally true of spatial relations. It is plain that this independence, which is a principle condition of the usefulness of framing purely geometrical concepts, is not necessary a priori. In my opinion, this concept of the interval, detached as it is from the selection of any special body to occupy it, is the starting point of the whole concept of space.<sup>8</sup>

The defect of Euclidean geometry for Einstein is that it is not a physical system like analytical mechanics at all. For what can any concept of straight line, etc., mean unless one can point to a referent sensible object? And unless the scientist, in examining his concepts, can discover their physical correspondents in some form? Einstein pictures the problem of an archaeologist who finds a book of Euclidean geometry to illustrate this defect of the ancient Greek science.

Suppose an archaeologist belonging to a later culture finds a text-book of Euclidean geometry without diagrams. He will discover how the words "point", "straight-line", "plane" are used in the propositions.

8. Ibid.

He will also see how the latter are deduced from each other. He will even be able to frame new propositions according to the known rules. But the framing of these propositions will remain an empty word-game for him, as long as "point", "straight-line", "plane", etc., convey nothing to him. Only when they do convey something will geometry possess any real content for him. The same will be true of analytical mechanics, and indeed of any exposition of the logically deductive sciences. What does this talk of "straight-line", "point", "intersection", etc., conveying something to one, mean? It means that one can point to the parts of sensible experience to which those words refer seeing if he can discover anything which corresponds to those primary terms of the theory and the axioms laid down for them.<sup>9</sup>

Thus, the whole value of Euclid's geometry stands or falls on the basis of the same test which would be applied to any science: "The empirical contents and their mutual relations must find their representation in the conclusion of the theory. In the possibility of such a representation lie the sole value and justification of the whole system....  
...."<sup>10</sup>

When such a representation is never confirmed but rather assumed, and this, in the name of an a priori psychological necessity, handed over to succeeding generations as a sacred tradition, then incalculable harm to science is the only result.

I am convinced that the philosophers have had a harmful effect upon the progress of scientific thinking in removing certain fundamental concepts from the domain of empiricism, where they are under our control, to the intangible heights of the a priori. This is

9. Op. cit. pp. 61-62.

10. A. EINSTEIN, "On Method....", p. 15.

particularly true of our concepts of time and space, which physicists have been obliged by the facts to bring down from Olympus of the a priori in order to adjust them and put them in a serviceable condition."<sup>11</sup>

Einstein, of course, is here referring to the Kantian category of space which as an a priori form of sensibility was identified with Euclidean geometry and made necessary a condition for objects being presented to the senses.

But space cannot play its critical role in the development of theoretical physics if it is locked permanently outside of geometry by the original oversight of Euclid and by the subsequent transmission of this error. It is Descartes who begins the work of destroying this pernicious a priori incubus by the invention of his system of coordinates within analytical geometry.

"This concept (of space) was first introduced by Descartes when he described the point-in-space by its coordinates. Here for the first time geometrical figures appear, up to a point, as parts of infinite space, which is conceived as a three-dimensional continuum."<sup>12</sup>

When in the evolution of scientific knowledge a need arose for a conceptual apparatus to cope with a Nature, behaving dynamically, Euclidean science could no longer serve. For motion could not be explained by a theory of mass points with static distances between them. Only space, viewed as a separate reality, and as conceived by Descartes was able to provide Newton with the framework he needed. The fact of acceleration, alone, needed something more than a metric

11. A. EINSTEIN, The Meaning of Relativity, Princeton, p.2

12. A. EINSTEIN, "Problem of Space....", pp. 64-65.

between points. It also needed space as a whole for the inertia-producing action that had to be explained.

Insofar as geometry is conceived as the science of laws governing the mutual relations of practically rigid bodies in space, it is to be regarded as the oldest branch of physics. This science was able, as I have already observed, to get along without the concept of space as such, the ideal corporeal forms—point, straight line, plane, length being sufficient for its needs. On the other hand, space as a whole, as conceived by Descartes, was absolutely necessary to Newtonian physics. For dynamics cannot manage with the concepts of the mass point and the (temporally variable) distance between mass points alone. In Newton's equations of motion the concept of acceleration plays a fundamental part, which cannot be defined by the temporally variable intervals between points alone. Newton's acceleration is only thinkable or definable in relation to space as a whole. Thus to the geometrical reality of the concept of space a new inertia-determining function of space was added.<sup>13</sup>

The events in the discovery of nature beginning with Descartes are so deeply related to the problem of space that it serves as a whole documentary scheme of evidence in the dethronement of Euclidean science as geometry for Einstein. For viewed in its best sense it appears to Einstein only as an unfruitful "empty word-game",<sup>14</sup> serving at its worst, as an albatross round the neck of scientific progress.

But it is not until the coordinate system was introduced that Euclidean geometry could be tested for its validity. Even then, logic could not provide the test for, from the standpoint of purely geometrical descriptions, all "rigid"

13. A. EINSTEIN, Op. Cit., pp. 65-66.

14. A. EINSTEIN, Op. Cit., p. 61

coordinate systems are, among themselves, logically equivalent.<sup>15</sup> But physics can and does provide a means of testing the validity of any geometry by actually measuring with the use of rods and clocks. The testing, therefore, could be done by a physical interpretation of the spatial coordinates.<sup>16</sup> In fact, it is the whole burden of relativity physics, especially of the special theory, to show the non-Euclidean structure of the universe is a fact of experience summarized in laws governing the status of solid bodies in space.

The introduction of co-ordinate systems accelerated relatively to each other as equally legitimate systems, such as they appear conditioned by the identity of inertia and weight, leads, in conjunction with the results of the special theory of relativity, to the conclusion that the laws governing the occupation of space by solid bodies, when gravitational fields are present, do not correspond to the laws of Euclidean geometry.<sup>17</sup>

But when the questions of the truth as opposed to correctness of geometry are concerned, there is a shift in the Einsteinian interpretation of the meaning of geometry.

Einstein makes the following distinction about propositions in general, first as related to a logical system and then, as related to experience.

A proposition is correct if, within a logical system, it is deduced according to the accepted logical rules.

15. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 27.

16. A. EINSTEIN, Op. cit. p. 55.

17. A. EINSTEIN, "On The Theory Of Relativity", p. 50.

A system has truth-content according to the certainty and completeness of its coordination-possibility to the totality of experience. A correct proposition borrows its "truth" from the truth-content of the system to which it belongs.<sup>18</sup>

Thus, a geometrical proposition would be correct (or "true") when, starting out from certain definite conceptions such as a plane, point, and straight line, we formulate this proposition or axiom in virtue of these ideas. Then by deduction, all remaining propositions are shown to follow as proven from the axioms. The question of the "truth" of the individual geometrical proposition is then reduced to "truth" of one of the axioms. But the concept "true" as applied to pure geometry is meaningless because there is no intention in it of relating it to reality but only to ideas within the system.

The concept "true" does not tally with the assertions of pure geometry, because by the word "true" we are eventually in the habit of designating always the correspondence with the "real" object; geometry, however, is not concerned with the relation of the ideas involved in it to objects of experience, but only with the logical connection of these ideas among themselves.<sup>19</sup>

There is a tendency in pure geometry to be carried along by the same deeply-lodged habit of thought derived from the relation of all thought and experience. Since, moreover, geometrical ideas correspond roughly to objects in nature, this tendency is understandable. Thus, if we pursue this

18. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 13.

19. A. EINSTEIN, "Special Theory of Relativity", Great Books Foundation edition, Henry Regnery 1931, p. 2.

habit of thought to the point of seeing distance in terms of two marked positions on an almost rigid body, then the changes in positions to which the body may be subject, make it a proposition to be treated now as a branch of physics. Now, the question of the real truth of the geometrical proposition can be made and tested by measuring rods on the objects involved.

If, in pursuance of our habit of thought, we now supplement the propositions of Euclidean geometry by the single proposition that two points on a practically rigid body always correspond to the same distance (line interval), independently of any changes in position to which we may subject the body, the proposition of Euclidean geometry then resolve themselves into propositions on the possible relative position of practically rigid bodies. (1.) Geometry which has been supplemented in this way is then to be treated as a branch of physics. We can now legitimately ask as to the "truth" of geometrical propositions interpreted in this way, since we are justified in asking whether these propositions are satisfied for the real things we have associated with the geometrical ideas. In less exact terms we can express this by saying that by the "truth" of a geometrical proposition in this sense we understand its validity for a construction with ruler and compasses.<sup>20</sup>

The question of the truth of the geometrical system has finally become the province of the physicists rather than the mathematician who can still criticise, but only the question of the logical coherence of the deductive processes. Here mathematics can serve as a tool of inestimable value by providing the machinery for the deduction leading from the postulates, which are now physically charged, to the theorems

20. A. EINSTEIN, "Special Theory of Relativity", Great Books Foundation edition, Henry Regnery, 1931, p. 2.

and conclusions of the whole theory. Here we may properly speak of the work of a mathematical physicist who at once carries out the task of reasoning about postulates freighted with physical meaning with the end in view of obtaining conclusions confirmable by sensible tests.

A complete system of theoretical physics is made up of concepts, fundamental laws which are supposed to be valid for those concepts and conclusions to be reached by logical deduction. It is these conclusions which must correspond without separate experiences; in any theoretical treatise their logical deduction occupies almost the whole book.<sup>21</sup>

Usually, the postulates are so remote from experience, that there is no way in which a direct experimental test can be made on them. There is, however, one celebrated test involving the postulates of the sum of the angles of triangles carried out by the great mathematician Gauss made possible by the implied difference between elliptical and hyperbolic geometries. Using optical methods and rays of lights as straight lines he calculated the angularity produced by three mountain-tops in Germany and found it to be Euclidean, that is  $180^\circ$ . The explanation provided many years later by Einstein was that only astronomical distances and those containing heavy mass distribution could give evidence for the non-Euclidean, Riemann continuum. But a physical geometry must have conclusions with empirical contents for "in the possibility of such representation lie the sole value and

21. A. EINSTEIN, "Of Method....". p. 14.

justification of the whole system and especially of the concept and fundamental principles which underlie it."<sup>22</sup>

It is in connection with this problem that the eminent French physicist, Henri Poincaré, raised doubts about experimental tests for physical geometry. Espousing a view called "Conventionalism", he declared after Gauss' test that Euclidean geometry had nothing to fear from such experiments. Einstein paraphrases Poincaré's views on Euclidean geometry as follows:

An examination of geometry by itself is not thinkable. Why should it consequently not be entirely up to me to choose geometry according to my own convenience (i.e. Euclidean) and to fit the remaining (in its usual sense, physical) laws to this choice in such manner that there can arise no contradiction of the whole with experience.<sup>23</sup>

To Poincaré, the advantage in terms of simplicity that Euclidean geometry had in addition to being more "natural" justified the use of ad hoc hypotheses, brought to "save Euclidean appearances". In this way, Euclidean geometry could always be maintained, and thus, the whole question of a choice between it and non-Euclidean forms was purely a matter of convention. Einstein replied directly to Poincaré asking him to respect the simplicity of the whole system, inclusive of geometry. Besides, says Einstein,

"Even if the empirically given bodies (used to test the geometry) are not rigid, ..... it is noteworthy that

22. A. EINSTEIN, "Of Method.....", p. 15.

23. A. EINSTEIN, "Reply to Criticism" AEPS, p. 679. Here Einstein uses Poincaré as his Socrates.

adherence to the objective meaning of length and to interpretation of the differences of coordinates as distances (in pre-relativity physics) has not led to complications.... In any case, it would have been impossible for Einstein de facto (even if not theoretically) to set up the theory of general relativity if he had not adhered to the objective meaning of length".<sup>24</sup>

Indeed, it is true on the question of physical geometry that, given the postulates of Relativity Theory, certain findings in astronomical readings, especially in the crucial 1918 experiment, represent solid evidence in terms of a physical structure to be understood in terms of non-Euclidean geometry. But to speak of confirming evidence is not to speak of truth absolutely, inasmuch as physical theory must perennially make use of incomplete evidence. Einstein recognized this from the theoretical standpoint for he said that "as far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality".<sup>25</sup> He recognized, therefore, the inherent limitation of the methods of physical examination of nature, viz., that this kind of "truth" is limited.<sup>26</sup> In any case, it is the mathematical side of mathematical

24. A. EINSTEIN, Op. Cit., pp. 677-678.

25. A. EINSTEIN, "Geometry and Experience", Ideas and Opinions, New York, Crown, 1954, p. 233.

26. A. EINSTEIN, "Special Theory of Relativity", Great Books edition, Chicago, Regnery, 1951, p. 3. This view must be placed beside the often-repeated one by EINSTEIN, in which he hopes by mathematico-physical investigation to "grasp reality in all its depths". For a fuller discussion of this problem see below Chapter II, Section A and Section C.

physics according to Einstein that is the bearer of whatever certainty ever can be in the method of theoretical physics.

And indeed, the method gains its very fruitfulness, convincing us that the right way can be found, by the fact that nature, herself, is the embodiment of mathematical ideas:

Can we hope to be guided in the right way by experience when there exist theories (such as classical mechanics) which to a large extent do justice to experience, without getting to the root of the matter? I answer without hesitation that there is, in my opinion, a right way, and that we are capable of finding it. Our experience hitherto justifies us in believing that nature is the realization of the simplest conceivable mathematical ideas. I am convinced that we can discover by means of purely mathematical constructions, the concepts and the laws connecting them with each other, which furnish the key to the understanding of natural phenomena.<sup>27</sup>

But there are certain dangers in this attempt to intelligibly penetrate into the nature of reality. If he is not to end up in logical isolation because of the tremendous diversity of nature which proportionately multiplies the possibility of his choices, the scientist must adhere closely to the world of experience once he is within his system. But how to pass from experience to the system without logic to help him, as it cannot, is the problem. For physics, related as it is to the world of experience, has a logical independency which can completely isolate him.

A logical conceptual system is physics insofar as its concepts and assertions are necessarily brought into relationship with the world of experiences. Whoever desires to set up such a system will find a dangerous

27. A. EINSTEIN, "Of Method.....", p. 17.

obstacle in arbitrary choice (embarras de richesse). This is why he seeks to connect his concepts as directly and necessarily as possible with the world of experience. In this case his attitude is empirical. This path is often fruitful, but it is always open to doubt, because the specific concept and the individual assertion can, after all, assert something confronted by the empirically given only in connection with the entire system. He then recognizes that there exists no logical path from the empirically given to that conceptual world. His attitude becomes then more nearly rationalistic, because he recognizes the logical independence of the system. The danger in this attitude lies in the fact that in the search for the system one can lose every contact with the world of experience.<sup>28</sup>

Time after time, Einstein is to stress the awful complexity of scientific knowing, rife with almost a Paulian catalogue of dangers: Perils from experimental errors, perils from the false brethren of the a priorists, the dangers of logical attenuation and isolations, excessive rationalism, naive positivism, and so on. But still the "investigator" of nature cannot tire because he is driven on to comprehend a reality that he is convinced is knowable.

When I, on a certain occasion, asked Professor Einstein how he found his theory of relativity, he answered that he found it because he was so strongly convinced of the harmony of the universe.<sup>29</sup>

The source of this deep conviction has been identified with the "spirit of the West" which had its beginnings and, in many ways, its greatest flowering in ancient Greece. Here the view of the world was that of a cosmos, an ordered universe, amenable to scientific investigation and

28. A. EINSTEIN, "Reply to Criticism", AEPS, p. 680.

29. H. REICHENBACH, "Philosophical Significance of Relativity", AEPS, p. 292.

expressible in terms of systematic concepts and judgments. Through the preservation of the spirit of that intellectual tradition, (at least in one of its phases) Einstein came under this spell of the West.

We reverence ancient Greece as the cradle of Western science. Here for the first time the world witnessed the miracle of a logical system which proceeded from step to step with such precision that every one of its deduced propositions was absolutely indisputable - I refer to Euclid's geometry. This admirable triumph of reasoning gave the human intellect the necessary confidence in itself for its subsequent achievements. If Euclid failed to kindle your youthful enthusiasm, then you were not born to be a scientific thinker.<sup>30</sup>

But there were other influences which had to prevail before science could be fully developed: This was the wedding of pure reason with the facts of experience.

But before mankind could be ripe for a science which takes in the whole of reality, a second fundamental truth was needed, which only became common property among philosophers with the advent of Kepler and Galileo. Pure logical thinking cannot yield us any knowledge of the empirical world; all knowledge of reality starts from experience and ends in it. Propositions arrived at by purely logical means are completely empty of reality. Because Galileo saw this, and particularly because he drummed it into the scientific world, he is the Father of Modern Physics - indeed modern science altogether.<sup>31</sup>

Here is represented a tension, an antithesis, which catches the eye of Einstein, as epistemologist of the scientific method. For what he is curious about in this context is "the relations between the content of the theory and the totality of empirical fact", which he calls "the two

30. A. EINSTEIN, "Of Method.....", p. 13.

31. A. EINSTEIN, *Op. Cit.*, pp. 13-14.

inseparable components of our knowledge, the empirical and the rational".<sup>32</sup>

In what sense, it must now be asked, is the first component validly empirical? Einstein promptly tells us it is not, and cannot be, in the sense of the empiricism of the modern era, typified by Ernst Mach.

I see Mach's greatness in his incorruptible skepticism and independence; in my younger years, however, Mach's epistemological position also influenced me very greatly, a position which today appears to me to be essentially untenable. For he did not place in the correct light the essentially constructive and speculative nature of thought and more especially of scientific thought; in consequence of which he condemned theory on precisely those points where its constructive-speculative character unconcealably comes to light, as for example in the kinetic atomic theory.<sup>33</sup>

The empiricist spirit of Einstein unlike that of Ernst Mach, would not limit itself, in a positivistic way, to the mere mastery of experience under the doctrine of usefulness or simplicity, merely attempting to catalogue or reduce the facts of experience to an ordered whole. There is the joy of discovery and the "reverences for the rational" that makes man more than a sorting and recording machine of data from without.

Although it is true that it is the goal of science to discover rules which permit the association and foretelling of facts, this is not its only aim. It also seeks to reduce the connections discovered to the smallest possible number of mutually independent conceptual elements. It is in this striving after the rational

32. A. EINSTEIN, "Of Method....", p. 13.

33. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 21.

unification of the manifold that it encounters its greatest successes, even though it is precisely this attempt which causes it to run the greatest risk of falling a prey to illusions. But whoever has undergone the intense experience of successful advances made in this domain, is moved by profound reverence for the rationality made manifest in existence.<sup>34</sup>

In addition to these objections to Positivism there is the epistemological one which cannot accept faith in facts in themselves as generative of knowledge without such facts coming under the influence of reason.

The antipathy of these scholars, (Ostwald, Mach) toward atomic theory can indubitably be traced back to their positivistic philosophical attitude. This is an interesting example of the fact that even scholars of audacious spirit and fine instinct can be obstructed in the interpretation of facts by philosophical prejudices. The prejudice - which has by no means died out in the meantime - consists in the faith that facts by themselves can and should yield scientific knowledge without free conceptual construction. Such a misconception is possible only because one does not easily become aware of the free choice of such concepts, which, through verification and long usage, appear to be immediately connected with the empirical material.<sup>35</sup>

In regard to the other component, the rational or logical, taken in itself, Einstein had said, unequivocally, that "propositions arrived at by purely logical means are completely empty as regards reality".<sup>36</sup> However, he adds that "in a certain sense I hold it true that pure thought can grasp reality, as the ancients dreamed".<sup>37</sup>

34. A. EINSTEIN, "Science and Religion", Ideas and Opinions, p. 49.

35. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 49.

36. A. EINSTEIN, "Of Method.....", p. 14.

37. A. EINSTEIN, Op. cit., pp. 36-37.

It must be therefore that, in some way, the logical deductive processes of mathematical reasoning become vested with a factual experiential content. But how is this done?<sup>37a</sup> Einstein tells us that this is accomplished through contact with experience. However, while "experience may suggest the appropriate mathematical concepts, they most certainly cannot be deduced from it. Experience remains, however, the sole criterion of the physical utility of a mathematical construction".<sup>38</sup> The ideal situation is when experience does actually succeed in suggesting fundamental hypothesis. This has happened frequently in the history of scientific thought and has resulted in immensely satisfying results when the hypotheses are handled properly. However, this is not to say that there is a direct inductive method which one follows from experience to the formulation of the fundamental concepts of the theory. The fact that this is not so is clearly demonstrated by certain positivistic failure of modern times which served to retard scientific progress until Maxwell broke through the belief with his

37a. "There is a lack of certainty in distinguishing the assumption of some sort of "dark qualities" of things from the fundamental theoretical thought.... And the same ambiguity remains to some extent in modern discussion. The most striking expression of such ambiguity is in the concept of description itself. For this term serves to unite investigators, who merely agree with each other in opposing speculation metaphysics, but who entirely disagree in their positive interpretations of the logical structure of physics." E. CASSIRER, Substance and Function, New York, Dover, 1953, p. 138.

38. A. EINSTEIN, "Autobiographical Notes", p. 89.

electromagnetic field theories.<sup>39</sup>

There is no inductive method which could lead to the fundamental concepts of physics. Failure to understand this fact constituted the basic philosophical error of so many investigators of the nineteenth century. It was probably the reason why the molecular theory, and Maxwell's theory were able to establish themselves only at a relatively late date. Logical thinking is necessarily deductive; it is based upon hypothetical concepts and axioms. How can we hope to choose the latter in such a manner as to justify us in expecting success as a consequence?

The most satisfactory situation is evidently to be found in cases where the new fundamental hypotheses are suggested by the world of experience itself. The hypothesis of the non-existence of perpetual motion as a basis for thermodynamics affords such an example of a fundamental hypothesis suggested by experience; the same thing holds for the principle of inertia of Galileo. In the same category, moreover, we find the fundamental hypotheses of the theory of relativity, which theory has led to an unexpected expansion and

39. "During the latter half of the nineteenth century many scientists, in particular Ernst Mach, envisaged the goal of physical science as the representation of processes through concepts inductively derived from sensory experiences. On Einstein's view the consistent application of Newtonian mechanics carried theoretical physics beyond the phenomenological standpoint. The kinetic-molecular theory of gases correlated phenomena which seems to be independent. Statistical mechanics furnished a mechanical interpretation of the concepts and laws of thermodynamics. This reduction of the phenomenological stratum to an atomistic one required assignment of real structure to material points which thereby became atoms or molecules. Einstein declares that the speculative-constructive character of these particles was obvious; no one could hope to perceive an atom directly. The kinetic-molecular theory of matter was opposed by an empiricism which was represented by Ernst Mach. Mach viewed atoms as auxiliary fictions which were to be discarded after the complete correlation of sensations was achieved." Victor LANZEN, "Einstein Theory of Knowledge", *AEPS*, pp. 375-6

broadening of the field theory, and to the superceding of the foundations of classical mechanics.<sup>40</sup>

And yet there is no way in which the concept can be made to grow out of sensible experience. Unlike John Stuart Mill who believed that mathematic ideas were direct inductions from experience, the system of numbers is an invention of the human mind whose constructive nature is easily discoverable even though the concept of number belongs to pre-scientific thought.<sup>41</sup> Nor is there any way in which theory may be said to copy reality. As Margenau says, "the central recognition of the theory of relativity is that geometry, regarded by Newton as a set of descriptive propositions flowing from and summarizing physical experience, is a construct of the intellect". On this point Einstein has taken sharp issue not only with Newton but, as a result, with the whole school of British empirism.<sup>42</sup>

Section B. The Formation of Primary Concepts  
According to Einstein. Their Invention.

The scientific mind, according to Einstein, needs to overthrow traditional notions of space and time and be free to

40. A. EINSTEIN, Out of My Later Years, New York, Wisdom Library, 1950, pp. 76-77.
41. A. EINSTEIN, "Remarks on Bertrand Russell's Theory of Knowledge", Philosophy of Bertrand Russell, Evanston, Illinois, Library of Living Philosophers, 1946, p. 286.
42. H. MARGENAU, "Einstein's Conception of Reality", AEPS, p. 250.

range over the whole spectrum of possibilities available for its use, confident that there is a "pre-established harmony" and that the right way can be found. The scientific investigator must intervene between the multitude of sense experiences and the dynamics of constructive thought joining them together by a deliberate act. This is the method of postulation of axioms which is the means of establishing contact between the mind and reality and giving the derived deductive system its factual referentials. Two close collaborators with Einstein have attempted to explain in their especially unique ways, the strange, inexplicable yet vitally necessary link that Einstein repeatedly says theory must have to experience. Henry Margenau writes:

A physical theory, i.e., an intelligible picture of reality, results when one geometry is postulationaly said to correspond to observation. Contact with reality has then been made. Mystic experience of the real is like a vast but formless reservoir of life-giving substance; mathematics alone is a gallery of robots. Select one of them and connect him with the real. If you have chosen the right one, you may witness the spectacle of man-made life; blood will course through the previously empty veins of the artifact and a functioning organism has been created. No one can tell in advance which robot will cause this success to be achieved; the scientist of genius makes the proper selection.<sup>43</sup>

And Hans Reichenbach, in another especially revealing passage, enlarges upon the manner in which Einstein set up his particular hypothesis, concerning first the equivalence of inertial mass and weight and then the hypothesis of the non-existence of the ether. The latter was done as a direct

43. H. MARGENAU, Op. Cit., p. 251.

result of the negative result of the Michelson experiments. There is no logical justification for such extended assumptions, Reichenbach suggests, Einstein being guided simply by an instinct for establishing what might be called "physical" concepts in the sense that they are factually meaningful.

The physical depth of Einstein's ideas can be, indeed, comprehended only when one realizes how this method of reasoning is employed in his basic assumptions. This was the case in the special theory of relativity. It was known that several important attempts failed to confirm the existence of ether; Einstein concluded from this that, in general, no similar attempt can do better no matter what means are used. The principle of equivalence reveals the same attitude. It is known that mechanical phenomena manifest no distinction between accelerated motion and gravitational field; Einstein concludes that this applies equally to all other phenomena. From the standpoint of logic, one cannot speak here of an inference, for this far-reaching assumption cannot be logically demonstrated by means of the scantily available facts. Rather, we have here a typical procedure in physics, that of the formation of a hypothesis; although a more extended assumption cannot be logically justified, nevertheless it is made in the spirit of a conjecture. There seems to exist something like an instinct for the hidden intentions of nature; and whoever possesses this instinct, takes the spade to the right place where gold is hidden, and thus arrives at deep scientific insights. It must be said that Einstein possesses this instinct to the highest degree. His assumption cannot be justified in a purely logical way; yet they introduce new ideas quite in the right place.<sup>44</sup>

This "instinct" for "physically real" concepts which these authors attribute to Einstein has been given at least a general epistemological evaluation by the latter. He feels self-conscious about the word "metaphysical", not in

44. H. REICHENBACH, From Copernicus to Einstein, New York, Philosophical Library, 1942, pp. 72-73.

itself, but because of the possible scandal he might produce in modern scientific minds who congratulate themselves on having escaped from such pernicious influences. First of all, Einstein remarks it is precisely "insofar as physical thinking justifies itself....by its ability to grasp experience intellectually (that) we regard it as 'knowledge of the real'".<sup>45</sup> A basic conceptual distinction must be made between sense on the one hand and mere ideas on the other. Now, one cannot give a definition of this conceptual distinction which is other than a circular one, i.e., one making hidden use of the object to be defined. Nor is there any basic evidence which would help the distinction, such as, when one distinguishes between two colors by means of frequency differences. Yet to overcome solipsism, a distinction must be made even though it must seem "metaphysical". We make the distinction because we can thus better find our way in the world of immediate sensations. But we must then go on to the next step. We now represent these same sense impressions as conditioned by two factors, namely the objective and subjective. Again, we lack logical justification for what we do. But, this second invention is also necessary to escape solipsism again. We must "suppose", as it were these two factors in order to hope to engage in physical thinking. Thus the criterion of usefulness again appears.

45. A. EINSTEIN, "Reply to Criticisms", AEPS, p. 674.

But it is strongly emphasized that such concepts, or categories, or even schemes of thought, which we presuppose as possessing objective factors are, in principle, freely chosen and qualified only by the degree they can make all the contents of our consciousness intelligible. The objective factor of our thoughts are all those concepts and conceptual relations which are thought, independent of our experience or our perceptions. Here, is the program we must follow if we are to think physically.<sup>46</sup>

It thus appears that objectivity to Einstein must come to reside within the structure of a theory itself, i.e., with the very character of the logical system pretending to represent reality. This is accomplished by the very postulates of the theory from which are to be derived the deductive consequences. These concepts of the theory are not basically unlike the way we form concepts in daily life, simply more precisely defined. This greater precision is achieved by that special technique characterizing the concepts of physics derived from measurement. As a result of this approach, the results, in turn, lend themselves to mathematical formulation in physics whose "whole realm is accordingly defined," as that part of the sum total of our knowledge which is capable of being expressed in mathematical terms".<sup>47</sup> Indeed, the realm of physics seems only

46. Cf. A. EINSTEIN, "Reply to Criticism", AEPS, pp. 673-674.

47. A. EINSTEIN, "The Fundamentals of Theoretical Physics", Out of My Later Years, p. 95.

limited by the limitation of the method itself and, theoretically at least, does need not exclude the subject of life itself from its proper field of investigation.

The general laws on which the structure of theoretical physics is based claim to be valid for any natural phenomenon whatsoever. With them, it ought to be possible to arrive at the description, that is to say, the theory, of every natural process, including life, by means of pure deduction, if that process of deduction were not far beyond the capacity of the human intellect.<sup>48</sup>

In physics there are several kinds of theory. There is the constructive, when starting point and foundation are hypothetical constituents, such as the kinetic theory of gases. Here by the use of the concept of the molecular movement of particles certain properties, e.g., their mechanical, thermal and diffusional ones are pictured. Here understanding is the embracing of these properties by the theory. There is, in addition, what Einstein calls the theories of principles which are suggested by experiences as a result of certain experiments. The theory of thermodynamics, which is one example, derived its principle from the negative result of attempts to demonstrate perpetual motion. The theory of relativity is another. Here the negative result of Michelson's experiments,<sup>49</sup> and others just as carefully carried out, suggested the principle from which "mathematical

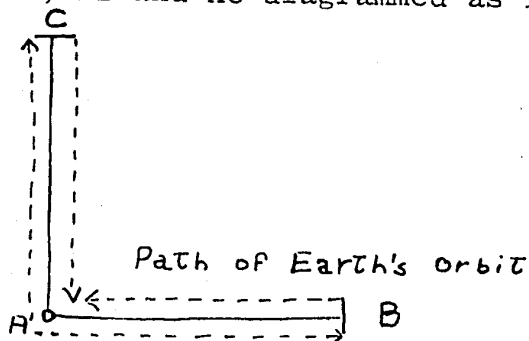
48. A. EINSTEIN, "Principles of Research", p. 3.

49. In the closing years of the nineteenth century, an American Physicist, Albert Michelson conducted his famous experiment (repeated many times since)

49. (continued)

to test certain reputed existence of the ether. The theory held that since light fills the spaces of the world, it must be supported by some medium and this was called the luminiferous ether. Now, inasmuch as the earth travels around the sun it must have a different state of motion from that of the ether. Thus, one may assume that the velocity of light on the earth must vary with the direction of the earth moving now on one side of its orbit then on the other and only with regard to it can light have its natural value.

His apparatus consisted of two horizontal metal tubes, AB and AC diagrammed as follows:



In A there is a source of light from which light is sent from to C and B denoted by arrows. The experiment tried to test the question of the simultaneous departure and return of the rays. This would happen if the apparatus were motionless with respect to the ether for then the speed of light would be the same in both directions. Actually, the tubes rest on the earth and are involved in the earth's own motion and aided by the movement of the ether from A to B to A in opposition to its movement from ACG to A the difference should be registered by the apparatus since it was calculated to be 10 times more accurate than necessary. Yet, surprisingly, there were only negative interference and results. This long perplexed the scientific world until Einstein theorized on the non-existence of the ether, leaving it a mathematical being. Cf. H. A. LORENTZ, "Michaelson's Interference Experiment" in The Principle of Relativity, Dover Press, pp. 3-7.

formulae are deduced of such a kind that they apply to every case which presents itself".<sup>50</sup>

Einstein does not appear to limit the achievement of contact with the real world to scientific thinking. In fact he uses the general process of human thinking as a framework within which, because of its more precise form of thinking produced by measurement, science may be located. Here, in some detail, he describes the formation of ordinary concepts from the welter of sense experience as well as the judgment which is the act wherein "we attribute to the bodily object a real existence". By this process we orient ourselves in the flux of sense impressions possessing as it does a stronger reference to reality however insecure it all may really be. But for any thinking, it is the connection with the sense impressions which alone justifies our knowledge of the real world.

I believe that the first step in setting of a "real external world" is the formation of the concept of bodily objects and of bodily objects of various kinds. Out of the multitude of our sense experiences we take, mentally and arbitrarily, certain repeatedly occurring complexes of sense impressions (partly in conjunction with sense impressions which are interpreted as signs for sense experiences of others), and we attribute to them a meaning - the meaning of the bodily object. Considered logically, this concept is not identical with the totality of sense impressions referred to; but it is an arbitrary creation of the human (or animal) mind. On the other hand, the concept owes its meaning and its justification exclusively to the totality of the sense impressions which we associate with it.

50. A. EINSTEIN, "Time, Space and Gravitation", Out of My Later Years, pp. 54-55.

The second step is to be found in the fact that, in our thinking (which determines our expectation), we attribute to this concept of the bodily object a significance, which is, to a high degree, independent of the sense impression which originally gives rise to it. This is what we mean when we attribute to the bodily object "a real existence". This justification of such a setting rests exclusively on the fact that, by means of such concepts and mental relations between them, we are able to orient ourselves in the labyrinth of sense impressions. These notions and relations, although free statements of our thoughts, appear to us as stronger and more unalterable than the individual sense experience itself, the character of which as anything other than the result of an illusion or hallucination is never completely guaranteed. On the other hand, these concepts and relations, and indeed the setting of real objects and, generally speaking, the existence of "the real world", have justification only insofar as they are connected with sense impressions between which they form a mental connection.<sup>51</sup>

The great Einsteinian emphasis on the formation of concepts both for general and particular, or scientific thinking, which is his prime epistemological interest is however that of "free invention". Thus he writes as follows:

The structure of the system is the work of reason; the empirical contents and their mutual relations must find their representation in the conclusions of the theory.

In the possibility of such a representation lie the sole value and justification of the whole system, and especially of the concepts and fundamental principles which underlie it. These latter, by the way, are free inventions of the human intellect, which cannot be justified either by the nature of that intellect or in any other fashion a priori.<sup>52</sup>

Indeed, it was the error of Galileo and Newton to believe that the ideas and axioms of physics were other than free inventions of the mind. Instead, they thought that it

51. A. EINSTEIN, Op. cit., pp. 59-60.

52. A. EINSTEIN, "Of Method ....", p. 15.

was the work of logical or extensive abstraction. He then goes on to explain how it was that Newton, whom he calls, "the first creator of a comprehensive, workable system of theoretical physics", could believe that the basic concepts and laws of his system were derived from sensible experiences.

The tremendous practical success of his doctrines may well have prevented him and the physicists of the eighteenth and nineteenth centuries from recognizing the fictitious character of the foundations of his system. The natural philosophers of those days were, on the contrary, most of them possessed with the idea that the fundamental concepts and postulates of physics were not in the logical sense free inventions of the human mind but could be deduced from experience by "abstraction" - that is to say by logical means. A clear recognition of the erroneousness of this notion really only came with the general theory of relativity, which showed that one could take account of a wider range of empirical facts, and that too in a more satisfactory and complete manner, on a foundation quite different from the Newtonian.<sup>53</sup>

Unfortunately, with respect to the discovery of the principles or postulates of the system, says Einstein, there is "no method capable of being learned and systematically applied so that it lead to the goal". And, of course, without the principles themselves, all the mathematical machinery avails nothing, for the theorist has found no starting point, literally nothing to think about. Meanwhile, "the individual fact is of no use to the theorist" nor can he "do anything with the isolated empirical generalization of more or less wide application". No, without the principles to

53. A. EINSTEIN, "Of Method ....." pp. 16-17.

form the basis of deductive reasoning the theorist is "helpless".<sup>54</sup>

Einstein is here laying down what has properly been called an epistemological system. Indeed, as F.S.C. Northrup has remarked, in this respect, Einstein is rare even among truly distinguished scientists.<sup>55</sup> Usually, he says the scientist's methods are so incorporated in his habits that he is like the truly natural athlete who performs spontaneously, and without giving any conscious attention to what he is doing. Einstein however, has given as much conscious effort to his own method of working as to the work itself. Northrup has suggested that this very fact may explain the immense success of Einstein's scientific work.

He writes:

Moreover, his analysis of scientific method has taken him beyond empirical logic into epistemology. In fact, his technical epoch-making contributions to theoretical physics owe their discovery and success in considerable part to the more careful attention which he has given, as compared with his predecessors, to the epistemological relation of the scientist as knower to the subject matter of physics as known.<sup>56</sup>

Einstein has emphasized the role that his theory has played in making clear the role that free invention of the fundamental concepts and postulates of physics along with

54. A. EINSTEIN, "Inaugural Address", p. 7.

55. F.S.C. NORTHRUP, "Einstein's Conception of Science", AEPS, p. 7.

56. Ibid.

their non-deducibility from experience by abstraction has played. He does not appear, however, to attribute the success of his scientific work directly to his thinking in epistemology, as Northrup suggests. In fact, he does warn about too strict a commitment to any one epistemological system (which of course is an epistemological precept itself), while taking notice of a due relationship which should fruitfully obtain between the two disciplines.

The reciprocal relationship of epistemology and science is of noteworthy kind. They are dependent upon each other. Epistemology without contact with science becomes an empty scheme. Science without epistemology is - insofar as it is thinkable at all - primitive and muddled. However, no sooner has the epistemologist, who is seeking a clear system, fought his way through to such a system, than he is inclined to interpret the thought-content of science in the sense of his system and to reject whatever does not fit into his system. The scientist, however, cannot afford to carry his striving for epistemological systematic that far. He accepts gratefully the epistemological conceptual analysis; but the external conditions, which are set for him by the facts of experience, do not permit him to let himself be too much restricted in the construction of his conceptual world by the adherence to an epistemological system. He therefore must appear to the systematic epistemologist as a type of unscrupulous opportunist; he appears as realist insofar as he seeks to describe a world independent of the acts of perception; as idealist insofar as he looks upon the concepts and the theories as the free inventions of the human spirit (not logically derivable from what is empirically given); as positivist insofar as he considers his concepts and theories justified only to the extent to which they furnish a logical representation of relations among sensory experiences. He may even appear as Platonist or Pythagorean insofar as he considers the viewpoint of logical simplicity an indispensable and effective tool of his research.<sup>57</sup>

57. A. EINSTEIN, "Reply to Criticism", AEPS, pp. 633-634.

Einstein throws some further light on the origins of these concepts when he discusses them from the psychological rather than the epistemological standpoint. In one of his few references to the importance of the image, he writes as follows:

The words or the language, as they are written or spoken, do not seem to play any role in my mechanism<sup>58</sup> of thought. The physical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined.

There is, of course, a certain connection between those elements and relevant logical concepts. It is also clear that the desire to arrive finally at logically connected concepts is the emotional basis of this rather vague play with the above mentioned elements. But taken from a psychological viewpoint, this combinatory play seems to be the essential feature in productive thought before there is any connection with logical construction in words or other kinds of signs which can be communicated to others.<sup>58</sup>

Here we find Einstein clearly turning to the phantasms in his imagination to serve him in his thought. He admits that there must be a certain connection between "those elements and relevant logical concepts". Unfortunately, one does not find him anywhere enlarging to any extent on this important aspect of his own psychological processes.

He does speak, of course, of his desire to produce logically connected concepts as the emotional basis of such play. It is the combinatory play of concepts, itself, which characterizes productive thought. But the theoretical

58. Jacques HADAMARD, The Psychology of Invention in the Mathematical Field, Princeton University Press, 1945, p. 143.

physicist should not allow himself to be hampered by epistemological prohibitions concerning either meaning or the source of the concepts. Indeed, "the theorist who undertakes such a labor should not be carped at as "fanciful"; on the contrary, he should be encouraged to "give free rein to his fancy, for there is no other way to the goal". Then he adds, "this plea was needed; it is the line of thought which has led from the special to the general theory and then to the latest offshot, the unitary field theory".<sup>59</sup>

According to Einstein, it is the General Theory of Relativity which demonstrated convincingly the free nature of the principles of a theory. This theory has revealed that by using principles quite differently conceived from those of Newton, it was possible to comprehend nature even more successfully than Newton has.

The fictitious character of fundamental principles is perfectly evident from the fact that we can point to two essentially different principles, both of which correspond with experience to a large extent; this proves at the same time that every attempt at a logical deduction of the basic concepts and postulates of mechanics from elementary experiences is doomed to failure.<sup>60</sup>

Thus, he is saying that there is no inductive path from experience to the postulates of a valid theory. The creative principle of theoretical physics lies with the free inventive mind. Nor is there for Einstein any limitation in

59. A. EINSTEIN, "The Problem of Space", p. 70.

60. A. EINSTEIN, "Of Method . . . .", p. 17.

this creative function, in the Kantian sense, by any a priori forms of intuition. Kant, however, "was thoroughly convinced of the indispensability of certain concepts (and) took these - just as they are selected - to be the necessary premises of every kind of thinking and differentiated them from concepts of empirical origin. I am convinced," says Einstein, "that this differentiation is erroneous".<sup>61</sup>

It was the very invention of non-Euclidean forms of geometry that first liberated mathematical thought historically, and Einstein concedes the difficulties for Kant in living before the time of these discoveries. But this is not to deny that there is not for Albert Einstein as well as for Kant, a spatio-temporal relatedness in thought other than a purely sensual relatedness. But for Einstein it is not a category imposed from the "intangible heights of the a priori".<sup>62</sup>

Instead, these spatio-temporal concepts are ones which have been discovered by the free play of the inventive mathematical mind. Far from being necessary such concepts are tentative,<sup>63</sup> and remain as such even after the resultant

61. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 13.

62. Cf. Supra, Note 52, p. 33.

63. EINSTEIN uses the word "tentative" often when referring to the deductive process of the theorist e.g. "The predominately inductive methods appropriate to the youth of science are giving place to tentative deduction." World As I See It, p. 92

implications of such concepts have been effectively correlated with sense data. Thus Einstein writes they "cannot be justified by the nature of the intellect".<sup>64</sup> As to the objective character of this Einsteinian concept of space-time, Northrup writes significantly:

The space-time of Einsteinian physics is the relatedness of the gravitational field of nature. It is fictitious in the sense that it is not a positivistically immediate, purely denotatively, inductively given datum; it is fictitious in the sense that it is discovered only by a free play of the scientist's imagination and not by the inductive method of extensive abstraction from empirical immediacy; it is fictitious also in the sense that it is only known positively by a leap of the imagination, a leap even of the formal, purely intellectual imagination; but it is not fictitious in the sense that the sole source of its being is in the knower or subject of knowledge. Instead, it constitutes and is literally the physical relatedness of the physical object of knowledge. It belongs to nature. It has its roots in nature; it is not restricted solely to the mind of man.<sup>65</sup>

And the concept of space-time, indeed any concept is tentative because mathematical invention is not reality itself but the method of grasping reality. Indeed to the extent that propositions of mathematics refer to reality, they are not at all certain, says Einstein.<sup>66</sup> In addition, in mathematics we are playing a game according to certain rules themselves arbitrary, whose fixation is not final

64. A. EINSTEIN, The World as I See It, p. 133.

65. H. MARGENAU, "Einstein's Conception of Science", AEPS, pp. 396-397.

66. Cf. Supra, Note 25, p. 17.

since "there are no final categories in the sense of Kant."<sup>67</sup> In addition, the confirmation of the theory is only approximate since the variables are interpreted by the results which are themselves approximate. The testing apparatus itself is constructed on the basis of Newtonian physics which as the Relativity Theory requires, hold only for short distances. Einstein speaks of this fact as follows:

In this methodological uncertainty, one might suppose that there were any number of possible systems of theoretical physics all with an equal amount to be said for them; and this opinion is no doubt correct, theoretically.<sup>68</sup>

Einstein underlines this fact of the tentative character of theory best of all when he says that sense perceptions only gives information of the external world indirectly.<sup>69</sup>

Here, no doubt, Einstein is aware of Berkeley's analysis of the datum of the senses and its relative, private, shifting characters. But what science needs is something exactly opposite, i.e., something public and objective and verifiable. For Einstein, this is achieved postulationally. But it is precisely because it is not related to sense data

67. A. EINSTEIN, "Physics and Reality", Out of My Later Years, Library, p. 61.

68. A. EINSTEIN, "Principles of Research", p. 4.

69. A. EINSTEIN, "Maxwell's Influence", p. 40.

directly that it is tentative.<sup>70</sup>

Thus, Einstein must say "it follows from this that our notions of physical reality can never be final".<sup>71</sup>

Einstein clearly states that a justification by the senses would thus be no justification at all. He tells us that what justifies the concept is the fact that they succeed in helping us understand reality.

What I dislike in this kind of argumentation is the basic positivistic attitude, which from my point of view is untenable, and which seems to me to come to the same thing as Berkeley's principle, esse est percipi. "Being" is always something which is mentally constructed by us, that is, something which we freely posit (in the logical sense). The justification of such constructs does not lie in their derivation from what is given by the senses. Such a type of derivation (in the sense of logical deducibility) is nowhere to be had, not even in the domain of pre-scientific thinking. The justification of the constructs, which represent "reality" for us, lies alone in their quality of making intelligible what is sensorily given.<sup>72</sup>

Einstein, of course, is allied to Kant on the question

70. "Formal logic in scientific method runs not from the empirical data to the postulates of the deductively formulated theory but in the converse direction; from the postulates back through the theorisms to the data. This means that in scientific verification, the logic of verification is always committing the fallacy of affirming the consequent of the hypothetical syllogism. This does not entail that a theory thus verified is false. It means merely that it cannot be shown to be necessarily true. The fact that the theory is thus indirectly confirmed justifies its retention. The fact that it is not, however, related to empirical data necessarily forces me to hold it tentatively". F. C. NORTHROP, Op. cit., p. 405.

71. A. EINSTEIN, "Clerk Maxwell's Influence ...", p. 40.

72. A. EINSTEIN, "Reply to Criticisms", AEPS, p. 669.

of the spontaneity of thinking. It is just that, according to Einstein, he went too far in calling these concepts "necessary a priori". If he had been satisfied to notice that our thinking depends on categories of thought non-deducible from the senses, there would be no objection to his epistemology.

It seems to me, moreover, that you have not at all done justice to the really significant philosophical achievement of Kant. From Hume Kant had learned that there are concepts (as for example, that of causal connection), which play a dominating role in our thinking, and which, nevertheless, can not be deduced by means of a logical process from the empirically given (a fact which several empiricists recognize, it is true, but seem always again to forget). What justifies the use of such concepts? Suppose he had replied in this sense: Thinking is necessary in order to understand the empirically given, and concepts and "categories" are necessary as indispensable elements of thinking.<sup>73</sup>

Section C. The Deductive Process. The Rules of Naturalness and Simplicity

In addition to the free, non-deducible character of the principles of scientific theory, there is also the strong belief with Einstein that the world is best described in the simplest way. Thus, when Poincaré, for example, recommended Euclidean geometry because of its greater simplicity compared to other geometries, Einstein goes him "one better" as it were, by rejecting Euclidean geometry for the same reason - the reason of the total simplicity of physics.

73. A. EINSTEIN, Op. cit., p. 678.

Against Poincaré's suggestion it is to be pointed out that what really matters is not merely the greatest possible simplicity of the geometry alone, but rather the greatest possible simplicity of all of physics (inclusive of geometry). This is what is, in the first instance, involved in the fact that today we must decline as unsuitable, the suggestion to adhere to Euclidean geometry.<sup>74</sup>

This criterion of simplicity, of course, has often been used by scientists and is often traced to the principles of Occam's Razor and Leibniz' Identity of Indiscernibles. Einstein notes that although an "exact formulation" of a "logical simplicity of the premises of the basic concepts and of the relations between them which are taken as a basis .....meets with great difficulties (however) it has played an important role in the selection and evaluation of theories since time immemorial".<sup>75</sup> The elucidation of the problem, he epistemologizes, is not simply one of listing the premises one by one, but of paying attention to the irreducible qualitative differences between each and evaluating them. In addition, a system whose principles are most concrete is best.

The problem here is not simply one of a kind of enumeration of the logically independent premises (if anything like this were at all unequivocally possible), but that of a kind of reciprocal weighing of incommensurable qualities. Furthermore, among theories of equally "simple" foundation that one is to be taken as superior which most sharply delimits the qualities of systems in the

74. Ibid.

75. C. F. Hans REICHENBACH, "Philosophical Significance of Relativity", AEPS, p. 291.

abstract (i.e. contains the most definite claims).<sup>76</sup>

By best, Einstein does not necessarily mean the truest. On this point, he says, there exists a great amount of confusion.<sup>77</sup> By the simplest is meant not the one easiest for the student to absorb, "but the one which contains the few possible mutually independent postulates or axioms".<sup>78</sup> One reason for this goal is to reduce to a minimum the content of the theory which is not comprehended.<sup>79</sup> Another reason

76. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 24.

77. "Some confusion has arisen from considerations referring to the property of simplicity. One descriptive system can be simpler than another; but that fact does not make it "truer" than the other. The decimal system is simpler than the yard-foot-inch system; but an architect's plan drawn in feet and inches is as true a description of a house as a plan drawn in the decimal system. A simplicity of this kind, for which I have used the name of descriptive simplicity, is not a criterion of truth. Only within the frame of inductive considerations can simplicity be a criterion of truth; for instance, the simplest curve between observational data plotted in a diagram is regarded as "truer", i.e., more probable, than other connecting curves. This inductive simplicity, however, refers to non-equivalent descriptions and does not play a part in the theory of relativity, in which only equivalent descriptions are compared. The simplicity of descriptions used in Einstein's theory is therefore always a descriptive simplicity. For instance, the fact that non-Euclidean geometry often supplies a simpler description of physical space than does Euclidean geometry does not make the non-Euclidean description "truer". H. REICHENBACH, "Philosophical Significance of Relativity," p. 236, AEPS.

78. A. EINSTEIN, "Address at Columbia", p. 113.

79. Ibid.

is in imitation of Nature, which manifests "the mysterious harmony".<sup>80</sup> And, as if in imitation of that fact of nature, men struggle to express themselves according to ideals of geometrical simplicity.

As far back as ancient times people devised the lines exhibiting the simplest conceivable form of regularity. Among these, next to the straight line and the circle, the most important were the ellipse and the hyperbola. We see the last two embodied - at least very nearly so - in the orbits of the heavenly bodies.<sup>81</sup>

Then, too, there is the creative function of the pursuit of this ideal. For if the scientist sets purposively about "looking for the mathematically simplest concepts and the link between them", he will arrive at the "simplest mathematical fields that are possible in a metrical continuum of four dimensions".<sup>82</sup> And in perhaps the classic passage in Einstein's epistemological writings, he says this goal bore fruit in the general theory of relativity.

The physical world is represented as a four-dimensional continuum, If in this I adopt a Riemannian metric, and look for the simplest laws which such a metric can satisfy, I arrive at the relativistic gravitation theory of empty space. If I adopt in this space a vector-field, or the anti-symmetrical tensor-field derived from it, and if I look for the simplest laws which such a field can satisfy, I arrive at Maxwell's equations for empty space.<sup>83</sup>

Beyond the successes of relativity theories which Einstein regards, of course, as short of the goal, is the struggle

80. A. EINSTEIN, "Principles of Research, AEPS, p. 27.

81. Ibid.

82. A. EINSTEIN, "Of Methods . . . .", AEPS, p. 19.

83. A. EINSTEIN, Op. cit., p. 13.

towards a Unified Field Theory which also must involve the ideal of the paucity of mathematically existent fields and of the relations between them "wherein lies the hope of comprehending reality in its depth".<sup>84</sup>

Einstein imposes this condition of simplicity both on the base or axiomatic foundations of the deductive process and on the steps of the process itself. This ideal of logical simplicity is borne out very well in the consideration of the cosmological constant of Einstein to which he gave the name of the Greek letter, lambda or  $\Lambda$ .<sup>85</sup>

84. "Simplicity and comprehensiveness are actualized in the theory of relativity in a most impressive way; the general theory includes the special theory for the special limiting case of  $g = \text{const.}$  The form of the laws of nature must be covariant with respect to arbitrary transformations, and the tensor analysis makes such a formulation possible. The immense heuristic value embodied in this postulate of general covariance is obvious; it restricts the possible laws of nature to those that satisfy the covariance condition." Ilse ROSENTHAL-SCHNEIDER, "Pre-Suppositisms and Anticipations, AEPS, p. 133.
85. "The story of the 'cosmological' constant' also throws an interesting side light on this issue. The simplest law of gravitation, which related the second order, divergence-free tensor  $R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}$  directly to the matter-energy tensor  $T_{\mu\nu}$ , was regrettably found to be in error because it failed to account for the finite mean density of matter in the universe. Proceeding under the restraint of the simplicity conviction, Einstein introduced into his law the minimum complication by adding the term  $\Lambda g_{\mu\nu}$  being the cosmological constant. This amounted to a most unwelcome sacrifice. In reading the Appendix for the Second Edition of The Meaning of Relativity (1945) one senses the relief which the author of this augmented law of gravitation experienced at the work of Friedmann, who showed that the cosmological constant is, after all, not needed." Henry MARGENAU, Op cit., p. 257.

After having discarded the inconsistent concept of a luminiferous ether and replaced the Lorentz's hypothesis, invented ad hoc to explain the negative results of Michelson's experiment, with his theory of the relativity of motion, based on the constant velocity of light as an absolute signal, he became dissatisfied with the introduction of the constant  $\Lambda$ . The reason was it seemed to interfere with the ideal of logical simplicity. Because of this he was relieved at Hubble's theory of the expanding universe and Friedman's assumption which did not employ the constant.

He says he was not happy about having to renounce the logical simplicity of his theory but it .....

appeared to me unavoidable only so long as one had no reason to doubt the essentially static nature of space. After Hubble's discovery of the "expansion" of the stellar system, and since Friedmann's discovery that the unsupplemented equations involve the possibility of the existence of an average (positive) density of matter in an expanding universe, the introduction of such a constant appears to me, from the theoretical standpoint, at present unjustified.<sup>36</sup>

Einstein is confident that physics is gradually but surely tending toward this goal of logical simplicity. The process is one which he calls "evolutionary".<sup>37</sup> But, in

36. In point of fact, the problem is by no means solved because Friedmann's equations imply an age of the universe of a mere billion years whereas, as Einstein says, in view of the reliably known age of minerals "the duration allowed for the expansion of space to the present appears smaller than is credible." Cf. A. EINSTEIN, "Reply to Criticisms", AEPS, p. 635.

37. A. EINSTEIN, "Physics and Reality", Out of My Later Years", p. 93.

order to accomplish it he says we must "make up our mind to accept the fact that the logical basis departs more and more from the facts of experience."<sup>88</sup> This means that the fundamental assumptions of a physical theory and the conclusions of such theories are separated by a gap growing progressively wider as the logical structure becomes more unified.<sup>89</sup> Thus, the theoretical structure of a science "needs to be thoroughly elaborated before it can be compared with experience".<sup>90</sup> This will result in the formation of a "wide chasm

88. Ibid.

89. "This drifting away from phenomenological physics, this loss of closeness to experience for the sake of greater comprehensiveness and unity, can be seen in the whole development of modern physics. In general relativity, for instance, the four co-ordinates by themselves had no longer any direct physical meaning, they were only mathematical symbols, and the theory obtained its physical foundation by the introduction of the invariant infinitesimal distance  $ds^2 = \sum_{\mu, \nu} g_{\mu\nu} dx_{\mu} dx_{\nu}$ ". Else ROSENTHAL-SCHNEIDER, "Pre-Suppositions and Anticipations", AEPS, p. 131.

Again, "In Maxwell's theory, the symbols, in the alteration of which the characteristic feature of the theory depends, are retained through the deduction and appear in the law which is compared with experiment. Accordingly, it is possible to give some idea of what these symbols mean in terms of things experimentally observed. But in Sommerfeld's or Einstein's theory the symbols, which are necessarily involved in the assumption which differentiates their theories from others, disappear during the deduction; they leave a mark on the other symbols which remain and later the relation between them; but the symbols, on the relations of which the whole theory hangs, do not appear at all in any law deduced from the theory. It is quite impossible to give any idea of what they mean in terms of experiment." Norman CAMPBELL, What is Science, Dover, (1921) 1952, p. 157.

90. A. EINSTEIN, "The Problem of Space", p. 69.

separating the axioms from their verifiable conclusions, which can only be bridged by much intense, hard thinking".<sup>91</sup>

The theory of Relativity shows this modern tendency of science especially well wherein, from a start in sense experience, the theory becomes more abstract and remote from sense data to be guided only by purely formal consideration.

The theory of relativity is a fine example of the fundamental character of the modern development of theoretical science. The hypotheses with which it starts become steadily more abstract and remote from experience. On the other hand it gets nearer to the grand aim of all science, which is to cover the greatest possible number of empirical facts by logical deduction from the smallest possible number of hypotheses or axioms. Meanwhile the train of thought leading from the axioms to the empirical facts or verifiable consequences gets steadily longer and more subtle. The theoretical scientist is compelled in an increasing degree to be guided by purely mathematical, formal considerations in his search for a theory.<sup>92</sup>

At this point in the consideration of the Einsteinian epistemology the fullest attention must be paid to the differences which obtain between Einstein and Mach on what might be called the question of "Phenomenological Physics". Einstein has always felt it necessary to explain himself on the question of "positivism" in science.

According to Mach and his school, the postulates and fundamental laws of physical theory should be limited to containing only such as are related to and definable by direct verification or by no more than a very short extension

91. Ibid.

92. A. EINSTEIN, "The Problem of Space", p. 69.

from such observation. Thus Einstein writes, "He (Mach) conceived every science as the task of bringing order into the elementary single observation which he described as sensations".<sup>93</sup>

As has been seen, Einstein formulates his theory in long deductive arguments which made no attempt to retain an empirical content.<sup>94</sup> However, he also held that there must be a connection in the conclusions of the theory which, in fact, are necessary to test the whole validity of the theory itself. This requirement regarding the theorems is positivistic, therefore, in the sense that the general principles are "ultimately" checked by direct experimental observations. However, it is necessary to "place in its correct light the essentially constructive and speculative nature of thought and especially of scientific thought".<sup>95</sup> And "this Mach and certain other nineteenth century scientific thinkers did not do, condemning a theory on precisely those points where its constructive-speculative character comes to light, as for example, in the kinetic atomic theory".<sup>96</sup>

Now it is true that Mach, himself, was reacting to the

93. A. EINSTEIN, "Obituary on Mach", Physicalisch Zeitschrift, XVII (1916), p. 101.

94. Cf. Supra, Note 89, p. 49.

95. Cf. Supra, Note 33, p. 21.

96. Cf. Supra, ibid.

prevalent nineteenth century idea that scientific laws and concepts could be derived from experience by "abstractions". In this respect, Einstein says, he and Mach agree. F.S.C. Northrup refers to this abstraction rejected by Einstein as the "extensive abstractions of Aristotle and Whitehead".

Einstein's dictum that the "axiomatic basis of theoretical physics cannot be abstracted from experience but must be freely invented" entails the rejection on the one hand of the positivistic, purely empirical, Humean philosophy, which would reduce all scientific meanings to nominalistic particulars, and also, on the other hand, of the Aristotelian and Whiteheadian epistemology, which, while admitting universal or nontemporal invariant meanings, would nonetheless insist upon deriving them from empirical immediacy by the method of extensive abstraction.<sup>97</sup>

In this connection it is interesting to read the criticism of Northrup by Paul Ushenko of Princeton which suggests that Northrup has misled Einstein on the doctrine of abstractions. Einstein regarded Whitehead's views as an attack upon his own doctrine of the Relativity of Simultaneity, but Ushenko maintains it was Northrup's interpretation of Whitehead's views which disaffected Einstein.

An examination of Northrup's contention is in order not only because, in the context of his interesting article on "Whitehead's Philosophy of Science" the misinterpretation enjoys an appearance of plausibility, but also because Northrup may have succeeded in misleading Einstein. In an attempt to explain to Einstein Whitehead's position Northrup made the following statement:

When Whitehead affirms an intuitively given meaning of simultaneity of spatially separated events he means immediately sensed phenomeno-logical events, not postulated public physically defined events..... We

97. F.S.C. NORTHRUP, "Einstein's Conception of Science", AEPS, p. 395.

certainly do see a flash in the distant visual space of the sky now, while (and subsequently?) we hear an explosion beside us. His reason for maintaining that this is the only kind of simultaneity which is given arises from his desire, in order to meet epistemological philosophical difficulties, to have only one continuum of intuitively given events, and to avoid the bifurcation between these phenomenal events and the postulated physically defined public events.

Northrup tells us that Einstein's comment on Whitehead's theory thus presented was: "on that theory there would be no meaning to two observers speaking about the same event". This comment is a reductio ad absurdum not of Whitehead's view but of Northrup's account of the latter.<sup>98</sup>

Einstein, however, gives at least some value to the doctrine of abstractions in the following words. He says:

(It is) because the physical experience of the experimenter cannot lift him into the regions of highest abstraction. The predominantly inductive methods appropriate to the youth of science are giving place to tentative deduction.<sup>99</sup>

However, more often, he rejects "abstraction" as productive of any fruitful scientific methodology.

On the question of Einstein's doctrine of the relativity of simultaneity, Ushenko admits that Whitehead has criticized the doctrine of simultaneity but not the scientific

98. A. USHENKO, "Einstein's Influence on Contemporary Philosophy", AEPS, p. 624.

99. A. EINSTEIN, "The Problems of Space", p. 69. The use of the word "abstraction" here seems to be something more than a concession to language custom by Einstein, but to call attention to the unavoidable of the notion of abstraction viewed not only as a terminal condition of knowledge but as an epistemological process as well. Thus it would seem one cannot reach "the regions of highest abstraction" without an abstractive act to get one there.

procedure of establishing it by postulated theory.<sup>100</sup> This is confirmed by lengthy deductive processes leading to conclusions capable of being tested and not by immediate apprehension. Ushenko insists that there is "ample room for knowledge by inference" in Whitehead's doctrine of extensive abstraction and that this very method in Whitehead's hands provides too many illustrations of the fact to doubt it. He claims that Northrup misunderstands Whitehead's axiom, "Nature is nothing else than the deliverance of sense-awareness".

Actually, he says, Whitehead does not assert that perceptions account for all our knowledge. His position is that "there are no kinds of things in nature except the kinds which, in principle, can be known directly through perception".<sup>101</sup> And yet, this would seem to connote a different kind of conceptual-sensible relationship than the

100. M. Bergson has devoted an entire book to the explanation of his views on this question and to the detailed refutation of what he considers an initial and essential error on the part of Einstein. In it Bergson tries to prove that Einstein's relativity of simultaneity is but a mirage, an artificial and false phenomenal image and that the simultaneity of two events does, in fact, have an absolute value which is accessible to all classes of observers. The attempt to appraise this criticism by Bergson as well as by M. Maritain is not the purpose of this thesis however. Cf. H. BERGSON, Durée et simultanéité, Paris, Alcan, 1926; also Cf. J. MARITAIN, "Nouveau Débats Einsteinien", in Revue Universelle, (April 1, 1923.)

101. A. USHENKO, Op Cit., pp. 624-625.

one proper to Einstein for whom, as he says, concepts are to the sense-experiences "not like the soup to the beef but more like the cloakroom number to the coat".<sup>102</sup> Using this analogy, then, Einstein would begin his work of theoretic deduction from a concept or complex of concepts quantitatively related to sense experiences but, of course, not abstracted from them. The cloak room number would then be freely invented, in the sense that another number could arbitrarily have been chosen for the coat. But a wrong number could also be given such as one proper for hats or umbrellas or even one already given out for another coat. There must then be an intuition or feeling for the right cloakroom number so well brought out by Reichenbach.<sup>103</sup> But there must be freedom in this intuition in order that the consequences must be successful i.e. the right coat given back. Using this analogy, then, there is implicit in the cloakroom number the whole chain of events leading to the successful handling of the coat. And it is to this "physical entity" i.e. the cloakroom number, that the scientist turns to begin his deductive work. There does not appear to be any doubt that the cloakroom number is really an image, which he said earlier, "seems to serve as elements in thought ....more or less clear....which can be "voluntarily" reproduced or combined.

102. A. EINSTEIN, "Physics & Reality", Out of My Later Years, p. 63.

103. Cf. H. REICHENBACH, From Copernicus to Einstein, New York, Philosophical Library, 1942, pp. 72-73.

Thus, Einstein seems to notice that the mind turns to the phantasms as material representations of sensible things in the first instance. Beyond this there is the realization by Einstein that the positivistic requirement that the chain of deductive thought needs to be kept short and close to observation, was an oversimplification of the problem of logical theory by Mach and his followers and harmful to scientific progress. Mach's rejection of atoms because they could not be seen, is an example of this.<sup>104</sup>

Einstein, in opposition to Mach, stressed the speculative-constructive character of thought and as a result of the insights gained into the structures of deductive theorizing, what might be called a liberalizing process began to take place among the neo-positivistic school of the early twentieth century. It was a case of trying to adjust to the successful method which had been employed by Einstein in his theoretic work.

The name of this new school of thought, of course, was that of "Logical Empiricism" which took the new view that the concepts and axioms of scientific thinking are free products of the creative imagination. These concepts were not limited to sensible positive experiences, viz: observational terms such as the color or weight of a body, but could include atoms, space, points, etc. They perpetuated the positivistic requirement however that the justification for the

104. Cf. Supra, Note 39, p. 24.

concepts and deductive processes however attenuated must be that of confirmation by experience. No other standard of validation was permitted such as ideals of mathematic form, simplicity, unity coherency, etc.

Actually, the insistence of Mach on positive observation and restriction to sense data as marks of science was in line with the general attack on the "empty talk of metaphysics", of which Hume's remarks are the classic example.

If we take in our hand any volume of divinity or school metaphysics, for instance, let us ask, "does it contain any abstract reasoning concerning quantity or number?" No. "Does it contain any experimental reasoning concerning matter of fact and existence?" No. Commit it then to the flames for it can obtain nothing but sophistry and illusion.<sup>105</sup>

Thus, when the "Science of Mechanics" of Mach appeared in 1883 its aim was described by him as that of trying to "clear up ideas, expose the real significance of the matter and get rid of "metaphysical obscurities".<sup>106</sup>

Einstein frequently admits his debt to Mach moreover<sup>107</sup> and goes so far as to suggest that if Mach had the benefit of Michaelson's experiments on light, he probably would have discovered the relativity of motion before him.<sup>108</sup>

105. David HUME, Enquiry Concerning Human Understanding, Harvard Classics, Vol. 37, p. 445.

106. E. MACH, The Science of Mechanics, preface to the first edition, London, Open Court Pub., Co., p. xiii.

107. Cf. Supra, Note 33, p. 21.

108. A. EINSTEIN, Ideas and Opinions, p. 248.

The relationship that Mach had to Hume was so close, however, that inevitably, Einstein who differed with Hume on the role of phenomenon, and on the notion of causality, came to differ with Mach on these two same issues. In the Science of Mechanics, Mach reveals his views on this subject:

In speaking of cause and effect we arbitrarily give relief to those elements to whose connection we have to attend in the reproduction of a fact in the respect in which it is important to us. There is no cause nor effect in nature; nature has but an individual existence; nature simply is. Recurrences of like cases in which A is always connected with B, that is, like results under like circumstances, that is again, the essence of the connection of cause and effect, exist but in the abstraction which we perform for the purpose of mentally reproducing the facts.<sup>109</sup>

Again, on the role of sensations:

Nature is composed of sensations as its elements. Primitive man, however, first picks out certain compounds of these elements - those namely that are relatively permanent and of greater importance to him. The first and oldest words are names of "things". Even here, there is an abstractive process, an abstraction from the surroundings of the things, and from the continual small changes which these compound sensations undergo, which being practically unimportant are not noticed. No inalterable thing exists. The thing is an abstraction, the name a symbol, for a compound of elements from whose changes we abstract.<sup>110</sup>

Thus, while Einstein had high esteem for Hume, remarking that he was surprised "so much obscure stuff" could still be written after him by philosophers and could find grateful readers, his actual debt to Hume was psychological rather than epistemological:

109. E. MACH, Op. cit., p. 580.

110. E. MACH, Op. cit. p. 579-580.

The type of critical reasoning which was required for the discovery of this central point was decisively furthered, in my case, especially by the reading of David Hume's and Ernst Mach's philosophical writings.<sup>111</sup>

Einstein's scientific methodology is predicated upon the strongest faith in a causality not as conceived by Hume in the subjectivist terms, stabilized by Kant and later practiced by Mach. His view was first of all an empirically determinable connection between a scientifically calculated event and the future state which it logically implies.<sup>112</sup> More accurately, it is a view of a universal, rigidly determined causation:

When one views the matter historically, one is inclined to look upon science and religion as irreconcilable antagonists, and for a very obvious reason. The man who is thoroughly convinced of the universal operation of the law of causation cannot for a moment entertain the idea of a being who interferes in the course of events - that is, if he takes the hypothesis of causality really seriously.<sup>113</sup>

It is a full dress causality for the world, considered macroscopically. But at the same time, it is neither a Humean-Machean subjectivist view denying that reason could discover the causal connections which operated in the real world or a Kantian one which imposes causality by a

111. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 53.

112. A. EINSTEIN, "Mechanics of Newton", p. 30. Here, Professor Einstein tells us that he refused to release certain ideas on his theory of General Relativity because they seemed to controvert his belief in causality.

113. A. EINSTEIN, "Religion and Science", Ideas and Opinions, p. 39.

113a 60

necessary causal category. To the extent that both Hume and Kant rejected the direct abstraction of causal connections between things from sense experience, Einstein, however, agrees with them. Thus he can write:

A remark to the historical development. Hume saw clearly that certain concepts, as for example, that of causality, cannot be deduced from the material of experience by logical methods. Kant, thoroughly convinced of the indispensability of certain concepts, took them - just as they are selected - to be the necessary premises of every kind of thinking and differentiated them from concepts of empirical origin. I am convinced, however, that his differentiation is erroneous, i.e., that it does not do justice to the problem in a natural way. All concepts even those which are closest to experience, are from the point of view of logic, freely chosen conventions, just as is the case with the concept of causality, with which this problematic concerned itself in the first place.<sup>114</sup>

Section D. - The Epistemological Elements of the  
Special Theory of Relativity.  
Confirmation of the Theory.

The Special Theory of Relativity appeared for the first time as a monograph by Albert Einstein in Annalen der Physik 17 in 1905 and was entitled, "On the Electrodynamics of Moving Bodies". Considering the Newtonian-type revolution it would produce in man's view of his universe, it is remarkably brief, running to no more than thirty small

113a. On this point, see the relevant remarks on scientific as opposed to "historical" causality by Ernst CASSIRER in his Substance and Function and Einstein's Theory of Relativity, New York, Dover, 1953, p. 226 n, ff.

114. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 13.

pages.<sup>115</sup>

In the opening paragraph Einstein reviews a fact of nature regarding the behavior of magnets and their conducting coils. He briefly describes the facts as follows:

If the magnet is in motion and the conductor at rest, there arises in the neighborhood of the magnet an electric field with a certain definite energy, producing a current at the places where parts of the conductor are situated. But if the magnet is stationary and the conductor in motion, no electric field arises in the neighborhood of the magnet. In the conductor, however, we find an electromotive force, to which in itself there is no corresponding energy, but which gives rise - assuming equality of relative motion in the two cases discussed - to electric currents of the same path and intensity as those produced by the electric forces in the former case.<sup>116</sup>

He then goes on to say that "examples of this sort suggest"....<sup>117</sup> (certain principles of physical nature to him) which escape the "customary view".<sup>118</sup> In the case of the relationship of magnets to a coil he says "the observable

115. "The views of space and time which I wish to lay before you have sprung from the soil of experimental physics, and therein lies their strength. They are radical. Henceforth, space by itself, and time by itself, are doomed to fall away into mere shadows, and only a kind of union of the two will preserve an independent reality." Opening remarks of H. MINKOWSKI, addressing 30th Assembly of German Natural Scientists and Physicians at Cologne, September 21, 1908, in Principles of Relativity, New York, Dover (no date), p. 75.

116. The Principles of Relativity, (A collection of original papers on the Special and General theory of relativity with notes by A. SOMMERFELD) New York: Dover Press (no date), p. 37.

117. Ibid.

118. Ibid.

phenomenon here depends only on the relative motion of the conductor and the magnet, whereas the customary view draws a sharp distinction between the two cases in which either the one or the other of these bodies is in motion".<sup>119</sup>

Now, this above-noted fact (together with its subjective interpretation) is an example of the sort of thing, says Einstein, which when taken "together with the unsuccessful attempts to discover any motion of the earth relatively to the light medium, suggest that the phenomena of electro-dynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small quantities, the same laws of electro-dynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good".<sup>120</sup>

Here attention must be given to this word used by Einstein, viz., "suggest". There has been seen in the previous sections Einstein's epistemologic insistence that (a) the scientist must start with experimental facts and that (b) these facts do not function as deductive but rather as suggestible material.

Writing much later in his career, Einstein is to reemphasize this beginning of Relativity theory in empirical

119. Ibid.

120. A. EINSTEIN, Op. cit. pp. 37-38. (Italics mine.)

fact. Thus:

The general theory of relativity owes its existence in the first place to the empirical fact of the numerical equality of the inertial and gravitational mass of bodies, for which fundamental fact classical mechanics provided no interpretation".<sup>121</sup>

These "facts" as Einstein calls them, must be scrutinized for their meaning, however. According to ordinary usage the fact that a magnet induces electric current in a closed coil, when the former is moved is what is commonly called a "fact". A typical "fact" is one which has the power by itself to overthrow a theory.

Newton's fundamental principles were so satisfactory from the logical point of view that the impetus to overhaul them could only spring from the imperious demands of empirical fact. Before I go into this I must insist that Newton himself was better aware of the weakness inherent in his intellectual edifice than the generations of scientists which followed him. This fact has always aroused my respectful admiration, and I should like therefore to dwell on it for a moment.

I. In spite of the fact that Newton's ambition to represent his system as necessarily conditioned by experience and to introduce the smallest possible number of concepts not directly referable to empirical objects is everywhere evident, he sets up the concept of absolute space and absolute time, for which he has often been criticized in recent years. But in this point Newton is particularly consistent. He had realized that observable geometrical magnitudes (distances of material points from one another) and their course in time do not completely characterize motion in its physical aspects. He proved this in the famous experiment with the rotating vessel of water. Therefore, in addition to masses and temporally variable distances, there must be something else that determines motion. That "something" he takes to be relation to "absolute space". He is aware that space must possess a kind of physical

121. A. EINSTEIN, "On the Theory of Relativity", pp. 50-51.

reality if his laws of motion are to have any meaning, a reality of the same sort as material point and the intervals between them.

II. The introduction of forces acting directly and instantaneously at a distance into the representation of the effects of gravity is not in keeping with the character of most of the processes familiar to us from everyday life. Newton meets this objection by pointing to the fact that his law of reciprocal gravitation is not supposed to be a final explanation but a rule derived by induction from experience.

III. Newton's teaching provided no explanation for the highly remarkable fact that the weight and the inertia of a body are determined by the same quantity (its mass). The remarkableness of this fact struck Newton himself.

None of these three points can rank as a logical objection to the theory. In a sense they merely represent unsatisfied desires of the scientific spirit in its struggle for a complete and unitary penetration of natural events by thought. This short account is enough to show how the elements of Newtonian theory passed over into the general theory of relativity, whereby the three defects above mentioned were overcome.

122

Einstein now tells us what the postulates of his special relativity theory are and gives a description of the first of them.

The special theory of relativity is based on the following postulate, which is also satisfied by the mechanics of Galileo and Newton.

If a system of co-ordinates  $K$  is chosen so that, in relation to it, physical laws hold good in their simplest form, the same laws also hold good in relation to any other system of co-ordinates  $K'$  moving in uniform translation relatively to  $K$ . This postulate we call the "special principle of relativity". The word "special" is meant to intimate that the principle is restricted to the case when  $K$  has a motion of uniform

122. A. EINSTEIN, "Mechanics of Newton", pp. 34-35.

translation relatively to K, but that the equivalence of K and K does not extend to the case of non-uniform motion of K relatively to K.<sup>123</sup>

At the same time he proposes a joint postulate, that of the constant definite velocity of light completely independent of motion. The special theory will need only these two postulates, furthermore, as the basis of a satisfactory electro-dynamic theory using Maxwell's theory for fixed bodies as a point of departure. In addition, the postulates will assume nothing at all about a luminiferous ether since the theory will attempt to overcome the need for an absolute immobile space which he, of course, referred to as an empirically defective "fact" cited in the previous quotation under heading one.

We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity which is independent of the state of motion of the emitting body. These two postulates suffice for the attainment of a simple and consistent theory of the electro-dynamics of moving bodies based on Maxwell's theory for stationary bodies. The introduction of a "luminiferous ether" will prove to be superfluous inasmuch as the view here to be developed will not require an "absolutely stationary space" provided with special properties, nor assign a velocity-vector to a point of the empty space in which electro-magnetic processes take place.<sup>124</sup>

123. A. EINSTEIN, "The Foundation of the General Theory of Relativity", Principles of Relativity, p. lll.

124. A. EINSTEIN, "Mechanics of Newton", p. 38.

Einstein uses the word "conjecture" in referring to his first postulate. He is not yet dignifying it with the name of a theory; something arrived at by sufficient consideration of the arbitrarily chosen objects of "rigid bodies, clocks and electro-magnetic processes" and in an atmosphere of novel and unprecedented reflection (free association).

The theory to be developed is based - like all electro-dynamics - on the kinematics of the rigid body, since the assertions of any such theory have to do with the relationships between rigid bodies (system of co-ordinates), clocks, and electro-magnetic processes. Insufficient consideration of this circumstance lies at the root of the difficulties which the electro-dynamics of moving bodies at present encounter.<sup>125</sup>

Einstein, in the opening sentence of his original paper on Special Relativity referred to these difficulties known to be inherent in the application of Maxwell's equation to moving bodies:

It is known that Maxwell's electro-dynamics - as usually understood at the present time - when applied to moving bodies, leads to asymmetries which do not appear to be inherent in the phenomena.<sup>126</sup>

The facts, then, have suggested the problem: the interpretations are made and postulated, the postulation is then completed and now the definitions need to be supplied before the deductive process can begin.

Since the whole deductive process is going to be based on two postulates viz. on the principle of relativity and

125. A. EINSTEIN, Op. cit., p. 38.

126. A. EINSTEIN, Op. cit., p. 37.

on the constancy of the speed of light, Einstein immediately supplies the definitions for them:

For the Principle of Relativity:

1. The laws by which this state of physical system undergo change are not affected, whether the change of state be referred to the one or the other of two systems of coordinates in uniform transitory motion.

For the Principle of Light-Speed Constancy:

2. Any ray of light moves in the "stationary" system of coordinates with the determined velocity  $c$ , whether the ray be emitted by a stationary or by a moving body. Hence:  

$$\text{velocity} = \text{light path} / \text{time of interval,}$$
 where time interval is to be taken in the sense of the definition in part 1. 127

We are now ready to begin the logical deductive process. The important fact to remember about the significance of this deductive process is that from this point on it is a purely logical one and as a result of this fact, the conclusions or theorems of the Special theory of Relativity will merely reveal what have been assumed in the postulates even though the gain to us (viewed psychologically) may be immense. Thus, as Carl Hempel of Yale writes:

It is typical of any purely logical deduction that the conclusion to which it leads simply re-asserts (a proper or improper) part of what has already been stated in the premises. Thus, to illustrate this point by a very elementary example, from the premise, "this figure is a right triangle," we can deduce the conclusion, "This figure is a triangle"; but this conclusion clearly reiterates part of the information already contained in the premise. Again, from the premises, "All primes different from 2 are odd" and "n is a prime different

127. A. EINSTEIN, Op. cit., p. 41.

from 2," we can infer logically that  $n$  is odd; but this consequence merely repeats part (indeed a relatively small part) of the information contained in the premises. The same situation prevails in all other cases of logical deduction; and we may, therefore, say that logical deduction - which is the one and only method of mathematical proof - is a technique of conceptual analysis; it discloses what assertions are concealed in a given set of premises, and it makes us realize to what we committed ourselves in accepting those premises; but none of the results obtained by this technique ever goes by one iota beyond the information already contained in the initial assumptions.

Since all mathematical proofs rest exclusively on logical deductions from certain postulates, it follows that a mathematical theorem, such as the Pythagorean theorem in geometry, asserts nothing that is objectively or theoretically new as compared with the postulates from which it is derived, although its content may well be psychologically new in the sense that we were not aware of its being implicitly contained in the postulates.<sup>128</sup>

Einstein demonstrates this character of the logical deductive process of revealing what is implicit in the postulates to give us a "new" truth, in the following way. He first presents an imaginary experiment involving two systems, a stationary one and one moving uniformly to it in parallel translation. Thus:

Let there be given a stationary rigid rod; and let its length be  $l$  as measured by a measuring rod which is also stationary. We now imagine the axis of the rod lying along the axis of  $x$  of the stationary system of co-ordinates, and that a uniform motion of parallel translation with velocity  $v$  along the axis of  $x$  in the direction of increasing  $x$  is then imparted to the rod.<sup>129</sup>

128. C. HEMPEL, "Geometry and Empirical Science", The World of Mathematics, Vol. 3, pp. 1637-1638.

129. A. EINSTEIN, "Mechanics of Newton", p. 41.

Einstein tells us we must now determine the length of the moving rod. Since this is an imaginary experiment we must ascertain this length by two imaginary operations.

Thus:

We now inquire as to the length of the moving rod, and imagine its length to be ascertained by the following two operations:

(a) The observer moves together with the given measuring-rod and the rod to be measured, and measures the length of the rod directly by superposing the measuring-rod, in just the same way as if all three were at rest.

(b) By means of stationary clocks set up in the stationary system and synchronizing in accordance with 1, the observer ascertains at what points of the stationary system the two ends of the rod to be measured are located at a definite time. The distance between these two points, measured by the measuring-rod already employed, which in this case is at rest, is also a length which may be designated "the length of the rod".<sup>130</sup>

The measuring operation involves (a) the process of superimposing the measuring rod on the rod to be measured by the observer in the typical way it is done and (b) the measuring of the length of the stationary rod and the computation of the time it took to measure it.

Now Einstein says:

In accordance with the principle of relativity the length to be discovered by the operation (a) - we will call it "the length of the rod in the moving system" - must be equal to the length  $l$  of the stationary rod.

The length to be discovered by the operation (b) we will call "the length of the (moving) rod in the stationary system". This we shall determine on the basis of our two principles, and we shall find that it differs from  $l$ .<sup>131</sup>

130. Ibid.

131. Ibid.

In other words, the measurement of the length of the rod in the moving system ascertained by imaginary operation (a) since it does not involve the second postulate, viz. that of the constancy of light must be equal to the length of the stationary rod. However this cannot be true of operation (b) because the second postulate is also involved.

Einstein tells us that the mistake is in assuming the lengths of (b) operation to be equal:

Current kinematics tacitly assumes that the lengths determined by these two operations are precisely equal, or in other words, that a moving rigid body at the epoch  $t$  may in geometrical respects be perfectly represented by the same body at rest in a definite position.

We imagine further that at the two ends A and B of the rod, clocks are placed which synchronize with the clocks of the stationary system, that is to say that their indications correspond at any instant to the "time of the stationary system" at the places where they happen to be. These clocks are therefore "synchronous in the stationary system". We imagine further that for each clock there is a moving observer, and that these observers apply to both clocks the criterion established in #1 for the synchronization of two clocks.<sup>132</sup>

In other words, the tendency is to think that the clocks of the stationary and of the moving system are synchronous and since the measurement of length requires the calculation of the lapse of time that, since synchronization between the clocks is assumed that the lengths will be the same (following the relativity principle of classical mechanics).

This, however, Einstein says is a fallacy for the following reasons (again making use of an imaginary experiment):

132. Ibid.

Let a ray of light depart from A at the time  $t_a$ , let it be reflected at B at the time of  $t_B$  and reach A again at the time  $t'_a$  taking into consideration the principles of the constancy of the velocity of light we find that  $T_B - T_a = \frac{r_{ab}}{c-v}$  and  $T'_a - T_B = \frac{r_{ab}}{c+v}$

Where  $r_{ab}$  denotes the length of the moving rod measured in the stationary system. Observers moving with the moving rod would thus find that the two clocks were not synchronous, while observers in the stationary system would declare the clocks to be synchronous.<sup>133</sup>

In other words, according to mathematical calculations based on the light speed-constancy postulate, from the vantage point of the stationary system, the clocks give the same time while from the moving system they do not. There can be only one conclusion, based on such deduction, a conclusion implicit as was said in the postulate when they are joined together. And it is the one that Einstein immediately makes, viz., that of the relativity of simultaneity:

So we see that we cannot attach any absolute significance to the concept of simultaneity, but that two events which, viewed from a system of coordinates, are simultaneous, can no longer be looked upon as simultaneous events when envisaged from a system which is in motion relatively to that system.<sup>134</sup>

It is not within the purposes of this thesis to present in any detail how the ideas of Einstein led to the development of his whole mathematical structure within either the Special or General theories of Relativity. Suffice it for our present purpose, - to show the actual workings of the epistemology of Einstein in order to expose the elements of

133. A. EINSTEIN, Op. cit., p. 42.

134. A. EINSTEIN, Op. cit., pp. 42-43.

empirical suggestion, free invention of the postulate and a small part of the deductive analytical process (only a part of which, it should be noticed was mathematical reasoning as distinct from non-mathematical or ordinary) as it occurred historically in the presentation of the special theory of relativity by Einstein in 1905 and which all led up to the confirmation of its theorems.

Regarding observational tests, de Broglie has the following to say about the Special Theory of Relativity:

As soon as Albert Einstein had laid the foundation of the special theory of relativity, innumerable consequences of great interest flowed from these unusual ideas. Some of the chief consequences were the Lorentz-Fitzgerald contraction, the apparent retardation of moving clocks, the variation of mass with velocity among high-speed particles, new formulas containing second-order terms (termes supplémentaires) for aberration and the Doppler effect, and new formulas for the compounding of velocities, yielding as a simple consequence of relative kinematics the celebrated formula of Fresnel, verified by Fizeau, specifying the light-wave-trains (l'entraînement des ondes lumineuses) of refracting bodies in motion. And these are not merely theoretical notions: one can not insist sufficiently upon the fact that the special theory of relativity today rests upon innumerable experimental verifications, for we can regularly obtain particles of velocities approaching that of light in vacuum, particles in regard to which it is necessary to take account of corrections introduced by the special theory of relativity. To cite only two examples among many, let us recall that the variation of mass with velocity deduced by Einstein from relativistic dynamics, after having been firmly established by the experiments of Guye and Lavanchy, is verified daily by observation of the motion of the high-speed particles of which nuclear physics currently makes such extensive use; let us recall that some of the beautiful experiments of Mr. Ives have made possible verification of the relativistic formulas of the Doppler effect, and thus, indirect verification of the existence of the

the retardation of clocks of which they are a consequence.<sup>135</sup>

Minkowski referred of course, to a conclusion of special relativity which he tells us was not at first seen by Einstein himself,<sup>136</sup> and which at a later date provoked the formulation of the General Theory of Relativity. One important concern of General Relativity was to demonstrate the

135. Louis de BROGLIE, "A General Survey of the Scientific Work of Albert Einstein (translated from French manuscript by Forrest W. WILLIAMS) AEPS, pp. 114-5.

136. Lorentz called the  $t'$  combination of  $x$  and  $t$  the local time of the electron in uniform motion, and applied a physical construction of this concept, for the better understanding of the hypothesis of contraction. But the credit of first recognizing clearly that the time of the one electron is just as good as that of the other, that is to say, that  $t$  and  $t'$  are to be treated identically, belongs to A. Einstein.\* Thus time, as a concept unequivocally determined by phenomena, was first deposed from its high seat. Neither Einstein nor Lorentz made any attack on the concept of space, perhaps because in the above-mentioned special transformation, where the plane of  $x, t$ , an interpretation is possible by saying that the  $x$ -axis of space maintains its position. One may expect to find a corresponding violation of the concept of space appraised as another act of audacity on the part of the higher mathematics. Nevertheless, this further step is indispensable for the true understanding of the group  $G_c$ , and when it has been taken, the word relativity-postulate for the requirement of an invariance with the group  $G_c$  seems to me very feeble. Since the postulate comes to mean that only the four-dimensional world in space and time is given by phenomena, but that the projection in space and in time may still be undertaken with a certain degree of freedom, I prefer to call it the postulate of the absolute world (or briefly, the world-postulate). \*A. EINSTEIN, Ann. d. Phys., 17, 1905, p. 891; Jahrb d. Radioaktivitat und Elektronik, 4, 1907, p. 411. H. MINKOWSKI, "Space and Time", The Principles of Relativity, p. 83.

physical validity of Minkowski's prediction about the fading away of "space-in-itself and time-in-itself in favor of a space-time unity".

The modification to which the special theory of relativity has subjected the theory of space and time is indeed far-reaching, but one important point has remained unaffected. We shall soon see that the general theory of relativity cannot adhere to (its) simple physical interpretation of space and time. <sup>137</sup>

Instead, the physical interpretation of space and time as having their own separate physical meaning must be abandoned, Einstein says. In classical mechanics there was a physical separation of space and time obtained by physical measurements involving the use of fixed rods and standard clocks.

In classical mechanics, as well as in the special theory of relativity, the co-ordinates of space and time have a direct physical meaning. To say that a point-event has the  $X_1$  co-ordinate  $x_1$  means that the projections of the point-event on the axis of  $X_1$  determined by rigid rods and in accordance with the rules of Euclidean geometry, is obtained by measuring off a given rod (the unit of length)  $x_1$  times from the origin of co-ordinates along the axis of  $X_1$ . To say that a point-event has the  $X_4$  co-ordinate  $x_4 = t$ , means that a standard clock made to measure time in a definite unit period, and which is stationary relatively to the system of co-ordinates and practically coincident in space with the point-event, will have measured off  $x_4 = t$  periods at the occurrence of the event. <sup>138</sup>

These unconscious habitual tendencies of physicists and people in general, must be put aside in favor of the postulate of general relativity which cannot be carried through

137. Cf. supra, note 123, p. 65

138. A. EINSTEIN, "The Foundation of the General Theory of Relativity", The Principles of Relativity, p. 115.

otherwise:

This view of space and time has always been in the minds of physicists, even if, as a rule, they have been unconscious of it. This is clear from the part which these concepts play in physical measurements; it must also have underlain the reader's reflexions on the preceding paragraph (2) for him to connect any meaning with what he there read. But we shall now show that we must put it aside and replace it by a more general view, in order to be able to carry through the postulate of general relativity, if the special theory of relativity applies to the special case of the absence of a gravitational field.<sup>139</sup>

At this point, we see the operation of the rule of simplicity for Einstein, for it is this very rule which demands this change in our view of nature's physical structure since there is no other way to achieve a simple formulation of the laws of nature except by abandoning the attempt to directly and individually measure spatial and temporal coordinates by ordinary rods and standard clocks.

We therefore reach this result: In the general theory of relativity, space and time cannot be defined in such a way that differences of the spatial co-ordinates can be directly measured by the unit measuring-rod, or differences in the time co-ordinate by a standard clock.

The method hitherto employed for laying co-ordinates into the space-time continuum in a definite manner thus breaks down, and there seems to be no other way which would allow us to adapt systems of co-ordinates to the four-dimensional universe so that we might expect from their application a particularly simple formulation of the laws of nature. So there is nothing for it but to regard all imaginable systems of co-ordinates, on principle, as equally suitable for the description of nature.<sup>140</sup>

Thus we are led to the postulate of the General Theory

139. Ibid.

140. A. EINSTEIN, Op. cit., p. 117.

which requires that:

The general laws of nature are to be expressed by equations which hold good for all systems of co-ordinates, that is, are co-variant with respect to any substitutions whatever (generally co-variant).

This postulate Einstein calls the "requirement of general co-variance (invariance)" and it is this which takes away from space and time the last remnant of physical objectivity.<sup>141</sup>

For Einstein, as has been seen, a point of criticism for certain physical theories is that they have not been "natural"; that they have not accounted for the facts "in a natural way" etc.... In fact, it was the very unnaturalness of Newton's theory of action at a distance which gave the "impetus to overhaul it".<sup>142</sup> Similarly, in his early part of the exposition of the General Theory, Einstein showed his pre-occupation with "naturalness" as an aim in the development of his theory.

It is not my purpose in this discussion to represent the general theory of relativity as a system that is as simple and logical as possible, and with the minimum number of axioms; but my main object is to develop this theory in such a way that the reader will feel that the path we have entered upon is psychologically the natural one, and that the underlying assumptions will seem to have the highest possible degree of security.<sup>143</sup>

This statement of purpose had just followed a rather lengthy argument for the "naturalness" of the principle of general

141. A. EINSTEIN, Op. cit., p. 117.

142. Cf. Supra, p. 63.

143. A. EINSTEIN, Op. cit., p. 116.

co-variance involving the reduction of events to the motions of material points whose meetings alone are observable in terms of coincidences, such as between the hands of a clock and points on the dial. Now the systems of references are just devices for facilitating the description of these coincidences. Thus he says:

As all our physical experience can be ultimately reduced to such coincidence, there is no immediate reason for preferring certain systems of co-ordinates to others; that is to say, we arrive at the requirement of general co-variance. <sup>144</sup>

In summary, the epistemology of Albert Einstein then breaks down into four main tenets: 1. The requirement of inductive beginnings; 2. the invention of the primary concepts; 3. the deductive process with its governing rules of naturalness and simplicity and finally; 4. the confirmation of the theorems. The detailed features pertaining to each of these tenets have been traced through both the properly epistemological as well as the mathematico-physical writings of Einstein. An essential point that must be reëmphasized, in summary, is the fact that Einstein, uniquely among scientists, took the trouble to develop a full-fledged epistemological doctrine which became a powerful investigative method in his scientific work. And it is clear that the insights he was to achieve into the nature of physical reality were the result of attention to both science and philosophy. Indeed, perhaps it was precisely because

144. A. EINSTEIN, *Op. cit.*, p. 118.

Einstein had seen the problem of space and time as something more than a merely experimental one, that he was able to break out of the futile search for an ether and approach it in a new way. In any case, he had the wisdom to see that more adequate epistemological methods would have to be fashioned.

It is necessary now to undertake an investigation of the Einsteinian view of reality, a view which must bear heavily on and even determine the kind of approach that would be made in Einstein's investigations into the material universe.

## CHAPTER II

A METAPHYSICAL ANALYSIS OF ALBERT EINSTEIN'S  
VIEW OF REALITYSection A. The Notion of Reality in Albert Einstein

Einstein has written occasionally about the fateful fear of metaphysics which has come to be a self-defeating prejudice practiced by many scientists and philosophers of the modern age. Now, Einstein himself has spoken of metaphysics as "empty talk", so that an inquiry must be made into what Einstein meant by metaphysics. He writes thus:

In order that thinking might not degenerate into "metaphysics", or into empty talk, it is only necessary that enough propositions of the conceptual system be firmly enough connected with sensory experience and that the conceptual system, in view of its task of ordering and surveying sense-experience, should show as much unity and parsimony as possible. Beyond that, however, the "system" is (as regards logic) a free play with symbols according to (logical) arbitrarily given rules of the game....which cannot inductively be gained from sense-experiences.<sup>1</sup>

Thus, in order to escape being "metaphysical" a system of thought according to Einstein must have (a) enough propositions firmly connected with sensory experience; (b) show as much unity and parsimony as possible; (c) be a free play with symbols following logically given rules and (d) not be inductively gained from sense experiences. This does not mean, therefore, that a concept is metaphysical if it is not

1. A. EINSTEIN, "Remarks on Bertrand Russell's Theory of Knowledge", Op. cit., p. 289.

deduced from sensory raw material. Nor, is it to be removed from thinking because we tend to think of it as "metaphysical".<sup>2</sup> Thus, the concept of space and time are not metaphysical merely because they are not positivistic in the Machean sense of the term, i.e., deducible from sense experience or kept closely connected with them in the deductive process of scientific thought.

For even if it should appear that the universe of ideas cannot be deduced from experience by logical means, but is, in a sense, a creation of the human mind, without which no science is possible, nevertheless the universe of ideas is just as little independent of the nature of our experiences as clothes are of the form of the human body. This is particularly true of our conceptions of time and space.<sup>3</sup>

But the problem for metaphysics in any context, reduces itself inevitably to the question of reality and as Carnap has written, the relation of Positivism to reality is no exception.

Among the metaphysical doctrines that have no theoretical sense, I have also mentioned Positivism, although the Vienna Circle is sometimes designated as Positivistic. It is doubtful whether this designation is quite suitable for us. In any case we do not assert the thesis that only the Given is Real, which is one of the principal theses of traditional Positivism.<sup>4</sup>

He then goes on to tell us that the Vienna Circle was not positivistic in this sense and should be more suitably

2. A. EINSTEIN, Op. cit., p. 287.

3. A. EINSTEIN, The Meaning of Relativity, p. 2.

4. R. CARNAP, Philosophy and Logical Syntax, London, Kegan, Paul, etc., 1935, p. 22.

called "Logical Positivism".<sup>5</sup> Furthermore, it has nothing to do with metaphysical questions except to condemn them as meaningless because they lacked the empirical content necessary to give predictive power.

Sometimes the views of the Vienna Circle have been mistaken for a denial of the Reality of the physical world, but we make no such denial. It is true that we reject the thesis of the Reality of the physical world; but we do not reject it as false, but as having no sense, and its Idealistic anti-thesis is subject to exactly the same rejection. We neither assert nor deny these theses; we reject the whole question.

All the considerations which apply to the question of the Reality of the physical world apply also to the other philosophical questions of Reality, e.g., the Reality of other minds, the Reality of the given, the Reality of universals, the Reality of qualities, the Reality of relations, the Reality of numbers, etc. If any philosophical thesis answering any of these questions positively or negatively is added to the system of scientific hypotheses, this system will not in the least become more effective; we shall not be able to make any further prediction as to future experiences. Thus all these philosophical theses are deprived of empirical content, of theoretical sense; they are pseudo-theses.<sup>6</sup>

There are, Carnap continues, two concepts of reality: the empirical one which is valid because verifiable, and the philosophical which is invalid because it cannot be tested. And the former's verifiability derives from the fact that it can be located in a system, the system of space-time. The problem of the system as a whole, just like the problem of reality as a whole, however, has no meaning because neither can be tested.

5. R. CARNAP, Op. Cit., p. 20.

6. R. CARNAP, Op. Cit., p. 19.

We have to distinguish between two concepts of reality, one occurring in empirical propositions and the other occurring in the philosophical propositions just mentioned. When a zoologist asserts the reality of kangaroos, his assertion means that there are things of a certain sort which can be found and perceived at certain times and places; in other words that there are objects of a certain sort which are elements of the space-time system of the physical world. This assertion is of course verifiable... The disagreement begins only when the question about the Reality of the physical world as a whole is raised. But this question has no sense, because the reality of anything is nothing else than the possibility of its being placed in a certain system, in this case, in the time-space system of the physical world and such a question has sense only if it concerns elements or parts, not if it concerns the system itself.<sup>7</sup>

Carnap says the same rule applies for "deduced propositions" namely, those that are ultimately "perceptive".

It is because of these views of Carnap that Phillip Frank calls the differences between Einstein's approach and that of the logical empiricists, "a verbal one". "Briefly", he says, "I do not see in the question of the origin of the fundamental concepts of science any essential divergence between Einstein and twentieth century logical empiricism".<sup>8</sup>

The question, however, must immediately be raised as to what properly are Einstein's views on the meaning of reality. Is space a reality for him and, if so, is it a system? If space is some sort of conceptual framework, Einstein would not be a logical empiricist or certainly not a Carnapian one tied as the latter is immediately to sense data and

7. R. CARNAP, Op. cit., p. 20.

8. Phillip FRANK, "Einstein Mach, Logical Positivism", AEPS, p. 232.

requiring that everything be verified by it. It is germane to the whole problem to give some attention to this view of reality of Albert Einstein.

In April 1955, addressing the Pontifical Academy of Science, Pope Pius XII called attention to a serious condition of mind affecting at least some scientists who appear to have despaired about the very possibility of achieving a wholistic view of the universe. At the same time, he himself refused to fall victim to such despair. He said at that time:

Many illustrious thinkers have been brought to skepticism when confronted with the problems of the philosophy of science. These claim that it is necessary to be satisfied with the simple verifying of facts and striving to have these included in formal presentations - synthetic and simple - in order to foresee the possible developments of a physical system from a given initial state.<sup>9</sup>

We will not follow, at this time, the argumentation of the Roman Pontiff but simply note that the views of Albert Einstein on this problem are very similar. In unmistakable language Einstein has spelled out what seems to have been for him a personal creed of faith in the powers of science to pass beyond mere prediction as the proper end of its work which is, he says, to grasp the real.

Now this reality or existence which is the ultimate end of science is, as has been seen,<sup>10</sup> a system of thought, the

9. PIUS XII, "Au Moment", reported in Osservatore Romano, (April 25-26, 1955.)

10. Cf. supra, Note 34, p. 22.

simplest possible system in fact, unifying the observed facts.<sup>11</sup> And because of this, the investigator seeking this logical unification must needs be tireless. He must, according to Einstein, always be ready to change his concepts or axioms since the work of unifying the continuing facts in as logically perfect a way as possible is his chief work and one with the quest for reality.<sup>12</sup> Einstein has expressly stated what the terms "physical reality" mean to him:

Physics is an attempt conceptually to grasp reality as it is thought independently of its being observed. In this sense one speaks of "physical reality".<sup>13</sup>

Thus, there are grounds for believing in "an external world independent of the perceiving subject (which) is the basis of all natural science; however, sense perceptions can only give information of this external world of "physical reality indirectly, (and) we can only grasp the latter by speculative means".<sup>14</sup>

11. Cf. Supra, pp. 46-47.

12. A. EINSTEIN, "On Clerk Maxwell's Influence...", p.40.

13. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 81.

14. A. EINSTEIN, "On Clerk Maxwell's Influence...", p.40. It will be seen in the two sections that follow that 1) this speculative method of Einstein cannot, for metaphysical reasons, grasp reality in all its depths, as Einstein hoped and 2) that the speculative method is not limited to mathematico-physical investigation, as Einstein seemed to believe.

The characteristic of this "simplest possible system of thought unifying the facts" for Einstein are described by a contemporary thinker in the field of the philosophy of science. It is invariance which is the ultimate criterion for testing the presence of the real.

The concept of space-time affords an excellent illustration of Einstein's epistemological position. The scientist's freedom of choice is fully exercised in the construction of a curved four-dimensional continuum, since no experience could dictate to him the idea. Yet his invention also happens to be an institution or discovery of an objective physical reality. For spatio-temporal invariance provides the word that solves the puzzle of alternative differentiation between space and time within frames of reference which are set in relative motion. The illustration brings out invariance as the ultimate criterion of physical reality.<sup>15</sup>

It is invariance, as Bridgman also has said, which is the "most sweeping characterization of Einstein's attitude of mind" toward the problem of the real; for Einstein believes it possible to get away from the special (variant) point of view of the individual observer which he relegates to the status of shadowy being and sublimate it into something universal, public and real.

Perhaps the most sweeping characterization of Einstein's attitude of mind with regard to the general theory is that he believes it possible to get away from the special point of view of the individual observer and sublimate it into something universal, "public", and real".<sup>16</sup>

15. A. USHENKO, "Einstein's Influence on Philosophy", AEPS, p. 337.

16. P. W. BRIDGMAN, "Einstein and Operationalism", AEPS, p. 349.

Again, another distinguished physicist, friend and contemporary of Einstein comments at length on this quality of invariance:

The Idea of invariance is the nucleus of the theory of relativity. To the layman, and sometimes to the philosopher, this theory represents quite the contrary, a set of laws which allow for variability from one observer to another. This one-sided conception is linguistically implied by the word relativity which does not characterize the theory as centrally as it should. The true state of affairs can be seen when attention is directed to the aforementioned postulate of objectivity which required that the basic laws (the differential equations of highest order used in the description of reality) shall be invariant with respect to certain transformations. From this the variability, or relativity, of detailed observations may be shown to follow as a logical consequence. To give a simple example: the basic laws of electro-dynamics involve the speed of light,  $C$ . If these laws are to be invariant,  $C$  must be constant. But the constancy of  $C$  in different inertial systems requires that moving objects contract, that moving clocks be retarded, that there be no universal simultaneity, and so forth. To achieve objectivity of basic description, the theory must confer relativity upon the domain of immediate observations. In philosophic discussions too much emphasis has been placed upon the incidental consequence, doubtless because the spectacular tests of the theory involve this consequence.<sup>17</sup>

In accordance with this criterion a distinction is made between the general laws of a nature such as the constant velocity of light, the gravitational constant or the unity of space-time as real, and phenomena which are special, local and adventitious, i.e., "unreal", because they are variant, e.g. the acceleration of gravity at the earth's

17. Henry MARGENAU, "Einstein's Conception of Reality", AEPS, p. 254.

surface as well as space in itself and time in itself. It is only the general laws which are capable of co-variant formulation.

And yet while Einstein seems to be speaking unmistakably of the conceptual system which, because of its invariance, answers the description of what he would mean by real there is always operating the belief in an individual objective, extra-conceptual and extra perceptual "thing in itself".

I still believe in the possibility of a model of reality - that is to say, of a theory which represents things themselves and not merely the probability of their occurrence.<sup>18</sup>

On this point he is bitterly at odds with the statistical probabilists who, according to Einstein, "are convinced that it is impossible to account for the essential aspects of quantum phenomena (. . .) by means of a theory which describes the real state of things (objects) ..."<sup>19</sup>

Einstein has set himself across the path of the exponents of the  $\psi$  or probability function as representative of a "real, factual situation in the sense that is true for a material system of points or of an electro-magnetic field".<sup>20</sup> His concern for "reality" is almost belligerent in this context. He worries deeply about the knowledge of the individual system (thing) which the statistical physicists have

18. A. EINSTEIN, "Of Methods.....", p. 20.

19. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 87.

20. A. EINSTEIN, Op. cit., p. 83.

turned their backs on. Einstein wants a complete description of the situation and rejects any a priori thesis that an incomplete description of nature could be final.<sup>21</sup> In fact, if a complete description is possible, the laws of nature would necessarily exclude realistics. He reconstructs the argumentation of the probabilist to prove his case.

He (the probabilist) may argue as follows:

True, I admit that the quantum and theoretical description is an incomplete description of the individual system. I even admit that a complete description is, in principle, thinkable. But I consider it proven that the search for such a complete description would be aimless. For the lawfulness of nature is thus constituted that the laws can be completely and suitably formulated within the framework of our incomplete description.

To this I can only reply as follows: Your point of view -- taken as theoretical possibility -- is incontestable. For me, however, the expectation that the adequate formulation of the universal laws involves the use of all conceptual elements which are necessary for a complete description, is more natural. It is furthermore not at all surprising that, by using an incomplete description, (in the main) only statistical statements can be obtained out of such description. If it should be possible to move forward to a complete description, it is likely that the laws would represent relations among all the conceptual elements of this description which, per se, have nothing to do with statistics.<sup>22</sup>

Einstein is left unsatisfied by a theory which in principle, has rejected what he considers as the "programmatic aim of all physics, the complete description of any (individual) real situation as it supposedly exists irrespective of

21. A. EINSTEIN, "Reply to Criticism", AEPS, p. 674.

22. A. EINSTEIN, "Reply to Criticism", AEPS, p. 673.

any act of observation or substantiation."<sup>23</sup>

Einstein rejects the objection which might be raised by positivists that he is reintroducing an approach to the world which science has long since vanquished as meaningless and to be pitied, namely that of metaphysics. This is precipitous, he says. The knowledge of the real situation is what he characterizes as essential and he hopes to be able to convince the probabilists of this in a fuller discussion.

Whenever the positivistically inclined modern physicist hears such a formulation, his reaction is that of a pitying smile. He says to himself: "There we have the naked formulation of a metaphysical prejudice, empty of content, a prejudice, moreover, the conquest of which constitutes the major epistemological achievement of physicists within the last quarter century. Has any man ever perceived a 'real physical situation'? How is it possible that a reasonable person could today still believe that he can refute our essential knowledge and understanding by drawing up a bloodless ghost?" Patience! The above laconic characterization was not meant to convince anyone; it was merely to indicate the point of view around which the following elementary considerations freely group themselves.<sup>24</sup>

These considerations will bring out what seems essential to him. But first, what are the grounds for being satisfied with a merely statistical knowledge of an ensemble of individual systems? Einstein reviews the position of the probabilists here very carefully whilst rejecting it.

In the case of disintegration of a single radioactive atom one cannot fail to assume that it happens at a definite

23. A. EINSTEIN, Op. cit., p. 367.

24. Ibid.

time. And yet the description by the  $\Psi$ -function implies no time value. It thus fails to be complete and must be taken as the description only of an ideal ensemble of systems. Furthermore, there is no room for a complete description in the conceptual framework of statistical quantum theory.<sup>25</sup> But to this the quantum theorist would reply that the assertion of a definite time instant of disintegration makes sense only if one can determine it empirically. But in principle it cannot be determined since any attempt to do so would permit only a conclusion concerning the status of a disturbed system. Thus no justification can be found empirically for a definite disintegration time status of a radioactive atom and criticism of statistic quantum theory description as being incomplete is also unjustified.<sup>26</sup>

Einstein reduces the whole difficulty on the question to the following analysis: "The entire alleged difficulty proceeds from the fact that one postulates something not observable as real. (This is the answer to the quantum theorist.)"<sup>27</sup>

Einstein is in fundamental disagreement with such "positivism". Perhaps this is what Margenau refers to as the everywhere apparent sign of Einstein's "keen intuitive sense

25. A. EINSTEIN, Op. cit., p. 668.

26. A. EINSTEIN, Op. cit., p. 669.

27. Ibid.

for what is physically real".<sup>28</sup> For Einstein's rejection of the quantum statisticians is based on the deeper rejection of a Berkelian subjectivism:

What I dislike in this mode of argumentation is the basic positivistic attitude, which from my point of view is untenable, and which seems to me to come to the same things as Berkeley's principle, esse est percipi.<sup>29</sup>

His criticism of Berkeley's formula is perhaps more revealing of his methodology than his ontology. Indeed as Margenau<sup>30</sup> and Northrup<sup>31</sup> have pointed out, little can be found in Einstein dealing with traditional questions of ontology: whether the real world has traces of the observer in a Kantian sense; the problems dealing with primary or secondary qualities or the relation of laws of nature as logical concepts to reality. There seems in fact to be little real attempt at a distinct definition of reality. Here, at least, however, Einstein seems clearly to posit the existence of a reality which does not depend for its constitution on sense perceptions. But, unfortunately, instead of pushing this argument into ontological territory as would seem appropriate at this moment he lapses into the argument of methodological linkage between logical construction and reality.

28. Henry MARGENAU, Op. cit., AEPS, p. 267.

29. A. EINSTEIN, "Reply to Criticism", AEPS, p. 369.

30. Henry MARGENAU, Op. cit., p. 243.

31. F.S.C. NORTHRUP, "Whitehead's Philosophy of Science", Philosophy of Alfred North Whitehead, Library of Living Philosophers, 1957, p. 205.

Being is always something which is mentally constructed by us, that is, something which we freely posit (in the logical sense). The justification of such constructs does not lie in their derivation from what is given by the senses. Such a type of derivation (in the sense of logical deducibility) is nowhere to be had, not even in the domain of pre-scientific thinking. The justification of the constructs which represent "reality" for us, lies alone in their quality of making intelligible what is sensorily given (the vague character of this expression is here forced upon me by my striving for brevity).<sup>32</sup>

Although Einstein fails to make any of the ordinary philosophical qualifications of "being" (either as logical or real being) it is apparent that he had on the one hand a being of the logical order which is verified not by its derivation from sense experience but by its successful representation of "reality", success here being identified with their "quality of making intelligible", and on the other an objective or real being. These distinctions in being he does not seem to have any desire to probe or investigate on any properly metaphysical tack. In fact he wishes it known that there are no grounds for any insinuation that his concept "being", i.e. one distinguished by intelligible-making characteristics, is to be rejected on the grounds of being "something metaphysical". The only justification for the preference for one concept over another is on the grounds of "usefulness". We are free to choose any one of them in the sense that neither nature or the mind dictates our choice and should be guided by only a single qualification namely

32. A. EINSTEIN, "Reply to Criticism", AEPS, p. 609.

by "the degree to which its (the concept's) use contributes to making the totality of the contents of consciousness "intelligible".<sup>33</sup> The objectivity of a thought is meant in this sense i.e. "as independent of experience".<sup>34</sup> The "reality" of concepts is intimately connected with this programmatic approach to reality and it should apply without qualification to the study of the microscopic as well as the macroscopic worlds which may not, from a natural point of view,<sup>35</sup> be considered to be indiscontinuous.

.....So long as we move within the thus programmatically fixed sphere of thought we are thinking physically. Insofar as physical thinking justifies itself, in the more than once indicated sense, by its ability to grasp experiences intellectually, we regard it as "knowledge of the real".

After what has been said, the "real" in physic is to be taken as a type of program, to which we are, however, not forced to cling a priori. No one is likely to be inclined to attempt to give up the program within the realm of the "macroscopic" (.....). But the "macroscopic" and the "microscopic" are so inter-related that it appears impractical to give up this program in the "microscopic" alone. Nor can I see any occasion anywhere within the observable facts of the quantum-field for doing so, unless, indeed, one clings a priori to the thesis that the description of nature by the statistical scheme of quantum mechanics is final.<sup>36</sup>

So that the Einsteinian rejection of quantum probability theory seems to be grounded on an ontology, however general

33. A. EINSTEIN, Op. cit., p. 673.

34. A. EINSTEIN, Op. cit., p. 674.

35. Ibid.

36. A. EINSTEIN, "Reply to Criticism", AEPS, p. 674:

and undeveloped.<sup>37</sup> His criticism of its "incomplete description" refers, on the level of scientific investigation, to its unnatural omission of certain "conceptual elements" necessary for a complete description.<sup>38</sup> This is inevitable with a statistical approach which arrives at only statistical and incomplete statements of reality.

For me, however, the expectation that the adequate formulation of the universal laws involves the use of all conceptual elements which are necessary for a complete description, is more natural. It is furthermore not at all surprising that, by using an incomplete description, (in the main) only statistical statements can be obtained out of such description. If it should be possible to move forward to a complete description, it is likely that the laws would represent relations among all the conceptual elements of the descriptions which, per se, have nothing to do with statistics.<sup>39</sup>

Einstein is worried about the future of a physics which "leaves out" something of reality. Since the statistical theorist renounces his ability to know the time-instant of an individual system (atom) although not admitting that this renders his theory "incomplete" Einstein feels obligated to prove to him that his theory actually is incomplete. The statistical theory has held that its time-instant doesn't

37. Exactly the way in which this distinctive attitude among scientists is related to an "intuitive sense for what is physically real" is hard to establish. An amalgam of Pythagorean Idealism with Jewish religious existential tendencies was orally suggested to this writer by Rev. Gerald Phelan, Professor at the Pontifical Institute of Med. Studies, Toronto

38. A. EINSTEIN, Op. cit., p. 373.

39. Ibid.

"exist". But this, says Einstein, is not the vital question at all.

One may not merely ask: "Does a definite time instant for the transformation of a single atom exist?" but rather: "Is it, within the framework of our theoretical total construction, reasonable to posit the existence of a definite point of time for the transformation of a single atom?" One may not even ask what this assertion means. One can only ask whether such a proposition, within the framework of the chosen conceptual system - with a view to its ability to grasp theoretically what is empirically given - is reasonable or not.<sup>40</sup>

It is because Einstein holds that it is reasonable to think it possible to "grasp the real in all its depths"<sup>41</sup> that he can reject the statistical position as unreasonable because it is incomplete as it stands.

It is furthermore "unreasonable" because it cannot provide, in principle, the basis for a completion of what is already known about nature. And it is being shunned as a result because of its "egg walking" performance done in order to avoid the physically real, which is psychologically disastrous.<sup>42</sup>

Thus, generally speaking, the meaning of "real" to Albert Einstein has several aspects which, having been presented textually may be reviewed as follows:

1) The reality which is the ultimate end of science is a simplest possible system of thought which can unify the

40. A. EINSTEIN, Op. cit., p. 669.

41. A. EINSTEIN, "Of Method ...", p. 19.

42. A. EINSTEIN, "Reply to Criticism", AEPS, p. 672.

observed facts.

2) This conceptual apparatus grasps reality independently of being observed. It has a "being" as does the "reality" which it grasps.

3) This conceptual system is invariant i.e. delivered from any special point of view and sublimated into something universal, public and real.

4) This conceptual system is at the same time a model of reality which represents things as they are in themselves.

5) This conceptual system does not stop at mere knowledge of ensembles of things but grasps things themselves.

6) It is reasonable to think that this reality can be grasped in all its depths.

#### Section B. The Problem of the Reality of Relations

Historically, it was the desire of Bertrand Russell to abandon absolutely the concept of the "thing" in favor of the "event" and Einstein's own unwillingness to do so which helped to underline the latter's realism. On this point, A. Ushenko writes: "As far as I can see, he (Einstein) had two reasons, the operational basis of physics and the technical meaning of the term, "event" (for doing so)."<sup>43</sup> At the same time, it must be noticed that for Einstein the concept of the material thing or particle, as the most fundamental reality,

43. A. USHENKO, "Einstein's Influence on Philosophy", AEPS, p. 630.

had to be abandoned with the discoveries of Relativity theory. He states this clearly in the following words:

It, therefore, appears unavoidable that physical reality must be described in terms of continuous functions in space. The material point, therefore, can hardly be conceived any more as the basic concept of the theory.<sup>44</sup>

It seems, then, as Ushenko has just suggested that Einstein's operationalism caused him to arrive at the view that the material thing was not the fundamental object of his search after all, but rather something that was relational; thus the name, "Relativity". As has already been seen, this insight lead from the Special to the General Theory, provoked by Minkowski's famous declaration that space and time were related. This relation in the four dimensional continuum, was, in fact, called by Einstein, the "event".

In the pre-relativity physics, space and time were separate entities..... It was not observed that the element of the space-time specification was the event specified by the four numbers,  $x_1, x_2, x_3, t$  ..... Upon giving up the hypothesis of the absolute character of time, particularly that of simultaneity, the four dimensionality of the time-space concept was immediately recognized. It is neither the point in space, nor the instant in time, at which something happens that has physical reality, but only the event itself.<sup>45</sup>

It also seems clear that the retention of the "concept of the thing" is operational for Einstein in the same sense that if there is nothing to relate, viz., two or more "things"

44. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 61.

45. A. EINSTEIN, The Meaning of Relativity, p. 30.

there obviously can be no possibility of relativity.<sup>46</sup> And in this sense we can speak of a realism in Einstein, dictated as it is by common sense. What must now be carefully examined is the metaphysical problem of relational being as it relates to the subject of the reality of things. This is of especial importance because of its bearing on the first

46. The discovery of the relativity of simultaneity, which is, without question, the key one of the Theory of Relativity, is generally imputed to Einstein. Based on the finite velocity of light Einstein concluded that two systems (i.e. bodies) could not causally affect one another if they are in spatial separation because the fastest energy exchange could not be in excess of light. Thus, he concluded that instantaneous action-at-a-distance in the sense of Newton (a charge wrongly imputed to Newton, but that is another question altogether) was physically impossible. Einstein then went on to define simultaneity as one in which two systems could not possibly have an effect upon each other. The following quotation, however, from the famous commentator on Aquinas, John of St. Thomas (1539 - 1644) is absolute historical evidence of the priority of the notion of simultaneity to Albert Einstein: "Every relation depends upon its term; moreover, relation and term are defined by each other. Accordingly, the theory that relatives are simultaneous in nature and in cognition raises difficulty. Rather than simultaneity, there seems to be priority of the one over the other, for where there is dependence there is also priority in nature. In order to solve this problem it is necessary to premise the two requirements of simultaneity: 1) none of the things said to be simultaneous can be the cause of each other and, 2) things simultaneous imply each other." The Material Logic of John of St. Thomas; ed. Yves SIMON, Chicago University Press, 1955, p. 361. (Italics mine.) There is, of course, no question that Einstein gave this principle operational significance in the sense of a theorem with a measurable test of validity. It is strictly a matter of opinion that, as Einstein contends, something can have no real significance until it is "provable" operationally, however.

tenet of the Einsteinian epistemology, viz., the inductive beginnings of scientific investigation. Obviously, if a successful distinction cannot be maintained between the concept and the thing against the Russellites, the first tenet would be indistinguishable from any of the other of Einstein's epistemological tenets and, as St. Thomas observed, science would then be a study of Ideas and reduce itself to psychology.<sup>47</sup>

The question that must be examined here, then, is this: Does the Einsteinian statement that science knows the relation between things or the "events", i.e., things as they are spatially and temporally related to other things and thus possessed of metrics, make Relativity physics an idealistic system? In other words, is the character of relational knowledge such that it is necessarily ideational? Clearly if this is the case, the Einsteinian requirement of inductive beginnings is meaningless notwithstanding the strongest faith that Einstein or other might have in it. It is crucial to the Einsteinian epistemology, therefore, that the problem be examined carefully and defended if possible with arguments which go deeper than the merely pragmatic. Since it is the necessarily idealistic character of relational knowledge on which Russell and his sympathizers base their attack, the subject will be examined in the light of St. Thomas' doctrine on relational being. Only after this has been done can the

47. Cf. Infra, note 8, p. 140.

problem of the constitution of things, so clearly demanded for the defense of Realism, as Lovejoy has indicated, be taken up.<sup>48</sup> But intermediate between an examination of the reality of relations and the reality of things, there must be an analysis of the exact, operational mode that scientific investigation of the Einsteinian type takes and of the depths metaphysically speaking, that such an investigation of reality can claim. This will be done in the next section.

48. As Lovejoy writes: "A thinker of the true realistic temperament craves a world of objects which have each some intrinsic and solid character, which do not endlessly delinquesee into mere relations to other things, themselves equally characterless and elusive." "Relativity, Reality and Contradiction", in Journal of Philosophy, Psychology and Scientific Method, Vol. XI, 10, (July 30, 1914) p. 530. On this point, Professor Morris Cohen wrote: "Professor Lovejoy.....confuses the reduction of qualities to relation with their reduction to quantitative differences. He then goes on to state the more serious objection that the reduction of qualities to relations would leave us with a world of relations with no terms to be related. This seems to me to be non sequitur. The demand of a distinction between qualities and relations does not mean a denial of terms or termini of relations. It only means.....a denial that things have a nature apart from all possible relations." "Qualities, Relations and things", Ibid., 16, 23, (Nov. 5, 1914) p. 623 - 624. It should be noted here that for St. Thomas the good and perfection of things is found not only in that which inheres in them absolutely, but also in their order to one another, a point Professor Cohen has made very well. A full discussion of this problem of St. Thomas' doctrine on the reality of relations is presented in this section of the thesis.

According to St. Thomas there is no justification for dismissing relation as unreal by calling it an idea. This is false as is plain, he says, "from the very fact that things themselves have a mutual relation and order".<sup>49</sup> This is not to say that there are not non-real or logical relations. But what must be determined are the conditions that make a relation real or logical.

Clearly, a relation is logical if its two extremes consist of ideas, St. Thomas says, "as when a mutual order or relation.... (is established) by apprehending one thing twice (and regarding) it as two".

Verumtamen sciendum est quod, cum relatio requirat duo extrema, tripliciter se habere potest ad hoc quod ut res naturae et rationis. Quandoque enim ex utraque parte est res rationis tantum, quando scilicet ordo vel habitudo non potest esse inter aliqua, nisi secundum apprehensionem rationis tantum, utpote cum dicimus idem eidem idem. Nam secundum quod ratio apprehendit bis aliquod unum statuit illud ut duo et sic apprehendit quandam habitudinem ipsius ad seipsum.<sup>50</sup>

Regarding this kind he says, "it is clear that the relation of a thing to itself is not a real relation".<sup>51</sup> The context here is a consideration of the distinction between the Three Persons of the Trinity, Who differ really but only in the mode of Their signification. St. Thomas says, "Paternity is the

49. S.T., Ia, q. 13, 7.

50. Ibidem.

51. S.T., Ia, q. 42, 1, ad 4; Ia, q. 28, 2.

Father, and Filiation is the Son, because in God the abstract and concrete do not differ".<sup>52</sup>

52. It is interesting to note how John of St. Thomas, depending upon a spurious document attributed to St. Thomas, differs from the latter on the reality of relation in the Trinity while in no way compromising the Divine simplicity. He writes: "St. Thomas) mentions (Com. to Annibald, 1, Dist. 26, q.2, a. 1) another argument drawn from the mystery of the Holy Trinity. Divine Relations, inasmuch as they are really distinct from each other do exist really; if they did not there would be no real distinction between the relative persons, which is heretical. But they are not distinguished from each other except as pure relations according to existence. If they were distinguished in any capacity other than that of pure relation, there would be division in God, not only of the relative but also of the absolute." He then adds a remark which provokes the editor to an interesting statement about the heuristic value of theology. "Why, then, should there be anything absurd about such relations existing in the world of creatures, where they do not have to be identical with substance and where they do not have to be infinite." The Material Logic of John of St. Thomas, pp. 308-309. Dr. Simon writes, "Here is a typical example of the guidance that faith and theology may exercise upon philosophical research. The theologian knows by faith and theological inference that there are in God real relations according to existence. This makes it easier for him to acknowledge the reality of pure relations in this world of ours. Owing to the certainty of the theological fact, he enjoys a facility contrary to the handicap suffered by the mystical metaphysicians whom Bertrand Russell described as constitutionally biased against the reality of pure relations." p. 603, note 6. For a study of how St. Thomas first met the problem of relation in theology, cf. M. BERGERON, "La structure du concept latine de personne," in Études d'histoire littéraire et doctrinale du XIIIe siècle deuxième série (Institute d'Études Médiévales, 1932, Ottawa), pp. 121-162. For a consideration of the question of individuation as regards the Persons of the Trinity, cf. J. CROTEAU, C.M.I., Les Fondements Thomistes Du Personnalisme de Maritain, Editions de l'Université d'Ottawa, 1955, p. 123 ff.

In addition, a relationship is logical when it involves extremes which are apprehended as being or non-being or which similarly "follow upon an act of reason, as genus and species and the like".<sup>53</sup> Yet, these are not the only kind of relations viz., the logical ones, for there is a second and third kind both of which are real and which are called "predicamental" and "transcendental or according to expression" respectively. St. Thomas describes the second type, of which relation according to quantity is one example, as follows:

Quaedam vero relationes sunt quantum ad utrumque extremum res naturae, quando scilicet est habitudo inter aliqua duo secundum aliquid realiter conveniens utrique; sicut patet de omnibus relationibus, quae consequuntur quantitatem, ut magnum, et parvum, duplum et dimidium, et hujusmodi; nam quantitas est in utroque extremorum; et simile est de relationibus, quae consequuntur actionem, et passionem, ut motivum, et mobile, pater et filius, et similia.<sup>54</sup>

These are the relations which Aristotle says of "their very essence (include) in its nature a reference to something else, not because something else involves a reference to it."<sup>55</sup>

Unlike the relations of reason, these relations have an existence apart from an apprehending intellect yet do not consist of anything besides relation itself, which also characterizes logical relations. The important difference is that predicamental relations have, as extremes, real

53. S.T., Ia, q. 13, 7.

54. Ibidem.

55. Metaphysics, V, 15. 1021b, 27-28 (ed. Bekker).

beings functioning as subject and term and having between them a real relationship which is the foundation of the relation itself and constitutes its form. Now the foundation of a relation, as John of St. Thomas says, only exists if one extreme serves the complete function of referring to the other extreme. Thus substance, which does not refer to something else cannot act as a foundation and it belongs in the third category of relations, viz., that of the transcendentals as St. Thomas teaches in the De Potentia.<sup>56</sup> Furthermore, he subscribes to the division by Aristotle of predicamentals into relations of being which are the foundation of measure, of action and passion which are the foundation of operation and power and according to quantity which are the foundation for unity and diversity.<sup>57</sup> Relations are not, however, to be confused with their foundations. Rather, they are distinct entities for, as St. Thomas says, "omnis enim relatio quae consequitur propriam operationem alicujus rei, aut potentiam aut quantitatem aut aliquid hujusmodi, realiter in eo existit".<sup>58</sup> But here a brief presentation of the doctrine of St. Thomas on the being of accidents must be given in order to achieve a clarification of his doctrine on

56. De Pot., 7, 9.

57. Ibidem. St. Thomas writes: "I answer that, according to the Philosopher, every relation is based either on quantity, as double or half, or an action and passion, as the doer and the deed, the father and the son, the master and the servant, and the like." S.T., Ia, q.23, 4.

58. Cont. Gent. IV, 14, ad6.

relation.

In chapter six of the opusculum, "De ente et essentia", St. Thomas says that accidents have only an incomplete definition based on the fact that they have a secondary act of existing as inhering in an anteriorly existing subject which is a substance. Thus "they (accidents) do not exist in virtue of themselves (per se), in separation from their subject".<sup>59</sup> And since this is so, accidents cause only a secondary act of existing which in no way demands the existence of the substance. "An accident, therefore, neither has the character of a complete essence nor is part of a complete essence ....(having) being....(and) essence in a qualified sense."<sup>60</sup> It also follows from this that substance is the cause of all accidents. Thus:

Sed, quia illud quod dicitur maxime et verissime in quolibet genere, est causa eorum quae sunt post in illo genere (sicut ignis qui est in fine caliditatis est causa caloris in rebus calidis, ut in secundo Meaphysicorum I dicitur); ideo substantia, quae est principium in genere entis, maxime et verissime essentiam habens, oportet quod sit causa accidentium quae secundario et quasi secundum quid rationem entis participant.<sup>61</sup>

But how, precisely, do accidents share in the being of substance? Since matter and form are the parts of substance, there will be accidents which derive from either the form or the matter. An example of derivation from the former would

59. Cf. De ente et essentia, Cap. VI, ed. Roland-Gosselin.

60. Ibidem.

61. Ibidem.

be the accident of risibility in man occurring because of an act of knowledge and therefore, proceeding from the soul. This accident would be found in everything having the nature of a genus or species, unlike accidents flowing from the matter, which as the principle of individuation, would characterize an individual, e.g., the color in a man's skin. The accident of quantity, as is evident, would be an accident following from the matter, since it is this accident which determines an individual substance to be extended in its own way. It is evident, as well, that since accidents are not composed of matter and form, that they cannot take their genus from matter and species from form as do composite substances. Instead, it is their manner of existing which determines their genus and species. Thus quantity, for example, is called the measure of substance, quality its disposition, etc. With regard to their differences, this is derived from the principles which cause the attributes of an accident. Thus action, passion and quantity are all principles of relation.<sup>62</sup>

Now, in the case of the accidents of relation, St. Thomas makes the all-important distinction which is to place these accidents in a very special category. Without referring in this opuscula to relations as such he lays down the principles for a distinction between relations as absolute

62. Ibidem.

accidents (relatio ut accidens) and relations "by way of aptitude" (relatio ut relatio). He writes as follows:

Sciendum etiam est quod aliquando accidentia ex principiis essentialibus causantur secundum actum perfectum, sicut calor in igne qui semper actu est calidus; aliquando vero secundum amplitudinem tantum, sed complementum accipiunt accidentia ex agente exteriori; sicut diaphaneitas in aere, quae completur per corpus lucidum exterius; et in talibus aptitudo est accidens inseparabile; sed complementum quod advenit ex aliquo principio quod est extra essentiam rei, vel quod non intrat constitutionem rei, est separabile, sicut moveri et huiusmodi.<sup>63</sup>

There, in a short passage, St. Thomas lays open at one stroke the heart of the matter regarding the special and unique character of accidents of relation of the two sorts. Here in a statement of his youth and even before he is to attain the full expression of his doctrine is laid down a teaching which, like so many of his writings on the nature of reality, is to break away from even the most illustrious of his antecedents and contemporaries. On the problem of the reality of relations, the influential Gilbert of Porrée, and his disciples in the Cathedral School of Chartres, are the ones St. Thomas is to vigorously oppose. He will even on occasion refer to them by the name that history was to give them, "the Porretani". It is Gilbert who, by a treatise traditionally ascribed to him,<sup>64</sup> viz., De Sex Principiis, is to present the Categories of Aristotle to the West and, in a

63. Ibidem.

64. The earliest attribution was by St. Albert, whose authority in these matters, as Gilson says, is not reliable. Cf. Infra, note 65, p.108, esp. Gilson's own note.

certain way, to fix the meaning of it according to his own interpretation.<sup>65</sup> Indeed, St. Thomas is to accuse the Porretani of limiting the consideration of the Aristotelian accident of relation to a conceptual one as contrasted to its other way of consideration, in its esse.<sup>66</sup>

As has already been pointed out, a consideration of the distinction of Persons in the Trinity was the setting from which the general problem of the nature of relations evolved. With Gilbert, it was his commentary on Boethius', On the Trinity in which he laid down a doctrine which was the cause of the censure of St. Bernard<sup>67</sup> and make him the object of many theological attacks. St. Thomas, in dealing with the question of relation in God says, "It is reported that Gilbert de la Porrée erred on this point but revoked his error later at the council of Rheims. For he said that the divine relations are assistant, or externally fixed."<sup>68</sup> Yet, while theology was the setting for the discussion and

65. "Gilbert's place....is clearly defined: he encouraged the diffusion of that particular form of Platonism we might call the realism of essences, and which the philosophy of Avicenna was soon to so powerfully endorse." E. GILSON, History of Christian Philosophy in Middle Ages, New York, Random House, 1955, p. 144.

66. In I Sent., d. 8, 4. 3.

67. Cf. St. Bernard, In Cant., serm. LXXX (PL 183, 1170).

68. Dicendum, quod circa hoc dicitur Gilbertus Porretanu errasse, set errorem suum postmodum in Rhemensi Concilio revocasse. Dixit enim, quod relationes in divinis sunt assistentes, sive extrinsecus affixae. S.T., Ia, q. 23, 2.

elaboration of the problem of relation, it was the interpretation which Gilbert gave to the Categories which was to undercut and distort his theological doctrines on relations in the Trinity. For in the De Sex Principiis, relation is located in the first division of the ten categories with substance, quantity and quality as having "inherent forms" in contrast to the last six categories having accessory forms (formae assistentes). On this point Gilson writes as follows:

Taken in itself, the distinction was an important one. The treatise calls "inherent", the forms or principles which are either substance itself or inherent in substance itself irrespective of its relations with other substances.

Such is manifestly the case with quantity and quality, the quantity of a substance being its own quantity and the quality its own qualities. At first glance, the contrary seems true of relations, yet taken in itself, relation is the natural aptitude of a substance to be one of the two terms of a relation. As such, it is inherent in the substance, since it is of the essence of a substance to be apt to become one of the terms of a relation. In thus binding relation to substance, this treatise initiated a controversy which was never to cease during the Middle Ages: is relation real, or is it a mere ens rationis? 69

Full consideration has already been given to the way in which St. Thomas transformed the Aristotelian metaphysics which itself never succeeded in rising above form. What Gilson is suggesting here is that the whole crucial problem of the reality of relations is completely bound up with the metaphysical question of essence and existence in such a way

69. E. GILSON, Op. Cit., pp.140-141.

that only a metaphysics of existence can truly escape a doctrine of relations which is logical in character. Certainly St. Thomas has accused the Porretani of considering the accidents of relation as only conceptual, as has been seen. The question to be answered now is this: was this error of Gilbert, a mere inadvertency or blunder in no way sequential to his doctrine of being or not? The former disjunction is a possibility at least and represents a problem which can only be decided by an historical study of the metaphysical doctrine of Gilbert of Porrée, itself.<sup>70</sup>

To St. Thomas the error of Gilbert was exactly that he had "bound relation to substance" in such a way that relation could not again be considered what it properly is, viz. as referring to something else. Gilbert had only one notion of relation and that was as an absolute accident, inhering in a subject according to the Aristotelian definition of a proper

70. This has been done by Gilson in his History of Christian Philosophy in the Middle Ages, pp. 141-143. His conclusions are given in the following words: "Received by Gilbert of la Porree (he is speaking here of the essentialism of the metaphysics of Boethius), these notions took on a new importance in his work. They correspond, in fact, to what was most Platonic in the Aristotelian conception of being, and Gilbert only accentuates its Platonism." Ibid., p. 143. Thus, there is no metaphysics of existence in Gilbert in the sense that St. Thomas' metaphysical doctrine is spoken of in that way. Instead, there is in Gilbert an attributing of a sort of reality to each of the intelligible essences conceived by the understanding (and a portrayal of) finite beings as composed of a subject and of abstract determinations which, by qualifying it, cause it to be what it is." Op. cit., p. 144.

accident. But this is a serious error as St. Thomas says:

Ad cujus evidentiam considerandum est, quod in quolibet novem generum accidentis est duo considerare. Quorum unum est esse, quod competit unicuique ipsorum, secundum quod est accidens; et hoc communiter in omnibus est inesse subjecto, accidentis enim esse est inesse. Aliud, quod potest considerari in unoquoque, est propria ratio uniuscujusque illorum generum. Et in aliis quidem generibus a relatione, utpote quantitate, et qualitate, etiam propria ratio generis accipitur secundum comparisonem ad subjectum: nam quantitas dicitur mensura substantiae, qualitas vero dispositio substantiae. Sed ratio propria relationis non accipitur secundum comparisonem ad illud, in quo est, sed secundum comparisonem ad aliquid extra. Si igitur consideremus etiam in rebus creatis relationes secundum id, quod relationes sunt, sic inveniuntur esse assistentes, non intrinsecus affixae, quasi significantes respectum quodammodo contingentem ipsam rem relatam, prout at ea tendit in alterum. Si vero consideratur relatio, secundum quod est accidens, sic est inhaerens subjecto, et habens esse accidentale in ipso. Sed Gilbertus Porriatanus consideravit relationem primo modo tantum.<sup>71</sup>

And since Gilbert considered relation only in the mode of a proper accident, it was inevitable that when he came to explain the Trinity within the requirements of divine simplicity, he should fail to do so in a consistent manner. For when accident, conceived in this manner, is transferred to God it immediately would become substantial with the divine essence, for, at St. Thomas says, "there is no accident in God since everything in Him is His essence".<sup>72</sup> In order, therefore, to account for the distinction in Persons there would need to be another kind of real relation which was not

71. S. T., Ia, q. 28, 2.

72. Ibidem.

an in esse, but entirely ad aliud, so that the divine essence itself is not signified in a relationship between the Persons of the Trinity. The point is delicate and cannot be maintained if real relation is limited, in the first place, to inherence in a subject. St. Thomas writes:

Et sic manifestum est, quod relatio realiter existens in Deo est idem essentiae secundum rem, et non differt, nisi secundum intelligentiae rationem, prout in relatione importatur respectus ad suum oppositum, qui non importatur in nomine essentiae. Patet ergo, quod in Deo non est aliud esse relationi, et essentiae, sed unum et idem.<sup>73</sup>

But it is clear that St. Thomas' success with explaining the Trinity in contrast to Gilbert of Porrée has ultimately to do, as has been said, with the former's metaphysics of existence. Proximately, however, it is traceable to his doctrine on the reality of relations which may be either an accident or simply a relation in the pure sense. This duality of relation is made unmistakably clear by St. Thomas in the following words, which, written much after his views contained in "On Being and Essence", already quoted, spell out all that was merely implicit in the earlier treatment.

Thus:

.....quod ipsa relatio quae nihil est aliud quam ordo unius creaturae ad aliam aliud habet in quantum est accidens, et aliud in quantum est relatio vel ordo. In quantum enim accidens est, habet quod sit in subjecto, non autem in quantum est relatio vel ordo; sed solum quod ad aliud ut quasi in aliud transiens, et quodammodo rei relatae assistens. Et ita relatio est aliquid.

73. Ibidem.

inhaerens, licet non ex hoc ipso quod est relatio; sicut et actio ex hoc quod est actio, consideratur ut ad agente; in quantum vero est accidens, consideratur ut in subjecto agente. Et ideo nihil prohibet quod esse designat hujusmodi accidens sine mutatione ejus in quo est; quia sua ratio non proficitur prout est in ipso subjecto, sed prout transit in aliud; quo sublato, ratio hujus accidentis tollitur quidem quantum ad actum, sed manet quantum ad causam, sicut et subtracta materia, tollitur calefactio, licet maneat calefactionis causa.<sup>74</sup>

Thus, St. Thomas says that relation as relation does not signify something in the sense of a substance or even in the sense of an accident. Its whole significance, then, is neither in se nor in alio, but simply ad aliud. Relation, considered as relation, is a "towardness" of one substance for another which it clearly would lack if it lacked this kind of relation. It would then not be open toward other realities, an openness which makes, according to St. Thomas, the actualization of the potencies latent in every created substance and gives it its fundamental tendency to perfection.

An absolute contrast to this doctrine of the openness of a created being toward other beings which assist in its own development "...in quantum est relatio vel ordo....quodammodo rei relatae assistens",<sup>75</sup> is provided by the doctrine of monads in Leibniz:

Further, there is no way of explaining how a monad can be altered or internally changed by any other created thing; for nothing can be transposed within it, nor can

74. De Pot., 7, 9 ad 7.

75. Ibidem.

any internal movement be conceived in it which could be directed, increased or diminished within it, as is possible with compounds, where there is change among the parts. The monads have no windows through which anything could come in or out. Accidents cannot detach themselves from substances, or go about outside of them, as the "sensible species" of the Schoolmen used to do. Thus neither substance nor accident can come into a monad from outside.<sup>76</sup>

The monads of Leibniz are, as he says, the "real atoms of nature". They are not, however, the physical atoms of the scientists since they lack extension. But everything in the universe ultimately consists of these units which possess only an "inner activity" flowing from a nature which contains in germ all that will happen to them. Furthermore, they are all arranged in a system which represent the best possible world that God could have created.<sup>77</sup> In this system external relations are impossible for "an external cause could not influence their (the monads) inner being".<sup>78</sup> Thus there is no cause which the human mind can know in terms of any relation to another created being. There is only "ideal" relation or interaction between the monads. So that for Leibniz, the causal problem of Hume does not exist. Instead, for Leibniz, the scientific problem is the discovery of the functional laws obtaining between monads and expressible in terms of mathematical relationships. All this is derived from his

76. G. W. LEIBNIZ, The Monadology and other Philosophical Writings, London: Oxford University Press, 1925, p. 219.

77. Op. cit., Introduction, p. 50.

78. Ibid.

major principle: "Praedicatum inest subjecto" which demands that all judgments except those of existence be analytic, since all predicates are implicit in the subject. From this principle, Leibniz derives his definition of substance, viz., that which can only be the subject of a proposition and can never be predicated of anything. It follows from this that no substance can affect another substance for all the properties of a substance are eternally inherent in it. The changes that a substance suffers are due to correlations among substances which reflect the pre-established harmony of the universe which at the same time is contingent.<sup>79</sup> Thus the laws which are formulated on the basis of scientific discovery of nature are themselves contingent inasmuch as the correlation between substances could have worked out in another way. This is because of the non-analytical character of the predicate of "existence" which is not contained in its subject implicitly. Thus while it is impossible that a certain property is not pre-contained in its subject, it is possible that some other substance might have been which lacked the particular property in question.<sup>80</sup> But it was not possible that the existence of God be contingent, for Leibniz maintains that the essence of God includes his

79. This view of the pre-established harmony of nature, as has been seen (cf. supra p. 46) was influential for Einstein's work.

80. G. W. LEIBNIZ, "On the Ultimate Origin of Things," in Philosophical Papers and Letters, ed. L. LEOMKER, Chicago, 1956, p. 791 ff.

existence.<sup>31</sup> And here Leibniz, in excepting God from the order of contingency, has done so after the manner of St. Anselm thereby revealing at the same time the logical character of his metaphysics and his view of the nature of relations. In this respect, he has simply carried out the views of Gilbert of Porrée to their logical reduction with his monadology, as Professor Gilson has remarked:

This (type) of demonstration of the existence of God is assuredly the triumph of pure dialectic operating on a definition..... There have always been philosophers to take it up and refashion it in their own way, and its implications are so manifold that the sole fact of having rejected it or admitted it almost suffices to determine the doctrinal group to which a philosophy belongs. ....Leibniz took it up again.....in his own way and (what it always means) is the identification of real existence with intelligible being conceived by thought.<sup>32</sup>

Now, the openness or "towardness" which is the ratio of relation for St. Thomas is not something physical after the manner of a connecting rod or chain, linking the subject to its correlative, And yet the two, subject and term, are so connected that one cannot be abstracted from the other. They each, therefore, imply the other. John of St. Thomas writes:

.....relatio transcendentalis non est primo et per se as aliud sicut praedicamentalis, quia licet tota earum species et essentia sumatur ab alio vel dependeat ab alio, non tamen ad aliud, sicut materia depende a forma

31. Ibidem.

32. E. GILSON, Cp. cit., pp. 133-134.

et actus ab obiecto sicut a causis, a quibus habent esse et specificationem. Et hoc consequitur, quod respiciunt illud ut terminum. Sed quod primo et per se sit ad aliud ut ad terminum, est proprium relationis praedicamentalis. Et ideo dicitur, quod respicit terminum ut pure terminum, id est tantum ut ad aliud, non ut ab alio vel circa aliud vel quocumque alio causalitatis modo sicut transcendentalis, quod vero relatio praedicamentalis dicitur esse in subiecto, non tollit, quin totum suum esse sit ad aliud, totum, inquam, id est proprium et peculiare ipsius esse, in quo differt ab aliis generibus absolutis; supponendo tamen rationem communem accidentis, scilicet esse in aliquo, ratione cuius non habet esse ad aliud, sed nec id excludit.<sup>83</sup>

Here is revealed a trait which is peculiar to relation apart from all other accidents. It is a well known part of the doctrine of St. Thomas that the actualization of the potencies inherent in a substance takes place through the medium of its accidents. Thus the accidents, in general, assist the substance to achieve its proper perfection through the maximizing of its act. But relations give the substance its openness to the rest of reality without which such actualization could not take place. Relations are, in fact, the very "windows" which Leibniz did not find in his monads, precisely because they did not have real existence. Relations however are real accidents for St. Thomas because they are caused by the substance of really existing beings. But this is not the only difference between other accidents and relations. For as St. Thomas tells us, "according to the respect it is a medium"; i.e., when two relations inhering in

83. John of St. Thomas, *Ars Logica II seu de forma et materia ratiocinandi*, ed. P. BEATO REISER, C.S.B., *Taurini, Marietti*, 1930, XVII, II, Resp III arg.

separate extremes are considered by the intellect this tendency of each for the other is completed by the intellect.<sup>84</sup> Thus, relation is an accident which, uniquely, has a ratio which is formed by the intellect. It is in this way that it becomes a "medium" in that the "towardness" is seen or anticipated as actual between the subject and term. But this is not to say that the conception of relation in this manner communicates reality to it, since this note is actually outside its ratio taken as a genus.<sup>85</sup> The reality of the relation is not determined by the concept but by the substance itself acting as cause, which the intellect may discover by a consideration of the real beings involved. Thus the truth expressed by the intellect depends upon a correspondence with the real order of beings. But, as St. Thomas says, relations are called real since a real intellect completes the relation which exists between two real beings, in contradistinction to a completion by the reason of two understood things:

....relationes, quae consequuntur solam operationem intellectus, in ipsis rebus intellectus, sunt relationes rationis tantum, quia scilicet eas ratio adinvenit inter duas res intellectas. Sed relationes quae consequuntur operationem intellectus, quae sunt inter verbum intellectualiter procedens, et illius, a quo procedit, non sunt relationes rationis tantum, sed rei; quia et ipse intellectus, et ratio est quaedam res; et comparatur realiter ad id, quod procedit intelligibiliter,

84. Cf. in III Phys., 4.

85. Quodlib., IX, a. 4. It may be that some species of relation by its own ratio implies reality.

sicut res corporalis ad id, quod procedit corporaliter.<sup>36</sup>

Here St. Thomas is emphasizing that there is a kind of triangular relationship involving a real connection between the intellect and the extremes which are themselves tending toward each other.<sup>37</sup>

Thus, it is clear that the ratio of relation, as distinct from relation as an absolute accident may be either real or logical depending upon the conditions operating in a

36. S. T. Ia, q. 28, 1, ad 4.

37. It is this special and unique quality of the accident of relation to be completed by the human intellect in the manner just described that, in the view of this thesis, became translated in the language of Einstein as the "inventive" factor in the discovery of the primary concepts of his scientific theorizing. It is precisely here, in this vital order of relation that the creative intellect of Einstein "joined", by the way of discovery or anticipation, the tendency of quantified substances to perfect themselves by a movement in the direction of other quantified beings. However, it must be remarked, without in any way attempting to minimize the achievement of Einstein that a more accurate and scientific word for the fruit of this "leap", as he chose to call it, is not "invention" but "discovery". The reason for this suggestion is, admittedly, a semantical one but nonetheless necessary inasmuch as the original meaning of invention as a simple discovery has been lost in favor of something presently connoting devising or originating.\* The suggestion, further, is clearly indicated by what is metaphysically implied in the description of the relational order given above, both in its ontological and psychological phases. For unless one is prepared to impute to the celebrated Swiss physicist other than purely human cognitive powers, it seems preferable and certainly more scientific to keep to language which relates to the objective facts involved rather than to purely personal and impressionistic criteria.

\*Cf. Webster's New Collegiate Dictionary, Merriam-Webster, 1950.

given context. In any case, this ratio in order to enjoy any being whatever, must have a two-fold stability: It must receive an esse from the intellect which it has as an accident inhering in a subject as well as a content of truth derived from its conformation to ontological reality, which serves as its foundation. This foundation may be of two kinds viz., immediate or mediate. An example of the former would be the reality that a relation of time would have when it is founded on a measurement of a really moving body undergoing change of place. A mediate foundation would be immediately based upon the mode of understanding of the intellect and remotely be based on external things through contraction, for example, from a genus. And, as St. Thomas says, the chain of remote reasoning, considered potentially, may be infinite:

....in nobis relationes intelligibiles in infinitum multiplicatur: quia alio actu intelligit homo lapidem, et alio actu intelligit se intelligere lapidem, et alio etiam intelligit hoc interrrogare; et sic in infinitum multiplicantur actus intelligendi, et per consequens relationes intellectae.<sup>38</sup>

Such relations for St. Thomas are called "intermediate relations and they are always beings of reasons. Thus:

....relationes, quibus subjectum refertur ad aliud, non referuntur ad subjectum aliqua alia relatione media, nec etiam ad oppositum; sicut paternitas neque ad patrem neque ad filium refertur aliqua alia relatione media: et si aliquae relationes mediae dicantur, sunt rationis tantum, et non rei.<sup>39</sup>

38. S.T., Ia, q. 28, 4, ad 2.

39. Com. on Metaph., V, 20 (ed. Cathala, 1933).

It is evident from the analysis just seen that an "event", as it is understood in Relativity physics by Einstein, can qualify as a real relation, if certain conditions are met, inasmuch as there do exist real relations. There are, then, absolutely no metaphysical grounds for insisting with Russell that an "event", understood as a quantitatively expressed relation between the objects of physics, is a logical being as a matter of necessity. It has been seen that relation can be purely logical, however, and it is because of the confusion that such a fact can cause that a lengthy and careful analysis with the aid of concrete, historical material was made.

Thus the essential thesis of this work may be repeated: the Einsteinian epistemology, depending upon mere scientific usefulness, is virtually defenseless against idealistic attacks of the kind made by Bertrand Russell. Nor can the pre-scientific "feeling for the real", as Margenau has called Einstein's realist orientation, when supported only by the weak metaphysical defenses that Einstein throws up, as seen in the first section of this chapter, avail much against idealistic professionalism. It is our further argument that neither would any ordinary counter-professionalism prevail, since only an existential metaphysics, such as that of St. Thomas, is fully disjunctive to it, a fact that the discussion just ended has also attempted to show.

Section C. The Grasp of Reality in  
Mathematico-physical Investigation.

It has been seen that, according to Einstein, the essential aim of the scientific examination of nature is the escape from the "private and adventitious" view into something "invariant and public" that would "succeed in grasping reality in all its depths." It must now be asked, given the inductive beginnings of scientific investigation in real relations, what exact operational mode do these investigations take in Einstein?

The answer to this question is derived from a consideration of the central idea of Special Relativity theory which states that in the very nature of things there cannot be any unique frame of reference serving as an absolute correlate with any measuring operation. In other words, according to Einstein, nature does not favor any particular frame of reference for itself. Put in the technical language of the General Theory this reads, "Natural laws are to be expressed by equations which are covariant under the group of continuous co-ordinate transformations."<sup>90</sup> This postulate of the General Theory, however, should be regarded as the fruit of the earlier discoveries in the Special Theory. But the central discovery and most profound insights of the Special Theory concerned precisely the alleged naïveté of the

90. A. EINSTEIN, "Autobiographical Notes", AEPS, p. 39.

traditional mode of measuring with rods and clocks. The Einsteinian innovation in this matter, as is well known, was the claim that not only the unit of measurement of geometry is a matter of definition but likewise the comparison of distances in physics. Einstein was maintaining, then, against all the traditions of physics up to that very moment that the congruence of a certain distance with another distance measured elsewhere could never be proven true; it could only be defined. What is more, the very notion of congruence is definitional and is the support of the truth of distance comparison, Einstein asserted. Thus a comparison of distances by transporting rigid rods is one, but by no means the only way to define the notion of congruence. Similarly, Einstein asserted that time was definitional when it concerned the question of simultaneity. In the latter case, as is well known, the definition of simultaneity which Einstein employed was that involving the traversing of equal distances by light rays. Since light rays move at a constant speed, i.e. independently of the speed of the emitting body, the distances covered by light rays in, say, five seconds, would necessarily be congruent according to the definition. On this point Einstein wrote:

In order to complete the definition of time we may employ the principle of the constance of light in a vacuum. Let us suppose that we place similar clocks at points of system K, at rest relatively to it and regulated according to the following scheme. A ray of light is sent out from one of the clocks,  $U_1$ , at the instant when it indicated the time  $T_1$ , and travels through a vacuum a distance  $R_{1n}$ , to the clock  $U_n$ ; at

the instant when this ray meets the clock. On the latter is set to indicate the time  $T_n = T_m$  plus  $\frac{Rv^2}{c^2}$ . The principle of the constancy of the velocity of light then states that this adjustment of the clocks will not lead to contradictions.

It is clear from these considerations that the Einsteinian revolution was accomplished by a successful attack upon the traditional use of measuring instruments. It is clear that in addition it succeeded also in making conscious and explicit the intimate way in which mathematico-physical investigation is bound up with such instruments and the work of mensuration. The following remarks of Dingle underline well this latter point.

Turning to the philosophical aspects of the theory, the first point to be noticed is the light which it throws on the meaning of time in physics. This has been perhaps the most widely misunderstood part of Einstein's theory. It has been supposed that the relativity theory gives us some insight into what is called the "nature" of time, and has shown that it is at bottom identical with the nature of space, so that these two things are simply arbitrarily separated parts of an objectively existing entity called space-time. It must be confessed that Minkowski's famous remark, "From henceforth space in itself and time in itself sink to mere shadows, and only a kind of union of the two preserves an independent existence", lends itself naturally enough to this interpretation; although Einstein has always insisted that the theory has no metaphysical implications. The fact is that time has become associated with space in physics simply because we have chosen to measure time in terms of space measurements. . . . . What relativity theory illuminates is not the metaphysical nature of time, but the function which time measurement can perform in physics.<sup>91</sup>

It is, then, the contribution that Einstein's theory made to a clearer and more perfect awareness of the nature

91. E. DINGLE, "Implications of the Special Theory", AEPS, pp. 550-551. (Italics mine.)

of mathematico-empirical investigation that leads directly to the question of the efficacy of the instrumental mode of investigating nature to grasp reality, as Einstein hoped, in "all its depths". Granted the efficacy of this operational mode, in unravelling some of Nature's physical secrets, the problem is to determine, by an appropriate metaphysical analysis, what grounds, if any, support such a hope as a grasp in depth of reality.

The first question that must be examined is: what makes a sensible being capable of being measured? The obvious reply would be that it is extended in space i.e., that such a being has parts outside of parts which render it capable of being sensed and as a result measured. The answer of St. Thomas is that it is the quantity of a being which renders it measurable for it is this which gives it parts outside of parts. He writes as follows:

*Materia autem dividi non potest nisi ex praesupposita quantitate, quo remota omnis substantia individibilis remanet, et sic prima ratio diversificandi ea, quae sunt unius speciei, est penes quantitatem. Quod quidem quantitate competit, in quantum in sui ratione situm quasi differentiam constitutivam habet, qui nihil est aliud quam ordo partium.*<sup>92</sup>

Thus St. Thomas is saying that quantity determines a material being to individuation and as a result must determine the being of its distinction of parts. In other words, it is one and the same principle which produces both

92. In de Trinitate, 70, 5, 3, ad 3.

distinction of parts and individuals. This is the way that the Angelic Doctor interprets the definition of quantity by Aristotle as that which is divisible into two or more constituent parts of which each is by nature a "one" and a "this".<sup>93</sup> This means that a material substance without quantity would not be formally extended with parts outside of parts, although it would have parts radically in the sense of retaining the ability to become extended. Thus the removal of quantity would cause its parts to be in a state of unity or confusion. To St. Thomas a diversity of parts in matter is unintelligible unless a division is presupposed, and a division of matter is unintelligible without dimension, for, if quantity is removed, substance is indivisible.<sup>94</sup> Thus, if quantity were removed from a substance it would lose its divisibility since it would no longer satisfy the conditions necessary for the extension of parts outside of parts. This, however, does not mean that a substance would be reduced to a point, for point is the principle of quantity and not of a substance. Rather, St. Thomas says, such a substance would simply lack divisibility while losing none of its entitative composition; it would lose its existence in a physical place, its ability to move and other characteristics which follow upon quantity but keep the same existence that

93. Metaphysics, V, 13, 1026a .

94. Cont. Gent., IV, 35; In de Trin. 5, 3, 3.

it always had.<sup>95</sup>

The substance would now possess its parts only in potency and radically, much in the same manner that matter would have a potency to formal being if it existed without form. Thus it is clear that quantity gives integral parts to substance but is in no way constitutive of the substance. Its function is to set the parts of the substance in a certain order from the confusion which it would have without the contribution of quantity. And since this ordering is accidental, rather than essential to the substance, quantity is an accident. It is, in fact, one of the predicamental accidents of Aristotle and thus falls into the category of real being.

The question that immediately follows regards the substantiality of the substance itself. It is clear that St. Thomas makes it radically independent of quantity insofar as the latter is an accident which merely order the parts that substance already has radically. Actually, substance needs nothing else but its own entity in order to exist. Meanwhile it has parts of its own, viz., matter and form which, being the unextended parts of an unextended substance, are themselves unextended, though physical.

The continuous quantity which is here being considered, is divided according to St. Thomas, following Aristotle, in two ways, viz., into the intrinsically measuring and the

<sup>95</sup>. Com. on the Sent. II, 3, 1, a. 1.

extrinsically measuring. According to this doctrine the real continuum is intrinsically measured into three ultimate species of this quantity: line, solid and surface. The continuum which is extrinsically measured is divided into place and time.<sup>96</sup>

Regarding the three species of intrinsically measured continuous quantity, Aristotle refers them to magnitude saying, "that which is continuous in one dimension is length, in two breadth, in three depth".<sup>97</sup> These in turn form the basis of the definition of the three species for line is magnitude in length, surface is magnitude in breadth and solid is magnitude in depth. Moreover, line, surface and depth are distinct from each other even though they enter into the composition of each other, which results from the very nature of quantity itself, which is to supply parts. This distinction of each of the three is made clear by the very diversity of the positions and properties of extension according to length, breadth and depth. As John of St. Thomas says, when a line or surface contribute to a solid, they do so materially not formally for both line and surface are genuine quantities in themselves. Thus, unlike matter and form whose whole formality lie in constituting a substance in a material sense, line and surface have an

96. For a lengthy statement on extrinsic measurement see the remarks of St. Thomas contained in note 101.

97. Metaphysics, V, 13, 1020a, 12, 13.

extension even apart from the solid.<sup>98</sup> Thus line is formally distinct from a solid not because it lacks depth but because it positively involves the entity of length. This is emphasized additionally by the fact that there is diversity in the types of lines, surfaces and solids, e.g., curved or straight lines, smooth or rough surfaces, round or square solids. This is also a sign of the reality of these species of quantities for only real beings can be modified in shape and be subject to situation.

The kind of quantity that has been considered so far is continuous quantity, the accident which gives a material being its part outside of parts. Following Aristotle, for St. Thomas there is another kind of quantity, viz. discrete or discontinuous quantity which instead of uniting parts separates them. It is this latter type which, as St. Thomas remarks,<sup>99</sup> causes a division in the continuum giving it the property of measurability and resulting in quantitative number. Thus he says that the character of measure is found primarily in discrete quantity.<sup>99</sup> This means for St. Thomas that we measure the continuum by counting its parts, there being no clearer kind of measure than counting, whereby the parts of the separated continuum are exhausted. It is essential, at this point to carefully consider that by which the measured continuum is counted or expressed, viz., number.

98. Com. on the Sent. I, 24, 1 a. 3.

99. On Instantis, cap. 1.

For St. Thomas, number is constituted by the real extended things which are counted. It is these things subjected to the act of counting. Thus, number is that which designates the quantitative condition or multitude which through the process of counting measures discrete being. Furthermore, number possessing as it does, according to Aquinas, an essential, per se unity is a true species of quantity. This means that since quantity is a condition of real being, the numerical unity two beings would possess, when we express this in counting them, places this kind of number in the category of real being as well. Thus St. Thomas writes:

Et sic dualitas non erunt duae unitates, sed aliquid ex duabus unitatibus compositum. Aliter numerus non esset unum per se et vere, sed per accidens, sicut quae coaccervantur.<sup>100</sup>

St. Thomas does not mean here that number is a substantial per se being for he is clearly putting it in the category of quantity. John of St. Thomas explains this doctrine of the Angelic Doctor by comparing the way in which number derives its own quantitative measure in contrast to the extension of time and motion which refer always to an existing continuum:

.... numerus dicit veram extensionem et rationem mensurae artam ex divisione continui, quam non dicit sola multitudo confuse accepta per modum acervi vel comuli. Quae ratio sic explicanda est: quia numerus fundatus in quantitate divisa habet veram et propriam mensurationem per modum extensionis et multiplicationis, qua exhaustire et adaequare potest ipsa partes et extensionem continui. Et hanc rationem mensurationis et extensionis non habet tamquam quantitas per accidens sicut tempus et motus,

100. In Metaph. II, 13; (ed. Cathala, 1889.)

quae ratione continui extenduntur. Numerus autem suam propriam mensurationem discretam non habet ratione quantitatis continuae, cum potius dividat et solvat continuitatem eius.....(et) sit mensura in genere quantitatis et extensionis. 101

Yet, if this kind of number is a per se, real being, where does it derive the form necessary to make it so? For St. Thomas, the unity that such numbers have is not the unity derived from a form at all but only the unity of order. It is an order that is quantitative in nature but does not derive from a quantity inhering in all the units contained implicitly within the last term but only from the last term

101. John of St. Thomas, Op. cit., II, XVI, II, Prima conclusio. According to St. Thomas, time, motion and place are not per se species of quantity but are quantitative by accident. St. Thomas writes as follows on this problem:

"Distinguit modos quantitatis per accidens: et ponit duos modos quantitatis per accidens: quorum unus est secundum quod aliqua dicuntur quanta per accidens ex hoc solo, quod sunt accidentia alicujus quanti, sicut album et musicum per hoc quod sunt accidentia alicujus subjecti quod est quantum.

Alio modo dicuntur aliqua quanta per accidens non ratione subjecti, in quo sunt, sed eo quod dividuntur secundum, quantitatem ad divisionem alicujus quantitatis; sicut motus et tempus, quae dicuntur quaedam quanta et continua, propterea quod ea, quorum sunt, sunt divisibilia, et ipsa dividuntur ad divisionem eorum. Tempus enim est, dividibile et continuum propter motum motus autem propter magnitudinem; non quidem propter magnitudinem ejus quod movetur, sed propter magnitudinem ejus in quo aliquid movetur. Ex eo enim quod illa magnitudo est quanta, et motus est quantus. Et propter hoc quod motus est quantus sequitur tempus esse quantum. Unde haec non solum, per accidens quantitates dici possunt, sed magis per posterius, in quantum, quantitates divisionem ab aliquo priori sortituntur." In Metaph. V, 15, 934.

of the series itself. Otherwise, it would be like continuous quantity itself which has a unity of form. Thus number, according to St. Thomas, is a distinct system of measurement characteristic only of discrete quantity. Nor is this order one of relation such as that obtaining in an accidental unity such as a group of people, for numerical unity is truly an essential unity. However, St. Thomas says that the one which is a number is not the one convertible with being for in the latter there is no division.<sup>102</sup> Instead the unity is the order given to a series of numbers when they are enclosed and set within a determined limit by the last number. The question of the role that the intellect takes in the designation of the last number of a series is taken up by John of St. Thomas because he recognizes it as a real difficulty and an attempt to impute to the intellect the formal role of the constitution of the ultimate number in a series thus converting the unit into a being of reason:

....unitas secundum se est materia numeri inadequata et partialis, ut autem ultima, est forma. Et rursus, quod sit ultima quantum ad effectum et formalitatem terminandi et claudendi omnes unitates sub termino determinati numeri, habet in re, licet designationem materialem habeat ab intellectu. Et ista terminatio seu ratio ultimi vere est aliquid in quolibet numero determinato, quia vere in re invenitur hoc officium claudendi et ultimandi unitates sub ratione numeri, v.g., in ratione quinarum vel senarum.<sup>103</sup>

102. In Metaph. V, 3, 375

103. John of St. Thomas, Op. cit., II, XVI, II, Resp. AD. 3.

The question which must be examined in this connection is that of the reality of numbers which are clearly the work of reason such as negative numbers, constants and so on. Before this is done, however, it should be noted that the problem of the capacity of sensible beings to be measured has been answered by St. Thomas in his doctrine of the accident of quantity, continuous and discrete and the species of real accident, number.

It is clear that in St. Thomas' metaphysical doctrine it is not the parts of the substance which render a sensible being capable of being measured inasmuch as substance, radically taken, has only a potency to have actually extended parts. The measurability is rather due to the actualization of the confused parts within the substance by the accident of quantity whether continuous or discrete giving extension to these parts. It is also clear that since the extension is a real property of the sensible being that quantity is a real or predicamental accident. Thus when this quantity of extension is known, it is a reality which the intellect is grasping. And since the whole essence of this accidental form of quantity is in being extended metrically it is eminently susceptible of analysis by mensuration so that the knowledge that is derived is continuous with the modification of being which it considers. And in achieving a knowledge of the metrical determinations of the quantified being, the substance, as the seat of the extension of parts, is

involved as object, too. Thus a measurement taken of a sensible being will reveal the metrical extension of the substance of such being. Yet it is not the substance which is known but the quantity which, as was seen, is not constitutive of the substance of the being itself. For this reason, while a substance can be known by means of measurement in the way that it is accidentally quantified it cannot itself be known by any such approach to either its constitutive physical parts, essence or being. And since mathematical physics has no existence outside of its measuring instruments it is clear that it can know nothing at all about any unextended reality. Indeed, only Duhem, of all modern scientists of the first rank has seen this clearly.<sup>104</sup> Nor does it have any knowledge of quantity which is not metrical, such as the accidental relation of quantity to substance, just considered. Rather, it is strictly limited to a knowledge of extended bodies insofar as they are extended and to what extent this is so.

Thus it is evident that mathematico-physical investigation does not, and cannot, succeed in "grasping reality in all its depths." The knowledge that it does achieve, however, is that of the 'quantified' extension of a real world, topical and metrically relational though it be. The investigation which attains to such knowledge is a true physics but

104. Cf. Introduction to this thesis, p. vii.

one that has allied itself, mutatis mutandis, only to mathematics rather than, as it clearly could, to metaphysics as well, in which case the resulting knowledge would be no more real for being deeper, satisfying at last Einstein's hope.

## CHAPTER III

## THE METAPHYSICAL FOUNDATIONS OF EINSTEIN'S EPISTEMOLOGY

Section A. The Foundations of Inductive Beginnings

The first requirement of scientific investigation for Einstein, as has already been seen, is that it begin with sensible experience. For him this was of pivotal importance. It can be called a mark of his realist approach to the material world. And yet, it is one thing to declare something a necessary feature of scientific investigation and quite another to give it an unshakeable, scientific character.

Now, it is an ironical twist of fate that the central and most revolutionary idea to come out of Relativity theory, viz., the fusion of space and time, should be seized upon by the idealist camp in the person of Bertrand Russell to challenge this first and, perhaps, most important epistemological tenet of Einstein. For it is not long after the pronouncement of Relativity Theory that Russell makes his provocative remarks (contested by Einstein) about the "implications" of the merging of space and time. Russell will settle for nothing less than the discarding of all reference to "things" in scientific vocabulary, agreeing with Whitehead:

Since Einstein, and still more since Heisenberg and Schrodinger, the physical world is no longer regarded as consisting of persistent pieces of matter moving in a three-dimensional space, but as a four-dimensional manifold of events in space-time. The old view resulted from an attempt to make the common-sense concept of

"things" available for science; the new view means that "things" are no longer part of the fundamental apparatus of physics..... The essential business of physics is the discovery of "causal laws", by which I mean any principles which, if true, enable us to infer something about a certain region of space-time from something about some other region or regions.<sup>1</sup>

Now, while Einstein seems to show at times an occasional inclination to dispense, in the manner of Russell, with the reality of material things, his realism is never more emphatic than in his brief remarks on Russell's theory of knowledge. Thus, with reference to "events" Einstein says the problem is complicated by the lack of clarity "in picturing to ourselves relations in this four-dimensional continuum".<sup>2</sup> And although it was easier to do so in the three-dimensional Euclidean continuum, even there, "its concepts and relations are only of an abstract nature in our minds, and not at all identical with the images we form visually and through our sense of touch".<sup>3</sup>

Indeed, to Einstein, any objection to the retention of the notion of the "thing" which is based on metaphysical bias is not sufficient grounds at all. And this is what is ailing Russell more than anything in his haste to dispense with the "thing". No matter how much one may admire the acute analysis which Russell has given us in his latest book on Meaning and Truth, it still

1. A. WHITEHEAD, Process and Reality, New York, 1929, p.401.
2. A. EINSTEIN, The Meaning of Reality, p. 31.
3. Ibidem.

seems to me that even there the specter of the metaphysical fear has caused some damage..... However, I see no "metaphysical" danger in taking the thing (the object in the sense of physics) as an independent concept into the system together with the proper spatio-temporal structure.<sup>4</sup>

The conflict between Einstein and Russell on the whole question of the reality of the objective world, therefore, is closely related to the question of events as opposed to things. This can be seen from a brief consideration of Russell's theory of knowledge.

For Russell, there is no ontological distinction between mind and matter, the distinction at best being a methodological one. Thus Russell says, "the distinction of mind and matter came into philosophy from religion, although, for a long time, it seemed to have valid grounds. I think that both mind and matter are merely convenient ways of grouping events".<sup>5</sup> This doctrine he calls "Neutral Monism", a doctrine in which the event destroys the possibility of the material thing and thus removes the ground for any continuing distinction between mind and matter. Science is converging from both ends in support of this doctrine.

While physics has been making matter less material, psychology has been making mind less mental..... Thus, from both ends physics and psychology have been

4. A. EINSTEIN, "Remarks on Bertrand Russell's Theory of Knowledge", Library of Living Philosophers, p. 291.
5. B. RUSSELL, A History of Western Philosophy, New York, Simon Schuster, 1945, p. 833.

approaching each other, and making more possible the doctrine of "Neutral Monism".<sup>6</sup>

Now, Einstein and Russell agree that events in the sense of world points are completely without extension. But, while this is proof to Einstein only that events are concepts and are the means used by the mind to understand extra-mental reality but not that reality itself, it is proof to Russell that there is no ontological difference between the contents of the mind and material things. Again, where Einstein would hold that, being concepts, events are not deduced from experience, Russell admits no dichotomy between mind and things and assumes a logical path from one to the other. Thus the controversy between the two on this point brings into relief the way in which Einstein's "concern for the real" guides him in an almost instinctive way not only in the maintenance of his own realist positions but also to a perception of the idealist positions of others.<sup>7</sup>

It is clear, at the same time, that Einstein does not throw up any adequate defense of his realist views. That is why it is of crucial importance that an attempt be made to provide one within metaphysics inasmuch as only epistemological tenets based on necessity, as distinct from the merely

6. Ibid.

7. Russell's remark on Relativity physics in this connection is corroborative: "Like all physics (Relativity physics) assumes the realistic hypothesis." B. RUSSELL, The Analysis of Matter, New York, Harcourt, Brace, 1927, p. 48.

useful, can be called "adequate". The special task for the thesis at this point is to try to find such adequacy within the metaphysical doctrines of St. Thomas Aquinas.

There can be no doubt at all that the metaphysical investigations of St. Thomas begin by a consideration of sensible beings. The reason for this is that all human cognitive activity has as its proper object the form as existing individually in corporeal matter. St. Thomas rejects Platonism and clearly makes objective, sensible being the first and the proper object of the knowing human intellect.

Manifestum est etiam, quod species intelligibiles, quibus intellectus possibilis fit in actu, non sunt objectum intellectus. Non enim se habent ad intellectum sicut quod intelligitur, sed sicut quo intelligat. Sicut enim species, quae est in visu, non est quod videtur, sed est quo visus videt; quod autem videtur est color, qui est in corpore; similiter quod intellectus intelligit est quidditas, quae est in rebus; non autem species intelligibilis, nisi in quantum intellectus in seipsum reflectitur. Manifestum est enim quod scientiae de rebus, non autem de speciebus, vel intentionibus intelligibilibus, nisi sola scientia rationalis. Unde manifestum est, quod species intelligibilis non est objectum intellectus, sed quidditas rei intellectae.<sup>8</sup>

Thus the beginnings of science for St. Thomas, just as they were for Einstein, are sensible beings in the world. It must be noted here that the former is not giving, as he might, a fundamental reason why this is so but is content to reduce its contradiction to an absurdity. Actually, he has given the real reason for this beginning in real beings in his metaphysical writings where they properly belong, and

8. In De Anima, 3, 8.

which will be examined at this time, for the full clarification of the tenet, so explicit in Einstein. Father Owens, writing in Mediaeval Studies, interprets the doctrine of St. Thomas on the proper starting point of metaphysics as follows:

In giving a metaphysical account of a thing, one cannot think of the essence as something already constituted by its form or matter and then having the act of being added to it. Rather, from a metaphysical viewpoint, one has to start with the act of being that the primary efficient cause gives by participation, . . . . It is the constituent that exercises the most fundamental priority in the thing that is produced.<sup>9</sup>

In other words, St. Thomas is interpreted as saying that one cannot know what does not exist and as a consequence if there were no existing beings there would be nothing to know. In addition it is because of the priority of this act of being which makes a thing real that we must turn to the really existent thing in the first cognitional movement.<sup>10</sup> Of course, if something other than the reality of the thing came first, it would be metaphysically possible, even necessary, to begin human cognition somewhere else, e.g., outside

9. REV. DR. Joseph OWENS, C.S.S.R., The Accidental and Essential Character of Being in the Doctrine of St. Thomas Aquinas, Vol. XX, p. 30.
10. This view of St. Thomas on the priority of existence was challenged by the important mediaeval scholar, Giles of Rome, who said that essences had an intelligibility of their own even in priority to becoming actualized by esse. Cf. William E. CARLO, The Doctrine of Creation in Giles of Rome, Ph.D. thesis, Toronto University; 1955; Joseph OWENS, C.S.S.R., ibid, p. 27.

real being itself. But this is not the case, says St. Thomas, for the reason that the only other constituent in a sensible thing is the essence, and this is something whose whole meaning is with reference to what a thing is, i.e., its definition.<sup>11</sup> It has nothing to do with the reality of the thing which is the result of efficient causality.

It is rather being for St. Thomas which is the terminus of efficient causality, "...ei quod fit faciens dat esse."<sup>12</sup> Without being a thing cannot exercise any efficient causality. St. Thomas clearly says that the essence cannot be the efficient cause of its own being because, if it could, a being could be known before it was a being: "Si ergo aliquid sibi ipsi esset causa essendi, intelligeretur esse antequam haberet esse, quod est impossibile; ...."<sup>13</sup>

Now all this does not mean, however, that with reference to accidental being that accidents cannot be actually known before the subject in which they inhere; "invenitur enim aliquod ens accidentale causatum ex principiis sui subjecti, ante quod esse intelligitur esse substantiale

11. "Moreover, since that by which a thing is constituted in its proper genus or species is what is signified by the definition expressing what the thing is, philosophers have taken to using the word quiddity for the word essence. The philosopher frequently calls this the what a thing was to be, in other words, that by which a thing is a what." On Being and Essence, transl. A. MAURER, pp. 27-28.

12. De Pot., III, 1, 17.

13. Cont. Gent. 1, 22.

subjecti."<sup>14</sup> But this, St. Thomas explains, is accidental rather than substantial being and therefore does not modify the priority of existence as an efficient cause of being or as a necessary first cause of human knowing.

In order to understand what St. Thomas means by the priority of the act of being, however, it is necessary to consider in what sense he says that the essences have "being". This will involve a consideration of the controversial (for Einstein) doctrine of abstraction.

St. Thomas says that there are two ways in which essence may be abstracted viz., with and without precision. In the former way, i.e. when essence is abstracted with precision, the essence is in no way identical to the thing it represents because the essence has excluded something from the thing in forming a conception of it, viz., its individuating principles and so represents only a part of the thing, even though the whole nature of the thing is represented. According to this mode of abstraction, one would consider the humanity of Socrates as operating in a formal way within the individual but not Socrates with the individual matter that characterizes him.<sup>15</sup> On the other hand, when the essence is abstracted without precision, the essence and the thing are identical. This is because the whole individual is being considered and

14. Ibidem.

15. Cf. De Ente et Essentia, Cap. II.

not just the part, albeit the formal and material (undesigned) principles. This is indicated by speech for while it is true to say that Socrates is a man, it is not true to say that he is humanity. Thus, St. Thomas says:

Sic ergo patet quod essentia hominis significatur hoc nomine homo et hoc nomine humanitas, sed diversimode, ut dictum est: quia hoc nomen homo significat eam ut totum, in quantum scilicet non praecedit designationem materiae, sed implicite continet eam et indistincte, sicut dictum est quod genus continet differentiam: et ideo praedicatur hoc nomen homo de individuis; sed hoc nomen humanitas significat eam ut partem, quia non continet nisi id quod est hominis in quantum homo, et praecedit omnem designationem materiae, unde de individuis hominis non praedicatur; et propter hoc, quandoque hoc nomen essentia invenitur praedicatum de re; dicitur enim Socrates essentia invenitur praedicatum de re; dicitur enim Socrates essentia quaedam est, et quandoque negatur, sicut dicimus quod essentia Socratis non est Socrates.<sup>16</sup>

Thus it is that essences abstracted with precision are said not to exist because only the individual, that is, the whole being exists. And when the individual is predicated it must be in terms of the whole, i.e. by essence taken without precision.<sup>17</sup>

Now, taken in this latter sense, St. Thomas says, the essence may be considered in two ways: either in an absolute sense or as existing either in the mind or in reality. In the first sense the essence "clearly abstracts from every act of existing, but in such a way that none may be excluded

16. Ibidem.

17. Ibidem.

from it".<sup>18</sup> The reason for this is clear if we take the nature of man, for "if existing in this individual belonged to man as man, it would never exist outside this individual. Similarly, if it belonged to man as man not to exist in this individual, human nature would never exist in it".<sup>19</sup> In other words; in its absolute consideration, an essence abstracts from being in any individual man or in the mind. It can be either, therefore, but it need not be in either.

Now, this abstraction, absolutely considered, is abstraction without precision, i.e., while abstracting from the mode of being in either the mind or in reality, it does not actually exclude being. Clearly, if it did St. Thomas implies, since he seems to regard it as self evident, there would be nothing to conceive in the first place. Thus, to think of something and at the same time exclude its being is impossible. The abstraction from being without precinding from being, therefore, remains open to all ways in which a thing can exist, i.e., whether in the mind or in reality.

The important thing to stress here is that the absolute consideration is precisely, a "consideration". Since the intellect always is dealing with an essence either as existing in the mind or in reality, it cannot experience it directly as an absolute in the above sense. But this does not

18. Ibidem.

19. Ibidem.

mean that it cannot appreciate that since it does not have to exist in either mode it can be considered absolutely, i.e. as existing in neither mode. But still it can never prescind from being despite the independence of the absolute consideration. It follows from this that, since the mind cannot prescind from being that every essence must be a being.

The question now concerns the exact nature of this essence which must be a being, concretely considered. St. Thomas has already pointed out that if the nature of man as such existed in any individual man that nature would be unique. He maintains, furthermore, the very same thing for being, i.e., if being exists as such in any nature that nature would be unique.<sup>20</sup> It would, in fact, be God. But this is precisely how God defined Himself to Moses in revelation: I AM Who Am. Thus:

31 autem ponatur aliqua res quae sit esse tantum, ita ut ipsum esse sit subsistens, hoc esse non recipiet additionem differentiae, quia iam non esset esse tantum, sed esse, et praeter hoc forma aliqua: et multo minus recipiet additionem materiae, quia iam esset esse non subsistens, sed materiale. Unde reliquitur quod talis res quae sit suum esse, non potest esse nisi una.<sup>21</sup>

Thus, according to St. Thomas, God's is a real nature whose act of existing is identical with His nature, i.e., unique. Therefore, It cannot coalesce with any other nature in reality. This means, of course, that the reality which God

20. S.T., Ia, 45, 5, ad 1 m.

21. Op. cit., cap. IV.

communicates to creatures cannot coalesce with their essences which it actualizes. Clearly, then, it is outside (praeter) the essence, and the reality can join it only accidentally. Thus St. Thomas says, "whatever is in something as outside its essence is in it accidentally."<sup>22</sup> Furthermore, it is in as an act received into a potency remaining really distinct from the potency itself. The existence then is the act received into the potency, the essence.

Omne autem quod recipit aliquid ab alio, est in potentia respectu illius; et hoc quod receptum est in eo, est actus eius. Ergo oportet quod ipsa forma vel quidditas, quae est intelligentia, sit in potentia respectu esse quod a Deo recipit; et illud esse receptum est per modum actus.<sup>23</sup>

Existence, then, is an accident but a prior accident because what has to be regarded as the first effect in a thing is its existence. And this is clear for, as has been previously noted, if the thing does not first exist no other aspect can be present as a second effect. Thus, St. Thomas can say, "the existence is the effect which all other effects presuppose and upon which they are all founded".<sup>24</sup>

The problem of establishing the metaphysical foundations of the Einsteinian epistemology on the problem of inductive beginnings of physics is still not fully solved, however, until

22. Comp. Theol., LXVI.

23. Op. cit., cap. IV, p. 47.

24. Comp. Theol., c. LXVIII. Here we are given the metaphysical ground for the relational being or "event" in Relativity physics. The material being or thing is constituted here with its own act of existence, not to deliquesce, as Lovejoy puts it, into a mere relation. Cf. Supra, note 48, p. 100

the exact role that the essence takes in the constitution of a being is itself clarified. This is especially important since it is the formal rather than efficient cause which is the object of mathematics, and thus careful consideration of the part played by the form in general, in the Thomistic metaphysics, is mandatory. To achieve this, attention must first be paid to the role of the form in Aristotle.

In Aristotle there is no more certain doctrine that there is nothing higher than the form. Since this is the case, it is the form which is going to carry the burden of the actuality of a thing in contrast to its matter which is its potentiality. Now this form is the *ousia*, that is to say, the substance. In contrast to Plato, however, who located the forms or "Ideas", as they are called, outside of things in a separate world, Aristotle locates the form in individual and real things in the sensible world.<sup>25</sup> Now, because the whole actuality of the thing comes from the form, whatever it is the form is, that, likewise, is what the individual is. Now since the form is ousia or substance, the individual is an ousia or substance as well. Thus the substantiality of things is the result of formal causality operating within the thing to make it whatever it is. But what precisely is a thing, e.g., a man, for Aristotle? The Stagirite is unmistakably clear that it is the essence of a

25. Metaphysics, I, 9, 991b.

man which is what the man is as is proved from the fact that when the essence is known the man is known.<sup>26</sup> Thus it follows from a consideration of sensible being that it is the form which is the whole actuality of a thing. Regarding the matter, Aristotle has no function for it but to serve as the principle of potentiality, i.e., it is essentially not a being at all since it is completely lacking in actuality. Indeed for matter to escape from being a pure nothingness, "prime matter" is what Aristotle calls it, the form must operate within a thing. In so doing the prime matter is then reduced to second or actual matter, i.e., real flesh and real bones.<sup>27</sup> Now while it is clear that Aristotle has done little more with the Platonic forms than to jam them into matter, since for both the forms are the whole actuality of the thing, still by insisting that the forms are located within the individual and not in a separate world of Ideas, there is an irrevocable difference between the two philosophers. For, as a result of the materialization of the forms, Aristotle's form becomes a "this", i.e., an individual perceivable by the senses and an object of science. It is in this way that Aristotle has deservedly come to be called a "realist" in contradistinction to Plato. And yet, the difference between this "realism" of Aristotle and the realism of

26. Metaphysics, vii, 1, 1028a, 11-12.

27. Op. cit., xiii, 3, 1070a, 10-11.

St. Thomas is so great that when it came to be appreciated in the thirteenth century for what it was, it produced a reaction that was nothing short of monumental. This was especially true in the reaction of the eminent Siger of Brabant.

The whole difficulty between St. Thomas and Siger really reduced itself to the question of how faithful to Aristotle, the pagan, a Christian theologian writing in the thirteenth century had to be. To St. Thomas, Aristotle was a guide, a valuable instrument but no more than an instrument in the service of Christian truth. Indeed, it was St. Thomas' view that to the extent that truth was to be found outside Christian teaching, it was to be seized as wrongfully possessed, but not without gratitude to its discoverer. To Siger, conversely, it seemed that the most devastating accusation that could be made against a philosopher in the University of Paris in those days was that he was non-Aristotlelian. For was not Brother Thomas ascribing a causal action to a principle, viz., the act of existing, thereby positing a fourth principle when for Aristotle there were only three: matter, form and accidents? Gilson writes as follows on this very crucial point:

.....in substances, there is nothing else besides matter, form and accidents. To add existence to them is to posit a fourth nature in things. This criticism brings out in full relief the novelty of the Thomistic answer to the problem: instead of repeating Aristotle, Thomas had indeed posited a fourth nature in beings (to use Siger's own words) namely, the act of being. At the same time, it typifies what was to be a very

common objection to the new doctrine: what can this act of being possibly be? Many a so-called Thomist will wonder about it.<sup>28</sup>

Siger has no brief with this formulation which is so compromising to the revered teaching of the Stagirite. In answering Thomas, as Gilson says,<sup>29</sup> he does not accuse him of falsity for with Thomas' conclusion Siger has no quarrel viz., that the being of a thing is constituted by its essence. This is Aristotelian doctrine. But St. Thomas' mode of expressing this truth comes in for rebuke, Siger accusing Thomas of trying to find a middle way between Avicenna and Aristotle.<sup>30</sup> For Siger it was Averroes who was the Commentator on Aristotle and not Avicenna. The latter's doctrine on this point was that being was an accident which was superadded in the being of a creature. And so when Siger finds Thomas talking about a fourth principle which is not the essence but constituted by the principles of the essence

28. E. GILSON, The History of Christian Philosophy in the Middle Ages, p. 394. "Sed dicere quod esse sit aliquid additum essentiae rei, ita quod non sit res ipsa, neque pars essentiae ut materia vel forma, et dicere quod non sit accidens, est ponere quartam naturam in entibus." Siger DE BRABANT, Quaest. in Metaph., Edited by Cornelio Andrea GRAIFF, O.S.B., Louvain, 1948, p. 16, 29-32.

29. E. GILSON, ibid., p. 394.

30. "Ponunt autem quidam modo medio, quod esse est aliquid additum essentiae rei, non pertinens ad essentiam rei, nec quod sit accidens, sed est aliquid additum quasi per essentiam constitutum sive ex principiis essentiae." Siger de Brabant, Op. cit., p. 16, 21-24.

he is understandably mystified. For something which is added to a thing in the Aristotelian sense would be an accident but Brother Thomas says that it is not an accident, understood as one of Aristotle's predicamentals. At the same time it is not the thing nor any of its essential parts while being constituted by the essence of the thing. Therefore, since it is not an Aristotelian accident, it cannot be posterior to the thing in the sense of inhering in a subject first constituted. Nor can it be coterminus with the essence for it is not the essence. It is precisely what St. Thomas calls it, viz., a prior accident which is outside of the thing itself. Clearly this is not Aristotelian doctrine and Siger is absolutely right.

The difficulty for Siger in this whole matter is clear. He is trying to explain a created universe with a doctrine formulated to explain an eternal one. But inasmuch as the difference between these two universes could not be more disjunctive, Aristotle needed to be changed organically to be put into the service of Christian truth. This St. Thomas saw and it seems equally clear that Siger did not. Fortunately for him, as Gilson says, "it is also clear that God does not intend to save mankind through metaphysics".<sup>31</sup>

Since this "fourth nature" is clearly not the Aristotelian form which was considered earlier, the final question

31. E. GILSON, The Christian Philosophy of St. Thomas Aquinas, p. 14.

that must be answered is: What role does the form play in the metaphysics of St. Thomas? It was noticed, for example, that Siger had no complaint with St. Thomas' conclusion that the being of a thing is constituted by its form or essence. Thus form plays its role of formal causality in Thomistic metaphysics and must be in its own way the cause of a thing's being. But how does it operate and in what manner is it comparable, if at all, to the work of efficient causality? Clearly if the efficient cause, which was seen earlier to be the cause of a thing's being is to be truly efficient how can a formal cause have any actualizing power of its own. And yet, the formal cause is a true cause in the Thomistic metaphysics. Might the two causes operate in the reciprocal way that form and matter work where the first specifies and the second individuates? But to be true of existence and essence, it would mean depriving the form of all actuality and reducing it to a potency like matter. If this is the change that St. Thomas has made in Aristotle, it could not possibly be a more radical or complete one, for as was seen, in Aristotle the form was identical with the act. And, to follow the logic, if the whole actuality is from the existence then since this is outside (praeter) the essence, the actuality would also be outside the essence.

St. Thomas has little or no difficulty reconciling the operations of the two principles while allowing them each their own proper function and autonomy. He writes:

Omnis enim effectus dependet a sua causa, secundum quod est causa ejus. Sed considerandum est, quod aliquod agens est causa sui effectus secundum fieri tantum, et non directe secundum esse ejus.... Sic autem se habet omnis creatura ad Deum, sicut aer ad solem illuminantem sicut enim sol est lucens per suam naturam; aer autem fir luminosus participando lumen a sole, non tamen participando naturam solis: ita solus Deus est ens per essentiam suam; quia ejus essentia est suum esse omnis autem creatura est ens participative, non quod sua essentia sit ejus esse.<sup>32</sup>

Here, in using the analogy of light which travels through the air, St. Thomas is revealing what he means by the form acting as a potency and yet operating as a true formal cause. For just as the ether has a potentiality per se to be illuminated, so the form has a tendency to receive the act of being that makes the thing a being, per se. This means that its receptivity is essentially, as distinct from accidentally, to being and what is more, operates to cause the kind of being that a thing has. This does not mean that it can cause its own being any more than the ether can cause its own illumination. And yet as a formal principle of being it exercises its formal causality determinatively.<sup>33</sup> But the most important point is that the essence or form is not an act for St. Thomas as it was for Aristotle. The act, which causes the thing to be absolutely is, as has been seen in Thomistic metaphysics, purely and simply existence (esse); and this act is other than the thing and prior to it in the

32. S.T. Ia, q. 104, a. 1.

33. De Pot., VII, 2, ad 9.

line of efficient causality.

We are in a position now to relate the Einsteinian requirement for empirical beginnings for physics to its metaphysical roots. It is clear from what has been seen that the analysis of being and reality is not a simple matter but involves the most careful and systematic treatment. In fact, it resembles the most rigorous type of mathematical or logical reasoning. But more importantly, for this study, this metaphysical analysis of reality reproduced here as the thought of St. Thomas is seen as bearing this mark of Einsteinian methodology, that of inductive beginnings, but in a deeper and more prototypal form.<sup>34</sup> It is the sensible object, as has been seen, which is first experienced in metaphysics and which must serve as the initial ground for analysis. And by pursuing this metaphysical analysis further, it is to discover the causes of its own experimental beginnings within reality itself, something which only a metaphysical analysis can do. And while it is significant to discover that both metaphysical and mathematico-physical analysis begin in experience, this fact could still be ascribed

34. It is noteworthy that the method of postulation is used in Thomistic metaphysics to develop the investigation of material being. The argument which goes to the Supreme Being for the full analysis of the problem is technically put in hypothetical form. Thus it argues that if a being existed whose very nature was to be that Being would be God and as a consequent such a nature could not coalesce with the being of creatures. The essentials of the argument have been presented in this section.

to coincidence until the roots are found within the structure of reality itself. And the roots of this requirement of empirical beginnings not only for scientific investigations, but for metaphysical ones as well, are the priority of the act of existence to the essence of nature in the formation of any material being. It is clear from this lengthy review of St. Thomas' metaphysical doctrines that it is existence which makes a thing knowable by first making it be. Nor, as has been seen, is it possible to speak of the reality of a material thing in terms of any nature constituted apart from the material thing enjoying real existence, even though the act of its existence does not coalesce with the nature in the material thing. It is clear, therefore, why for St. Thomas there is simply no way of knowing other than by beginning with the material thing. And this is why the material being is the starting point of scientific investigation in its most fundamental and radical cause. Thus it is not simply a coincidence that scientific and metaphysical investigations begin with concrete experience. And yet, without laying bare the very structure of reality in the way that St. Thomas has done it, it needs must have always appeared just that, a coincidence. And, by the same token, would the instinctively realist epistemology of Albert Einstein remain weak and inexplicable in the face of idealist criticisms and assaults.

Section B. The Roots of the Formation of the  
Primary Concepts.

Einstein has repeatedly said that sensible experience cannot dictate the primary concepts and postulates which are to serve as the foundation for the deductive system however-much it is true that the beginnings of scientific knowledge are in the world of sensible beings. Rather, he says, experience can but suggest them. In any case, Einstein is emphatic in his belief that the scientist cannot go from sense data to the postulates by any "process of abstraction". Now, on this very critical point, it seems quite clear that there is some essential agreement between Einstein and St. Thomas.

Einstein has said that images seem to serve him as "elements" of his thought which are reproducible at will. Furthermore, he says, "there is, of course, a certain connection between those elements and relevant logical concepts".<sup>35</sup> St. Thomas tells us what that "connection" is, showing that for him as well there is no such thing as abstracting from sensible beings in themselves. In discussing the three grades of cognitive powers viz., angelic, human and brute, he says:

Intellectus autem humanus medio modo se habet: non enim est actus alicujus organi, set tamen est quaedam virtus

35. J. MADAMARD, Op. cit., p. 142.

animae, quae est forma corporis...et ideo proprium ejus est cognoscere formam, in materia quidem corporali individualiter existentem, non tamen prout est in tali materia; cognoscere vero id, quod est in materia individuali, non prout est in tali materia, est abstrahere formam a materia individuali, quam repraesentant phantasmata; ed ideo necesse est dicere, quod intellectus noster intelligit materialia abstrahendo a phantasmatibus et per materialia sic considerata in immaterialium aliqualem cognitionem devenimus.<sup>35</sup>

But the word "abstraction" clearly appears in the text of St. Thomas and Einstein has objected to this word in a general way, insisting that the scientist does not abstract from experience but rather freely invents the primary concepts of his system on the strength of what experience may suggest to him. The problem is to determine in the light of what has just been seen as the meaning of the word "invention", if the difference between the two thinkers on this critical point of connecting the images to "relevant logical concepts" as Einstein calls them, is a semantical or a real one.<sup>37</sup>

35. S.T., I, q. 35, 1, p.

37. On this point Father Lonergan writes: "...just as the Thomist definition abstracts from the material conditions of space and time that characterize the sensible conditions, so, according to the theories of Special and General Relativity, the mathematical expression of physical principles and laws is invariant with respect to inertial and, more generally continuous transformations of spatio-temporal reference frames. Now, abstraction and invariance are not exactly the same thing, for abstraction is predicated on the concept or inner word, while invariance is predicated of the mathematical expression of certain concepts or inner words. Still, expression and concept, outer and inner word, differ only as sign and signified, as effect and cause; and both Thomist abstraction and Einsteinian invariance affirm in different manners that the products of investigation are independent of the spatio-temporal conditions of their origins on the level of sense." Bernard Lonergan, S.J., "Isomorphism of Thomist and Scientific Thought", Sapientia Aquinatis, Romae, Officium Libri Catholici, (1955) p. 112. For invariance in Einstein see above pp. 85 ff.

Discovery, St. Thomas says, proceeds in the first place through the use of general principles which implicitly contain the conclusions of knowledge gained from a study of the external world. He describes these principles as follows:

....quod praeexistunt in nobis quaedam scientiarum semina, scilicet primae conceptiones intellectus, quae statim lumine intellectus agentis cognoscuntur per species a sensibilibus abstractas, sive complexa, ut dignitates, sive incompleta, sicut ratio entis, et unius, et huiusmodi, quae statim intellectus apprehendit. Ex istis autem principiis universalibus omnia principia sequuntur, sicut ex quibusdam rationibus seminalibus. Quando ergo ex istis universalibus cognitionibus mens educitur ut actu cognoscat particularia, quae prius in potentia, et quasi in universali cognoscebantur, tunc aliquis dicitur scientiam acquirere.<sup>38</sup>

These principles are innate within us having been "implanted in us by God as a kind of reflected likeness in us of uncreated truth".<sup>39</sup> These principles form the basis of understanding self-evident truths and even of those which are not self-evident it is in some way the cause:

Ex ipsis enim principiis per se notis considerat, quod ea quae ex eis necessario consequuntur, sunt certitudinaliter tenenda; quae vero eis sunt contraria, totaliter respuenda; aliis autem assensum praebere potest, vel non.<sup>40</sup>

38. De. Verit., II, I. c.

39. Ibidem.

40. Ibidem. St. Thomas and Einstein use the word "primary" to refer to the most general principles of human knowing and the first principles of relativity theory, respectively. Certainly both principles may be called "primary" without any contradiction as it is clear from what follows.

Now by an immediate or self-evident truth St. Thomas does not mean a truth that is necessarily evident to everyone for if, due to ignorance, some person cannot see that non-bodily things are not in a place, to use the example St. Thomas takes from Boethius, the truth would still remain immediately evident in itself.<sup>41</sup> There is, however, a kind of truth that is immediately evident to everyone, whatever their education, e.g., "if you take equal parts from things things that are equal".<sup>42</sup> Aquinas tells what is required for something to be immediately evident in the following words:

Ad hoc enim quod aliquid sit per se notum, nihil aliud requiritur nisi ut praedicatum sit de ratione subjecti; tunc enim subiectum cogitari non potest sine hoc quod praedicatum sibi inesse appareat. Ad hoc autem quod sit per se notum, oportet quod nobis sit cognita ratio subiecti in qua concluditur praedicatum. Et inde est quod quaedam per se nota sunt omnibus; quando scilicet propositiones habent talia subjecta quorum ratio omnibus nota est, ut, omne totum maius est sua parte; quilibet enim scit quid est totum et quid est pars. Quaedam vero sunt per se nota sapientibus tantum, qui rationes terminorum cognoscunt, vulgo eas ignorante.<sup>43</sup>

Thus, a truth self-evident in itself would not be discovered by means of reasoning from principles which reaches conclusions and, then, "by way of judgment examines the conclusions which have been found, analyzing them back to the

41. De. Verit., 10, 12, c.

42. Ibidem.

43. Ibidem.

principles".<sup>44</sup> This, rather, is a description of the truth obtained "by way of discovery" wherein what is predicated of the subject is later seen as actually true of it. In this latter case, reason resorts to other than the primary, innate principle since, as St. Thomas says, all intelligible things are not equally near to the intellect. Some rather can be seen immediately, while others only by examining other principles.<sup>45</sup> Now, these "other principles" are gained through the action of the agent intellect, just as are the primary concepts.

One difference is that the primary principles are immediately evident following conceptualization while the other principles await the action of the two subsequent acts of the mind, viz., judgment and reasoning. The origin of these two types of principles, viz., the innate and the acquired, is however, a common one, according to St. Thomas.

Quantum igitur ad utrumque, Deus hominis scientiae causa est excellentissimo modo; quia et ipsam animam intellectuali lumine insignivit, et notitiam primorum principiorum ei impressit, quae sunt quasi quaedam seminaria scientiarum; sicut et aliis naturalibus rebus impressit seminales rationes omnium effectuum producendorum.<sup>46</sup>

Thus, if scientific discovery of scientific principles is to be explained, there is required the existence of an

44. Op. cit., 10, 8, ad 10.

45. Op. cit., 11, 3, c. Such secondary principles appear in special relativity theory as 1) the constant speed of light in vacuo and 2) the special principle of relativity. Cf. Supra, p. 67.

46. Ibidem.

active intellectual power in each man. And, for St. Thomas, the very nature of the agent intellect is that it is always in act according to its very substance.

Nihil enim prohibet hoc respectu illius esse secundum in potentia et secundum aliud in actu, sicut in rebus naturalibus videmus: aer enim est actu humidus et potentia siccus, terra autem e converso. Hanc autem comparatio invenitur esse inter animam intellectivam et phantasmata. Habet enim anima intellectiva aliquid in actu ad quod phantasma est in potentia: at ad aliquid est in potentia quod in phantasmatis actu invenitur.<sup>47</sup>

Now all this is an activity proper to man whereby he employs the natural light of his own intellect to illumine, as Einstein has noticed, certain images he has formed within him as a result of the activity of his external senses. And the reliance of the intellect upon the imagination is clear, as St. Thomas says, from what happens in our understanding when the brain is diseased or the imagination disturbed or even when we reflect on our own experiences concerning the attempt to understand anything:

Unde manifestum est quod ad hoc quod intellectus actu intelligat, non solum accipiendo scientiam de novo, sed etiam utendo scientia iam acquistia requiritur actus imaginationis et ceterarum virtutum. Videmus enim quod, impedito actu virtutis imaginativae per laesionem organi, ut in pneneticis; et similiter impedito actu memorativae virtutis, ut in lethargicis; impeditur homo ab intelligendo in actu etiam ea quorum scientiam praeceperit. Secundo, quia hoc quilibet in seipso experiri potest, quod quando aliquis cognatur aliquid intelligere format aliqua phantasmata sibi per modum exemplorum, in quibus quasi inspiciat quod intelligere studet. Et inde est etiam quod quando alium volumus facere aliquid intelligere, proponimus ei exempla, ex quibus sibi

47. Cont. Gent., 2, 77.

phantasmata formare possit ad intelligendum.<sup>48</sup>

Following this clue of St. Thomas it seems that it would not be distorting Einstein's own statements about his cognitive life to justly picture the latter mentally "examining" an imaginary representation of the Michelson experiment in an attempt to understand its true meaning. There seems to be little difference between a theory of knowledge stating that the "knower examines" his phantasms and finds their meaning and one which states that the phantasms "suggest to the knower" their meaning, except a semantical one. Indeed, the verbal preference of Einstein, whose active intellectual creativity revolutionized classical physics emphasizes, if anything, this purely semantical difference.

And it is on this very point of the active intellect of Einstein, which "saw something", as it were, in his imaginary reproduction of the Michelson experiment which his contemporaries did not, that St. Thomas' doctrine of the agent intellect impinges with the greatest force.<sup>49</sup> It is clear that if the meaning of this experiment was seen only by Einstein it must have been a) because the meaning was obscure, or that the phantasm was dark, using the analogy of the absence of physical light on it; and b) Einstein was able to see the meaning or to illuminate the phantasm. Now this is

48. S. T., Ia, q. 84, 7. This fact, in relationship to Einstein's postulates, will be considered in detail in the next section.

49. Cf. S.T. I-II, 50, 5, ad 2; In De Anima III, 11.

precisely what the active intellect of a person does according to St. Thomas and, by inference, what it seems to have done for Einstein. For there was a time before he saw the meaning of the experiment and after he saw it, and St. Thomas would call the former state of mind Einstein's possible intellect and the latter his condition of actually understanding. Furthermore, it was the meaning that Einstein saw through the power of his active intellect which transformed or reduced the possible intellect to actual understanding. This meaning St. Thomas would call the "intelligible species" which is the likeness of the thing understood, in this case, the quantitative realities of the experiment in their relationship to each other.

Thus St. Thomas writes:

Et ideo prae omnibus praedictis positionibus rationabilior videtur sententia Philosophi, qui ponit scientiam mentis nostrae partim ab intrinseco esse, partim ab extrinseco; non solum a rebus a materia separatis, sed etiam ab ipsis sensibilibus. Cum enim mens nostra comparatur ad res sensibiles quae sunt extra animam, invenitur se habere ad eas in duplici habitudine.

Uno modo ut actus ad potentiam: in quantum, scilicet, res quae sunt extra animam sunt intelligibiles in potentia. Ipsa vero mens est intelligibilis in actu; et secundum hoc ponitur in ea intellectus agens, qui faciat intelligibilia actu.

Alio modo, ut potentia ad actum: prout scilicet in mente nostra, formae rerum determinatae, sunt in potentia tantum, quae in rebus extra animam sunt in actu; et secundum hoc ponitur in anima nostra intellectus possibilis, cuius est recipere formas a sensibilibus abstractas, factas intelligibiles actu per lumen intellectus agentis.

Quod quidem lumen intellectus agentis in anima rationali procedit, sicut a prima origine, a substantiis

separatis, praecipue a Deo.<sup>50</sup>

It would seem, however, that not only the external realities of the experiment, viz., the actual quantified bodies which supplied their intelligibilities in the form of numbers for distances, velocities, etc., but the whole of present and past scientific history was operating in the capacity of a teacher for Einstein. Here the words of St. Thomas are of the highest significance:

Unde ipsa verba doctoris audita, vel visa in scripta, hoc modo se habent ad causandum scientiam in intellectu sicut res quae sunt extra animam, quia ex utrusque intellectus intentiones intelligibiles accipit; quamvis verba doctoris propinquis se habeant ad causandum scientiam quam sensibilia extra animam existentia in quantum sunt signa intelligibilium intentionum.<sup>51</sup>

Yet, it is not as though the teacher causes knowledge by helping the person to "see" better. Nor does he impart a knowledge of the primary principles. The work of the teacher is to furnish signs to the external sense faculties.

Homo autem, quia secundum ordinem naturae alteri homini par est in specie intellectualis luminis, nullo modo potest alteri homini causa scientiae existere, in eo lumen causando vel augendo. Sed ex parte illa qua scientia ignotorum per principia per se nota causatur, alteri homini causa sciendi quodammodo existit, non sicut notitiam principiorum tradens, sed sicut id quod implicite, et quodammodo in potentia.<sup>52</sup>

St. Thomas is saying here that the teacher does not implant ideas in the intellect of the pupil, but provides him

50. De. Verit., 10, 6.

51. Op. cit., 2, 1, ad 11.<sup>v</sup>

52. Op. cit., 11, 3.

with sensible signs "of the manner in which conclusions are deduced from the principles".<sup>53</sup> St. Thomas makes clear the exact efficacy of the work of the teacher in the following words:

....unde et secundum hoc unus alium docere dicitur, quod istum discursum rationis, quem in se facit ratione naturali, alteri exponit per signa et sic ratio naturalis discipuli, per huiusmodi sibi proposita, sicut per quaedam instrumenta, pervenit in cognitionem ignotorum .... Et secundum hoc dicit Philosophus, I Posteriorum, quod demonstratio est syllogismus faciens scire.<sup>54</sup>

It is clear that the learning process through the instrumentality of the teacher involves, similarly, the abstraction of intelligible species from phantasms, for, "the teacher leads the pupil to knowledge of things he does not know in the same way that one directs himself through the process of discovering something he does not know."<sup>55</sup> And since the original source of the teacher's knowledge was the natures of sensible things, it is clear that knowledge gained by the pupil is just as truly gained from experience as that gained by immediate personal contact.

There is no question but that Einstein received a vast amount of the intelligible likenesses of the world of physical reality through the instruments of known and unknown teachers whether they spoke to him as living persons or

53. Ibidem.

54. Op. cit., II, 1.

55. Ibidem.

across the grave. As has been seen, he was quite aware of his debt to many and quite candid and grateful for all that he had received by way of instruction from others. It is also accurate to point out that short of the profoundest knowledge of the history of ideas, something which Einstein did not claim, it would have been impossible for him to separate the original from the merely secondary human sources of the knowledge that made up his fund of knowledge at one given time.<sup>56</sup>

Now the whole sufficiency of the intelligible forms which have been abstracted from the phantasms as representative of the sensible objects themselves is that they are likenesses which have the same intelligible character of that the things have in potency. For, as Aquinas says:

Non enim oportet quod eiusmodi esse habeat similitudo cuiusmodi est id cuius est similitudo, sed solum quod in ratione conveniat; sicut forma hominis non habet tale esse in statua aurea, quale esse habet forma hominis in carnibus et ossibus.<sup>57</sup>

A problem, however, soon arises regarding the difference in the manner of existing of the forms in the intellect and in the material thing, itself. For, as the first objector pointed out in St. Thomas' consideration of whether our intellect understands corporeal and material things by

56. All the essential ingredients of relativity theory, for example, were known to John of St. Thomas and expressed by him in the most explicit terms. Cf. note 46. Considering his role as a transmitter of considerable importance of Western ideas, what debt, if any, does Einstein owe him? Obviously an unanswerable question.

57. De Verit., 10, 4, ad 4.

abstraction from the phantasm:

Videtur, quod intellectus noster non intelligat res corporeas, et materiales per abstractionem a phantasmatis. Quicumque enim intellectus intelligit rem aliter, quam sit, est falsus: formae autem rerum materialium non sunt abstractae a particularibus, quorum similitudines sunt phantasmata; si ergo intelligamus res materiales per abstractionem specierum a phantasmatis, erit falsitas in intellectu nostro.<sup>58</sup>

And St. Thomas would agree if this meant that the intellect understood a thing otherwise than it is. But this is clearly not so in the case of abstraction from the phantasm

because the intellect does not, for example, abstract "the species of a stone from its matter in such a way as to think that the species did not exist in matter, as Plato held".<sup>59</sup>

This is not to say that there is not a difference between the thing in sensible reality and the thing as understood since the thing understood is immaterially in the one who understands, according to the mode of the intellect, and not materially, according to the mode of a material thing.<sup>60</sup>

However, St. Thomas is emphatic in saying that the nature of a stone or of any material thing cannot be known completely and truly, except inasmuch as it is known as existing in the individual.<sup>61</sup>

But since they do exist as natures in material things

58. S.T., Ia, q. 85, 1, ap. 1.

59. Ibidem.

60. Ibidem.

61. Op. cit., Ia, q. 84, 7.

and not as subsistent realities in the Platonic sense,<sup>62</sup> these forms of material things are only potentially intelligible, to become actual only when they have been disengaged not only from their designated matter as "this flesh or this bone" in the individual but from material condition as represented in the phantasms.<sup>63</sup>

Thus, according to St. Thomas, the act of human cognition is something far more extraordinary than a mere absorption of certain facts of the universe that it has succeeded in forcing nature to relinquish. Instead, there is to be found in his psychological writing a particular term which is its whole leitmotif, viz., the concept. And while it is true that he himself did not first use this term in connection with human cognition, he did give the biological character of it, as connoted by the employment of this term, a profoundly truer meaning and accuracy. Human knowledge for Aquinas, as the consideration which is to follow will reveal, involves an assimilation of the knower with the known in such a way that a condition of being is achieved by the knower possessing all the formality that actualized the thing in the first place. But this is only the first stage in the assimilation because, if the knower is to become in his knowledge like the known in a true possession, there must be an act whereby that which the thing has over and

62. Op. cit., Ia, q. 84, 6.

63. De Ente et Essentia, cap. 2.

above its form, namely its act of existing, is attained.

This is precisely accomplished in the act of the judgment.

But it is an act which will be assimilated to being in all its fullness and in this sense, as Gilson has remarked, it is not, however, the judgment of Aristotle:

The radical ordination of the judgment to the existing real had already been stressed by Aristotle on the plane of substantial being as he himself understood it. For Aristotle, it is quite true that substances alone exist, but it is equally true that, for him, to exist is simply to be a substance, or, in other words, that to be is before all to be something. More particularly, and in the fullest sense, it is to be one of those things which, owing to their form, possess in themselves the cause of what they are. Thus, the being at which Aristotle stops is "that-which-has-the-act-of-being", minus the act-of-being itself.<sup>64</sup>

Indeed, it is not at all surprising that the judgment for St. Thomas should be so profoundly important in his psychology given on the one hand his metaphysics of reality and, on the other, the career that the human knower has laid out for him. On this point, St. Thomas and Aristotle were as one in agreeing that the soul is in a way all things.<sup>65</sup>

The reason, it is clear, is that for both knowledge had to be a complete assimilation of the real. But only an assimilation to the whole of reality of a material thing can produce real fecundity.

64. E. GILSON, The Christian Philosophy of St. Thomas Aquinas, p. 42.

65. ARISTOTLE, De Anima, 5, 430a.; ST. THOMAS, De Verit. 2, 2.

Kept on the plane of quiddity, Thomism will spend its strength making one inventory after another of its inheritance. Raised to the plane of the judgment, Thomism will again make contact with the very heart of the reality it is interpreting. It will become fecund once more, and again will be able to create. If history has any lesson for us on this point, it is because it enables us to watch that flowering of new truths which marked the appearance of Thomism.<sup>66</sup>

It is evident, then, that there is a way to account for the formation of the primary concepts of Einstein by locating it within the doctrine of abstraction of St. Thomas Aquinas. The blame that the word "abstraction" is not descriptive of this part of the work of scientific theorization must be laid at some other philosophical door of history. And yet, it is not so important that the word "abstraction" be defended as the doctrine that beginning with sensible experience, the intellect by its own active power, awakens first to the requirements of the primary, innate principles which govern all knowledge, and in whose light it then postulates those secondary principles of human science which occur to the intellect as new meanings within the phantasms of experience, only later, by the acts of judgment and reasoning to "discover" that they are actually true (or false). Such a doctrine seems properly and profoundly to account for the tenet of the Einsteinian epistemology dealing with the formation of the primary concepts, as well as

66. Op. cit., p. 45. GILSON gives us an example of an inventory that was a masterpiece, viz., that of Alberto LEPIDI, O.P., De Ente generalissimo prout est aliquid psychologium, logicum, ontologicum, Pladentiae, Tedeschi, 1381.

the larger epistemological and psychological problems which Einstein does not raise.

Section C. Judgment and Reasoning as Related  
to Scientific Postulation.

It is evident that the formulation of postulates of the Einsteinian epistemology connotes the proposal of a set of ideas which are not yet known as true or false. In the postulation, then, the concepts which came into being in the first act, just considered, are proposed, i.e., put in a form which makes a definite statement as to meaning, but not as to truth or falsity. Obviously, if a postulation proposes something which is more than a mere meaning, there would be no need of the discursive and confirmatory labors which must be undergone in Einstein's scientific theorizing.<sup>67</sup>

67. The relation that scientific hypothesis and its verification has to the whole metaphysical question of essence and existence is brought out sharply by Father Lonergan in the following way: "..... If we ask why scientific hypothesis needs verification and why Thomist definition needs judgment, we meet with similar answers. The scientist will insist that it is a mistake to try to base science on a priori necessities, that the one fruitful procedure is to scrutinize things as in fact they are, to discern in them what possibly may be their laws, to formulate these possibilities as mere hypotheses, and to submit such hypotheses to every test before placing any great reliance on them. The Thomist will reply in apparently quite a different manner. He will point out that definition stands for judgment as essence to existence, that a finite essence

In point of fact, it is the very task of this post-postulational work to make a determination as to the truth or falsity of what has been proposed. This is not to deny that in some implicit way, as Einstein has maintained, and has just been seen in St. Thomas' doctrine, the postulates do pre-contain the truth if they are, in fact, true. However, psychologically speaking, the mind does not yet know it, and therefore cannot give its consent. The views of St. Thomas on this point are especially revealing.

The intellect has not stopped with the assimilation of

exists not necessarily but contingently, that divine wisdom can select any set of finite essences and arrange them in any of a vast variety of world orders while divine will is free to choose any whatever of the possible orders, and consequently that, while divine wisdom guarantees that there is a reason for everything, still in each case the ultimate reason must be the fact of divine free choice (Contra Gentes II, 24, et 26: S. Theol., III, q. 97, aa 3 ss.) Plainly, the empirical character of science and the freedom of divine choice are two different things, yet there is a notable similarity between their functional significance in scientific and Thomistic thought. The scientist has to verify his hypothesis because ultimately what counts is that it is in fact so; and the Thomist has to pass judgment on definitions because ultimately what counts is that God chose to be so." B. LONERGAN, S.J., Op. cit., p. 120.

itself to the object through the instrumentality of the species. It has gone on immediately under the impulse of that actualizing process to form within itself a concept, that is to say a mental word which is the fruit of the new mode of existence which it has just achieved. It is "what the intellect conceives in itself and expresses by a word",<sup>68</sup> in which it "seeks naturally to manifest or to 'tell itself' what it has just perceived".<sup>69</sup> As St. Thomas says:

Dico autem intentionem intellectam id quod intellectus in seipso concipit de re intellecta. Quae quidem in nobis neque est ipsa res quae intelligitur; neque ipsa substantia intellectus; sed est quaedam similitudo concepta in intellectu de re intellecta, quam voces exteriores significant; unde et ipsa intentio verbum interius nominatur, quod est exteriori verbo significatum. Et quidem quod praedicta intentio non sit in nobis res intellecta, inde apparet quod aliud est intelligere rem, et aliud est intelligere ipsam intentionem intellectam, quod intellectus facit dum super suum opus reflectitur: unde et aliae scientiae sunt de rebus, et aliae de intentionibus intellectis.<sup>70</sup>

It is clear from these words that we are dealing with a substitute for the object in the concept. It is a likeness but not in the way that the species which is abstracted from the phantasm resembles the thing because it is related to the thing, but a likeness which is "nothing more than a representation".<sup>71</sup> At the same time, as St. Thomas, says, the

68. E. GILSON, Op. cit., p. 229.

69. J. MARITAIN, Formal Logic, New York, Sheed and Ward, 1946, p. 17.

70. Contra Gent., IV, 11, 6.

71. E. GILSON, Op. cit., p. 229.

intellect forming the intention in this manner, knows the thing.<sup>72</sup> This is because the continuity between the concept and the species was not broken inasmuch as the latter caused the former. For the only way in which the species could give rise to the concept of the thing was by first being the species of that same thing. And yet, unlike the species, the concept is not one with both the intellect and the thing since at St. Thomas says, it is, "what the intellect conceives in itself of the thing understood".<sup>73</sup> It is therefore distinct from the thing inasmuch as it exists only within the intellect whereas the thing exists in reality apart from a conceiving intellect. Yet the concept, likewise, is not a quod but an a quo, for it is the very instrument by means of which the intellect grasps the "whatness" of the thing. In doing so, two things are clear: 1) the formation of the concept by the intellect with which it grasps the quiddity of a thing is a completely natural, unreflective operation performed effortlessly by the knower; 2) there is yet no question of truth or error involved because there is no deliberation, no judgment pronounced, simply a grasping of proper object by a faculty acting according to its nature. In this respect, the intellect can be compared to a sense faculty and its proper object:

72. Cf. Op. cit., I, 53.

73. Cf. Op. cit., IV, II, 6.

Quidditas autem rei est proprie obiectum intellectus; unde, sicut sensus sensibilium priorum semper est verus, ita et intellectus in cognoscendo quod quid est.<sup>74</sup>

The question of truth does not arise until the conformity that the concept has to its object becomes known to the knower.

.....dicendum quod quamvis formatio quidditatis sit prima operatio intellectus, tamen per eam non habet intellectus aliquid aliud proprium quod possit rei adequari; et ideo non est ibi proprie veritas.<sup>75</sup>

The intellect now has the power to reflect on its apprehension of a thing, this taking place not in apprehension itself, but in the judgment.

Tunc autem iudicat intellectus de re apprehensa quando dicit quod aliquid est vel non est, quod est intellectus componentis et dividitatis.....<sup>76</sup>

The problem of truth then for the first time arises with the judgment. This is clear for another reason. In simple apprehension there is no essential discontinuity either between the species and the thing or the concept and the thing. It represented a natural, indeliberate act, as has been said. With the judgment, however, there is a "free activity of mind which dominates and enriches reality..... (adding) something of its own to the exterior reality it has just assimilated.....and this time there are really two distinct realities".<sup>77</sup> On this point Gilson has written:

74. De Verit., I, 12.

75. Op. cit., I, 3.

76. Ibid.

77. E. GILSON, Op. cit., p. 231. Cf. De Verit., I, 3.

Taken in itself, the notion of truth applied not directly to things, but to thought's knowledge of things..... Now judgment is an operation of reason associating or disassociating concepts. Therefore, it is rather in thought that truth is properly said to reside.<sup>78</sup>

But this is a statement that Gilson quickly hastens to explicate:

On the other hand, if we look at the relation of thought to things from the point of view of its basis, we have to say that truth is in things, rather than in thought. I say that Peter exists; if this judgment of existence is true, it is because Peter does indeed exist. I say that Peter is a rational animal; if I am speaking truly, it is because indeed Peter is a living being endowed with reason. Let us go further. I say that a thing cannot be both itself and its contrary; if this principle is true, it is indeed because each being is the being that it is and not another. This principle is obviously true because the first basis of everything true which we can say of any being is the primary fact, beyond which thought cannot go, that this being is what it is.<sup>79</sup>

And yet, it is equally true that in the act which is beyond conceptualization, viz., the enunciation, there is still nothing more than an act of juxtaposing ideas in propositional form with a meaning compounded from the new composition. The mind now must consider the adequacy to reality of its proposal and then decide whether it is true or false.<sup>80</sup>

We have seen, that in the first act of the mind, the knowing process is confined to a simple conformity of the

78. Ibidem.

79. Ibidem.

80. Einstein has seen this clearly. Cf Supra, p. 51.

intellect to the thing in which there is an assimilation of the knower to the known. Such truth as is present is not in the knower as such but as in a true being. With the judgment, however, the intellect must reflect on the conformity which it has to the thing or to the principles on which the truth depends and enunciate whether or not it exists. When it does so, moreover, it is immediately subject to the question of truth as defined in the classic formula, viz., adaequatio rei et intellectus. St. Thomas called this the act of composing and dividing.<sup>31</sup>

Now, St. Thomas does not limit his consideration to a single phase of this second act of the mind wherein one concept is compared with another in order to apprehend the identity or diversity of the things conceived, composing the concepts in the former case and dividing them in the latter.<sup>32</sup> This is because the term compositio should be applied also to the act wherein the intellect compares concepts not as objects but as intentional likenesses insofar as they are true. For the Angelic Doctor, as has been seen, speaks of truth "in the intellect knowing what a thing is".<sup>33</sup> But here the

31. De Verit., I, 3.

32. In I Perihern., 3, 4. The distinction between the two phases of judgment does not always involve a temporal separation. For example, in self-evident propositions or ones of immediate experience, the assent is virtually instantaneous with the enunciation. There, the only sequence is one of logical necessity,

33. Cf. Note 75, p. 176.

truth is not yet known to be true. There is simply a composition or synthesis of simple concepts in which they are encompassed in a mental unity. This is necessary if the intellect is later to be able to affirm or deny the terms when they are known as being in conformity or disconformity with the things or principles being considered. Thus the concepts are brought into unity or enunciated for the later purposes of the act of assent or dissent.

Seen in this light, it is clear that the use of postulation by Einstein is an outgrowth of the very structure of the judgment in its two phases. The method of hypothesis is the very way the mind proceeds in its advance toward knowledge viz., by proposing to itself various enunciations which later in the theorems will receive corroboration (assent) or rejection (dissent) by the employment of experimental tests. It is therefore only natural that Einstein should propose his scientific hypothesis postulationally wherein, for the time being, nothing more is intended than their meaning be understood or enunciated. However, as also seen in Einstein, there must then be a deductive effort made, involving as it does in Relativity theory, lengthy and technically abstruse mathematical reasoning in order to bring the mind to a point where, in theorem form, the appropriate tests and checks can be made and assent given or withheld. This postulational method used by Einstein is clearly related

34. S. T., Ia, q.85, 3;q58, 2.

to and rendered necessary by the second act of the mind wherein it first enunciates (compositio) and then truly judges (compositio aut divisio) its postulates in the light of evidence rendered proximate and applicable by reasoning.

Here in this order, too, which is the intellect's own proper one (aliquid proprium) the problem about the distance of the deductive process from its inductive beginnings, which was such a scandal for Mach and other of the positivistic school as has been seen,<sup>85</sup> fades into unimportance. For just as it is the relation of conformity, in which, according to St. Thomas, truth consists, so a real diversity is demanded by the way in which the extra mental world differs from the world of thought. Here in its own proper world, the intellect is free to journey down its own paths, long or short as it may itself decide, governed only by the laws of its own inner logic and subject at last, no matter how far it has strayed from experience, to experience again as its measure and justification.

Section D. The Confirmation of the Theorems and the Nature of Scientific Proof.

It is a widely held popular belief that the validity of Relativity Theory has been demonstrated by the verification of certain of its predictions. The case of the perihelion of Mercury had a great deal to do with this feeling of.

85. Cf. Supra, p. 58.

confirmation. A. Sommerfeld refers to this prediction made to him by Einstein, personally, in a letter written November 23, 1915:

The experimental verification was not to be long delayed. In the year 1919 a British solar eclipse expedition to the tropics had photographed the surroundings of the eclipsed sun and compared the positions of the fixed stars nearest to the sun with their normal positions. They showed deviations from these latter to the extent of the effect predicted by Einstein. The light-rays of these stars in passing close by the edge of the sun, go through an area of modified spatial structure and thereby are deflected, just as the rays of the sun are deflected in the inhomogeneous atmosphere of the earth and no longer follow a straight line. The great, now already deceased British astronomer, Sir Arthur Eddington, became an inspired apostle of Einstein's doctrine and has worked it out in its manifold consequences. From then on this doctrine entered into the publicity of home and foreign countries.<sup>38</sup>

These remarks of Sommerfeld being out strikingly the persuasive power of the so-called "experimental verification" of the predictions in the theory not only for the popular mind but even for a mind of the scientific competence of Eddington.

At the same time, a distinction must be noticed between being simply impressed by a theory and regarding it as proved or final. It is known to specialists that such pragmatic signs of a theory's validity, since they are lacking the quality of necessity in forever affirming the consequent cannot serve as a means of final validation. This means that it is unable to show that only its own postulates lead

38. A. SOMMERFELD, "To Einstein's 70th Birthday", AEPS, p. 101.

necessarily to confirmed theorems. Einstein refers to this, for example, when he asserts that the notions of physical reality "can never be final".

Since, however, sense perceptions only give information of this external world or of 'physical reality' indirectly, we can only grasp the latter by speculative means. It follows from this that our notions of physical reality can never be final. We must always be ready to change these notions - that is to say, the axiomatic substructure of physics - in order to do justice to perceived facts in the most logically perfect way. Actually, a glance at the development of physics shows that it has undergone far-reaching changes in the course of time.<sup>37</sup>

Einstein is telling us here that the mere experimental verification of the theorems of a theory is not a guarantee of the validity of that theory and, furthermore, that a theory has never been proved by mere experimental confirmation to be the only theory capable of doing justice to observed data.<sup>38</sup>

37. A. EINSTEIN, "On Clerk Maxwell's Influence", p. 40.

38. A variant of this limitation is expressed by Bridgman in the following manner: "Two general aspects of the general theory of relativity may be recognized. Firstly, there is the mathematical edifice of the system of equations and the rules by which the symbols of the equations are to be correlated with the results of physical operations; and secondly, there is the attitude of mind, or what I may call the philosophy, that leads to the arguments used in deriving the equations and to the expectation that the equations so derived will have physical validity. These two aspects are not uniquely connected; from a given mathematical edifice one cannot uniquely deduce the philosophy that led to the erection of the edifice, and even less can one infer from the success of the mathematics in reproducing certain aspects of experience that therefore the philosophy back of it was true." P. W. BRIDGMAN, "Einstein and Operationalism", AEPS, p. 347.

Yet, though a theory may never aspire to be proved, it can and often does aspire to be unique. This may be done by submitting the theory to a test by experimentum crucis. In the case of Relativity theory, the Michelson experiment is often regarded as just such a test. The essence of this kind of test is to show by means of a theoretical and experimental examination of every other actual or possible theory, that a particular theory is the only one which is able to "save the appearances", i.e., to explain the facts of observation. Thus, an experimentum crucis, involves in its very definition, the existence of at least one other theoretically possible explanation of the facts. But, in referring to the "Fragile foundations" of present day physics, Einstein is calling attention to the role that mathematicians and physicists are always playing which consists in continually formulating new theories and new critical experiments to account for the new facts which keep crowding into its field of vision.<sup>89</sup>

But it is in absolute contrast to this empiriological development that the position of Thomistic metaphysics is seen as truly and finally "unique". Expressed in the language of Einsteinian methodology, this means that the postulates of Thomistic metaphysics are truly confirmed by each succeeding test made upon the constitution of material

89. Cf. F.C.S. NORTHROP, The Logic of the Sciences and Humanities, p. 146 ff.

beings. Thus, for example, the modern atomic theory of material beings, a view which, when first formulated and, for some years succeeding, seemed to many to be a final one, is now in a state of serious compromise, while the hylomorphic theory of the physical constitution of material things remains empirically unshaken.<sup>90</sup> This is so because the latter theory refers to the real physical constituents of material beings, viz., matter and form as distinct from a certain mode, fruitful it is true, of conceiving bodies under the accidental aspects of their extension and mobility

90. D'Abro calls attention to this fact in the following words: "Consider again the FitzGerald contraction. Here Lorentz thought it permissible to apply the transformations; but owing to the slight difference in their significance in his theory, he concluded that a body in motion was really contracted owing to its real motion through the ether. Although the observer carried along with the body could not detect the contraction, yet it was physically real and would be observed by the observer at rest in the ether. A similar interpretation would have to be placed on the slowing down of phenomena. In Lorentz's theory the difficulty consisted in accounting for an identical contraction manifesting itself in exactly the same way for all bodies soft or hard. Lorentz again appeals to the electronic and atomic constitution of matter and has to take into consideration elastic forces.

With Einstein the explanation is simple. The contraction is due solely to a modification in our space and time measurements due to relative motion, and is completely irrelevant to the hardness or softness of the body, whose atomic or electronic structure need not be taken into consideration at all. In much the same way an object appears magnified under the microscope, and this magnification is independent of the body's nature." A. D'Abro, The Evolution of Scientific Thought, New York, Dover, 1950, pp. 149-150. (Italics mine.)

In addition, another type of experimentum crucis, validating the philosophy of St. Thomas, an historical one, is aptly recalled in the following quotation by M. Maritain:

The men of today have the very instructive privilege of watching the historic failure of rationalism. It would be suicidal to blame reason. But they can observe everywhere, even in the economic order, what is produced by the claim of imposing upon matter, the rule of a reason which itself refuses to be guided by the highest and most essential realities. All rationalization inevitably engenders absurd results when it is not the work of an integral reason which heeds the order of wisdom and nature.<sup>91</sup>

And there is yet, still another "critical test" of the absolute validity of Thomistic metaphysics which has been used as a basis of explanation and confirmation of the Einsteinian methodology in this thesis. It is this: The existential metaphysical synthesis of the Angelic Doctor not only can account for the epistemological procedures of Albert Einstein that have been presented, providing them with the foundation without which they can have no stability, but it alone of all known philosophies seems able to do so.

91. J. MARITAIN, The Dream of Descartes, Editions Poetry, London 1946, p. VIII. F.S.C. Northrup has dealt with the subject of the experimentum crucis of philosophical systems as applied to religion in his Logic of the Sciences and the Humanities, in the chapter, "The Methods and Grounds of Religious Knowledge". While he does not refrain from criticizing the system of St. Thomas, he appears to rate it higher than any other Western or Eastern philosophical system.

## CONCLUSION

There are two considerations under-riding the achievements of Albert Einstein in Relativity theory. The first, openly declared by him but, it would seem neither known by scientists generally nor, when known, accepted, is this: Relativity theory is the fruit of a unique, epistemological procedure. The main elements of that procedure which were presented in the first chapter may be listed as follows:

- 1) The requirement of strictly inductive beginnings, 2) the factor of free invention of the postulates, 3) the remote character of the deductive process with respect to the inductive beginnings and the rules of simplicity and naturalness which act to guide the deductive work, and 4) the requirement of physical confirmation of the theorems. The second consideration, one which does not appear to have been grasped by Einstein is this: Just as there is an epistemology which inevitably under-rides Relativity theory, there is a metaphysics which grounds and explains this epistemology. The writer learned of the existence of this unique Einsteinian epistemology for the first time from the words and work of Einstein and part of the thesis problem has been to abstract the Einsteinian methodology from the actual workings of Relativity theory, as well as to reconstruct it from the hints and declarations within his critical writings. It is, of course, no surprise that Relativity theory uses a definite epistemological procedure for this is true of any and every

properly scientific work and relates to the laws and dynamics of human thought on the one hand and the structure of extra-mental reality on the other.

The second and most important part of the thesis has been to provide metaphysical foundations for Einstein's epistemology. It was felt at the outset that this base could be found in the metaphysical and psychological writings of St. Thomas, especially if its claims to being a true metaphysics were valid ones. And while the failure to accomplish this thesis, like the negative experiments in physics itself, e.g., those of Michelson and Morley, would not prove that it could not be done, a successfully maintained thesis would provide new evidence of the perennial and even heuristic character of the system and body of insights of the Angelic Doctor.

But the main objective was not so much to prove the value of Thomistic doctrines but to provide the critical and epistemic views of Albert Einstein with a solid and sure foundation and with guarantees that go beyond the utilitarian. It was felt that Einstein's epistemology, which stands as something critical if not causal to the discoveries of Relativity theory, not only deserved a surer base for it but, if idealistic assaults by thinkers within the empiriological domain were to be successfully met, such a base would be needed.

Thus, the second part of the thesis concerned itself

with the problem of providing a foundation for the first part. The approach made was to take each of the main tenets of the epistemological doctrines of Einstein laid out in the first part and, without distorting or converting its precise meaning, to ground it in the similarly undistorted pertinent metaphysical doctrines of St. Thomas wherever possible. The writer felt that a consensus gained at the expense of the integrity of doctrine of either Einstein or Aquinas would defeat the main purpose of the thesis, expressed in its title and any other secondary and accidental purposes which might be also served.

It is the conclusion of this thesis that there is no main Einsteinian epistemological doctrine that does not receive, in a completely natural and undistorted manner, such hoped-for support by way of essential explanation within the relevant metaphysical and psychological positions of St. Thomas Aquinas. For example it was discovered that 1) the requirement of inductive beginnings by Einstein receive their necessity from the doctrine of the priority of existence of St. Thomas, a doctrine which, incidentally, appears to uniquely characterize the Angelic Doctor's whole synthesis as Gilson, Owens and others have worked to show. It was found further that 2) the factor of free invention of the postulates receives grounding and explanation within the doctrines of relational being, of the formation of concepts (which had to be elaborated at some length) and of the provisional character of the enunciative part of the judgment.

The tenet of 3) the remote character of the deductive process with respect to the inductive beginnings seems to have its explanation and justification in the general character of activity of knowing following conceptualization wherein the intellect is working with something peculiarly its own (aliquid proprium) which the extra-mental object does not have, and demanding therefore a true diversity. The Einsteinian guiding rules of simplicity and naturalness, acting to guide the deductive work relate well to the notion of an ordered and efficient universe stamped with the creative work of a primal and radically simple Intelligence Whose Nature is To Be. Finally, 4) the requirement of physical confirmation of the theorems is related to the whole manner in which human thought is directed to the world of material beings which is the cornerstone of the psychological doctrines of Aquinas to ultimately be founded upon his metaphysics.

The writer found it necessary, for the full delineation of the thesis' parts, to consider, sometimes at length, certain collateral material of an historical nature in order to bring into sharper relief the particular views of both Einstein and St. Thomas. Thus, for example, the positivistic views of Hume, Mach, Carnap and others were presented in their relevant connections to Einstein and those of Gilbert de la Porrée, Leibniz, and others, to Aquinas.

The thesis is submitted in the hope that its purpose, which has been to provide the theory of knowledge of Albert

Einstein with a secure metaphysical foundation, may help in some way to serve the larger purposes of Science and Philosophy and in some small way carry out the Leonine program:

"vetera novis augere et perficere". A fitting closing quotation to the thesis might well be:

.....His Holiness, Pope Pius XII, has invited scientists to seek the unity of all scientific knowledge in a philosophy, (Au Moment, April 25, 1955); but scientific certainty regards not the changing content of theories but the permanent structure of method; and so one might suggest that scientists will find the philosophy they seek by reflecting on their method and through the structure arriving at a corresponding, isomorphic epistemology and metaphysics.<sup>91</sup>

91. B. LONERGAN, S.J., Op. cit., p. 127.

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