Chapter 30

"Critical or Empiricist Interpretation of Modern Physics?" (1921)¹

REMARKS ON ERNST CASSIRER'S EINSTEIN'S THEORY OF RELATIVITY (1921)

An indelible, inalienable feature of critical philosophy is the way in which it is rooted in exact science. Just as Kant himself, according to a well-attested view (particularly upheld by Hermann Cohen) was pursuing, in his critique of knowledge, the goal of providing a philosophical justification for the Newtonian principles of nature, so the neo-Kantian schools endeavor to prove the truth of the basic ideas of the critical philosophy by seeking to demonstrate its usefulness and fertility for present-day physics as well. It has not been difficult for neo-Kantianism to keep pace with the development of natural science, as it passed from the mechanical to the energetical, and finally to the electrodynamical view of the world; but does it also have sufficient power and elasticity to share in the leap whereby physics in our own day has set out on a new path? At a time when there were only quite few attempts to assimilate the special theory of relativity to the critical point of view, and when the general theory had not yet been completed at all, I thought it necessary to answer this question in the negative. It seemed to me that the principles needed for a philosophical illumination and vindication of that theory could be drawn far more readily from the empiricist than the Kantian theory of knowledge²; and even on subsequent occasions I found no reason to abandon this position, more especially since the successful completion of the general theory, which took place soon afterwards, brought victory to an idea that had arisen from the soil of extreme empiricism (namely the positivism of Mach). But, given the importance and difficulty of the question, it is a duty to test the matter once more at every serious opportunity. Such an opportunity is provided by the appearance of Ernst Cassirer's book³, and I therefore gladly accede to the request of the editors of Kant-Studien, that I make a renewed examination of the problem in the light of this book; an examination, to be sure, which for external reasons can be made only in a comparatively brief form.

Cassirer, in his book, has made it his object to prove that the philosophical foundations of relativity theory can be found only in the field of critical philosophy, and more precisely in that form of the critical viewpoint which he is pleased to label logical idealism. He sets himself the task of deciding, by epistemological analysis, "whether the theory in its origin and development is to be taken as an example and witness of the critical or of the sensualistic concept of experience".

¹ Meiner, 2009.
² The Mind-body
³ Logical, Philosophical, Social.
But in light of this formulation, doubts are immediately bound to arise: Is the problem really reducible to these alternatives? Do we have here a tertium non datur? There is certainly an empiricism that is distinct from sensualism and cannot be reduced to it, as can easily be discerned both historically and in terms of subject-matter. So if it is shown (as it is not hard to do) that the theory of relativity cannot be made out upon purely sensualist premises, this alone does not prove either the necessity or even the admissibility of the critical interpretation of the theory, unless the concept of logical idealism has been taken so broadly that the above alternative is in fact permitted. But then it runs the risk of losing its bold coloring, and hence its philosophical value; the most heterogeneous opinions could be brought in under it. At some points Cassirer does actually seem inclined to such general formulations that the borderlines of his critical viewpoint threaten to become unclear. We must try to trace the boundaries here.

In order to establish a firm basis for the considerations to follow, I must state briefly the indispensable features that I take to be associated with the concept of criticism. Such a foundation is absolutely necessary for any discussion of the compatibility of relativity theory with the critical theory of knowledge, for only so do we avoid the tiresome intrusion of questions concerning the interpretation of Kant; the discussion remains unprofitable, so long as everyone can resort to the not uncommon argument, that his opponent is not giving a correct account of the Kantian view.

So let us lay down the following preliminaries. All exact science, whose philosophical justification undoubtedly forms the prime goal of the theory of knowledge founded by Kant, rests upon observations and measurements. But mere sensations and perceptions are not yet observations and measurements; they only become so by being ordered and interpreted. Thus the forming of concepts of physical objects unquestionably presupposes certain principles of ordering and interpretation. Now I see the essence of the critical viewpoint in the claim that these constitutive principles are synthetic a priori judgments, in which the concept of the a priori has the property of apodicticity (of universal, necessary and inevitable validity) inseparably attached to it. I am convinced, indeed, that this explanation is a correct account of Kant’s own view, but even if neither he nor his followers had ever professed this type of criticism, the factual truth or falsity of the following assertions would be quite unaffected thereby, and this is all that matters in an inquiry directed to systematic rather than historical questions.

The most important consequence of the view just elaborated is that a thinker who simply perceives the necessity of constitutive principles for scientific experience should not yet be called a critical philosopher on that account. An empiricist, for example, can very well acknowledge the presence of such principles; he will deny only that they are synthetic and a priori in the sense described above.

Cassirer recognizes that “empiricism and idealism meet in certain presuppositions.... Both here grant to experience the decisive role, and both teach that every exact measurement presupposes universal empirical law”. But in then addressing himself to the pressing question of “how we reach these laws, on which rests the possibility of all empirical measurement, and what sort of validity...we grant to them”; he contrasts the critical viewpoint only with the sensualist one, under the name of ’strict’ positivism. He quite rightly condemns the attempt sometimes made by Mach, to treat even analytic-mathematical laws like things “whose properties one can read off by immediate perception”, but that does not prove the truth of logical idealism, it merely refutes the sensualist theory. Between the two we still have the empiricist viewpoint, according to which these constitutive principles are either hypotheses or conventions; in the first case they are not a priori (since they lack apodicticity), and in the second they are not synthetic. How fares it with the proof that the principles of Einsteinian physics do not have this character, but are to be claimed as synthetic a priori propositions?

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There can be no doubt that Kant himself included among the synthetic a priori principles constitute of objects the axioms of Euclidean geometry and Galilean kinematics. And even after the mathematical discovery of the non-Euclidean geometries, the majority of Kantians have clung to the Euclidean view of nature as the only possible one, declaring (quite openly, for example in the case of Alois Riehl and Richard Hönigswald) that Euclidean geometry in fact has the intuitive necessity attributed to it by Kant, whereas the other geometries possess only conceptual thinkability, which does not conflict with the Kantian view.

Now the special theory of relativity is incompatible with the principles of Galilean kinematics, and the general theory is also irreconcilable with the propositions of Euclid. Anyone who accepts Einstein's theory must reject Kant's theory in its original form; as Cassirer himself often stresses, we have to take a step beyond Kant. But that is by no means our concern here. The critical viewpoint, as above defined, could nevertheless maintain and preserve itself in face of the new theory, and even celebrate still greater triumphs; all that would be needed is for the ultimate foundations of the theory to disclose themselves as synthetic propositions of absolutely necessary validity for all experience. What are these propositions?

For this must assuredly be noted: anyone who upholds the critical claim, must, if we are to accord him credence, also really set forth the a priori principles which must form the solid basis of all exact science. For transcendental philosophy, as Cassirer rightly says, space and time are not things, but 'sources of knowledge'. We therefore have to demand a statement of the cognitions of which space, for example, is the source. The critical idealist must designate them as definitely and clearly as Kant was able to point to the geometry and 'general theory of motion' which alone were known and recognized in his day. All those who have judged relativity theory from the Kantian standpoint have pointed out that it is concerned with empirical time (that is, time measured by physical methods) and empirical space, and to these they contrast the Kantian 'pure intuition' of space and time as that which first makes these empirical constructions possible, and so must remain quite undisturbed by any advance in physics, which can invariably refer only to the empirical. By this turn the state of the problem is not altered, but merely expressed in another way, for pure intuition is simply the cognitive source of those a priori principles that are needed for the construction of empirical time and empirical space; for many it is simply a comprehensive term for the essence of those principles themselves. In each case the existence of a 'pure space' and 'pure time' can be demonstrated as such only by actually pointing out the system of the relevant synthetic a priori principles, or at least giving an unambiguous indication of how it is to be found. It cannot be sufficiently emphasized that an adherent of the critical philosophy can vindicate himself only by producing such a system of judgments. Every attempt to reconcile Einstein with Kant must discover synthetic a priori principles in the theory of relativity; otherwise it must be regarded from the outset as a failure, since it has not even got to the point of stating the problem correctly.

Cassirer, of course, sees the problem in its proper light, and at two places in his book seems to give closer definition to the content of the pure intuition proclaimed by logical idealism. In the first passage he sees in the concept of the coincidence of 'world-points', to which the general theory notoriously reduces all laws of nature. But this 'coincidence' simply cannot, in my view, be regarded as the sheer essence and nodal point of a priori propositions, being initially just representative of a psychological experience of coming together, much as the word 'yellow' designates a simple color-experience that cannot be further defined. Only so can it play the intermediary role between reality and scientifically-conceptual construction that the theory attributes to it. In other words, we are confronted with an empirical intuition.
A second answer to the question of what synthetic a priori propositions about space are now left standing is given by Cassirer on p. 101 [p. 433], where he says:

For the a priori of space...involves...no assertion concerning any definite particular structure of space in itself, but is concerned only with that function of 'spatiality' in general, that is expressed even in the general concept of the linear element...as such, quite without regard to its character in detail.

But this formulation, which seeks to affirm that there simply has to be such a thing as a linear element in the description of nature, can hardly satisfy. For what is the set of axioms that is supposed to be included in this claim? It cannot be the axioms of constancy, for the possibility, already envisaged by Riemann, of discontinuous determinations of space, has been brought within arm's length by modern quantum theory. And whatever other axioms one might choose, there is no seeing why just these should constitute the one necessary structure of space, since others that are no less 'self-evident' have fallen victim to the progress of physics.

Any claim about content, however general it may be, already seems too special here, and it is perfectly consistent to reply to the question, as to what the ultimate synthetic a priori principles of all science may be, with the answer (which I take from a kind letter of Cassirer's), that they 'really consist only of the idea of the 'unity of nature', that is, of the law-abiding character of experience in general, or, more briefly perhaps, of the 'univocal nature of coordination'. But this seems to me to involve the inescapable intrusion of the danger that I described above as the inevitable consequence of too great an extension in the range of the critical conception. For it would now no longer be possible ever to claim of a physical theory that it confirmed the critical philosophy: the latter would have, rather, to be compatible with every theory, in the same way, and without possibility of selection, so long as such a theory satisfies the mere conditions of being scientific. Unitary obedience to natural law is assuredly the conditio sine qua non of science, since, as Cassirer himself says, "the general doctrine of the invariability and determinateness of certain values...must recur in some form in any theory of nature." Even for the empiricists, as Cassirer acknowledges, laws are "what is truly permanent and substantial"; even the empiricist believes in the unity of nature, in the law-abiding character of all experience; all he holds is that its validity and objective necessity cannot be proved by a transcendental deduction or in any other way. Here the critical philosopher can appeal to no physical theory, for each of them proves by its verification in experience only the factual, not the necessary validity of the principle of the unity of nature.

Like a scarlet thread there runs through Cassirer's book the demonstration, conducted by a brilliant use of the finest historical and philosophical scholarship, that the theory of relativity not only does not contradict the ideal that has guided the development of exact science from Plato to the present day, but represents, on the contrary, its currently most perfect fulfillment; that the relativity of measurements laid down by the theory in no way signifies a renunciation of strictly univocal objective lawfulness, but provides, on the contrary, the way to attain to the most universal laws and to discover the ultimate invariants. A more recent essay of Cassirer's (in the December number of the Neue Rundschau) is essentially devoted to the same argument. However necessary and valuable it was to counter by such considerations the natural lay misunderstandings of Einstein's theory, and to set it at a proper remove from any sophistical 'relativism' of the skeptical type, this only serves to confirm that the theory of relativity, precisely because it is a scientific theory, naturally represents an establishment, not an abolition, of the most universal, objectively valid laws. The Einsteinian world-picture allows the unity of nature to emerge more perfectly than the Newtonian, not, however, because it is in better accord with the critical philosophy, but because, even when it

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because, even when measured by the physical conception of knowledge, and regardless of its
ultimate philosophical interpretation, it represents a higher stage of knowledge.

The question whether Cassirer's so deeply thought-out logical idealism has succeeded
in proving the correctness of the claim, that only on the basis of the critical epistemology can
the theory of relativity be philosophically founded and justified, is one to which, in virtue of
the foregoing, we are unable to give an affirmative answer, precisely on the decisive point:
the doctrine of synthetic a priori judgments as the constructive principles of exact science
obtains no unambiguous confirmation from the new theory. Cassirer's observations appear
to me to provide no convincing evidence of how we may deal with the problem dealt with the original
Kantian viewpoint by the overthrow of Euclidean physics. But that is not yet to say that the
relation between transcendental philosophy and relativity theory has now been shown to be
a purely negative one; on other points significant contacts may occur between the two
viewpoints, and important common elements be disclosed.

It is very natural to seek in the critical doctrine of the ideality of space and time a close
natural affinity with the ideas of relativity theory. The inessentiality which seems to
distinguish the space of Einstein's theory of nature from the fixed space of Newton (and so,
too, with time), has in fact been seen as a welcome confirmation of the Kantian philosophy.
Cassirer also takes this view. With reference to my statement that, on the general theory of
relativity, only an indissoluble unity of space, time and matter still possesses the predicate of
reality, he observes that this insight "belongs to the fundamental doctrines of critical idealism",
and goes on: "the ideal separation of pure space and pure time from things (more
exactly, from empirical phenomena), not only permits but demands precisely their empirical
'union'". This latter is true enough, for as forms of intuition space and time are no more
separable from the formed matter in them than the matter, conversely, can exist without a
form. But the 'union' proclaimed by relativity theory, which I was trying to specify in this
remark, is a far more intimate one than the unity of matter and form on which transcendental
philosophy has nowhere made any advance. So when Cassirer goes on: "This union the
general theory of relativity has verified and proved in a new way...", the stress has to be laid
entirely on the word new. This novelty is utterly misconstrued by E. Sellen, who says:

For the factual determination of space and time in experience, space, time and
bodies belong together. This proposition is no achievement of Einstein's theory, as
Schlick maintains with such emphasis; it has long been known, and in no way
refutes Kant's doctrine of pure time, since it simply does not touch it.

It is, however, a quite fundamental misunderstanding of general relativity theory to think it
possible to construe my above-mentioned observation as though it merely denied in a
negative way the separate existence of time and space in contrast to matter (and vice versa);
that would certainly be a long familiar triviality. In Einstein's theory, the mutual dependence
of space, time, and matter goes far deeper than that; it is, for example, impossible on that
theory to speak of the measurements of a spatial configuration without reference to the
manner of its material occupancy. That in this way the theory of space becomes a branch of
physics, deserves to be dwelt on with great emphasis. Only Riemann has anticipated this
idea with complete clarity; it was not only at a far remove from the critical philosophy, but
seems to contradict it, since it makes it impossible to view space and time as mere forms in
the traditional sense, whose laws are to be dealt with independently of their content. When
Einstein remarks on the working-out of general relativity that it takes from space and time
"the last remainder of physical objectivity", Cassirer thinks "that the theory only
accomplishes the most definite application and carrying through of the standpoint of critical
idealism within empirical science itself". But if—which Cassirer rightly insists—as the first
task of the epistemologist—we set out in full clarity the meaning of the term ‘physical objectivity’, we again run into the aforementioned finding, to which the doctrine of the ideality of space and time can do justice only on its negative side; for it turns out that with this denial of ‘objectivity’ we do indeed deny to space and time any independent nature at all; they only remain of the same kind from the standpoint of physics, but in the combination with matter, also enjoy the same reality as the latter. Einstein himself has at times declared that, even according to general relativity, physical space has reality, but no independent reality. Thus the spatial and temporal retain a meaning in which they can no longer be regarded merely as ‘forms’ in the usual sense, but now belong to the physical determinants of bodies; the ‘metric’ does not just mean a mathematical measuring of the physically real, but itself gives expression to the presence of this. Space and matter, as Cassirer aptly puts it, “no longer occur as different classes of physical object–concepts”. So when it is supposed that Einsteinian physics “in this respect displays fewer contradictions to the Kantian transcendental aesthetic than any earlier physics”, this seems to me to harbor a misapprehension of the positive aspect of Einstein’s theory of space and time. It would also be extraordinary if the Kantian theory of knowledge were held to stand in such clear contradiction to the Newtonian view of nature, whose philosophical vindication was one of its principal goals.

But even though critical principles may fare ill in correctly evaluating the most general form of relativity (covariance under any substitutions, in the language of the theory), they could yet perhaps furnish a viable basis for Einstein’s theory, insofar as they at least stand in a favorable relation to the principle of the relativity of all motions (covariance under a certain group of substitutions). It cannot, of course, be demanded of a philosophical system that it carry through this principle as a theory, but the principle can very well derive from it, qua indispensable postulate. If even this is too much to ask, we may at the very least expect that the principle, once established on other grounds, will at once be recognized as congenial and taken up with maximum vigor by the system. On its own premises, the critical philosophy would in fact have been very well placed to do this; yet in its historical manifestations it has satisfied none of the requirements just stated. On the contrary, it was the positivist Mach who first emphatically elevated the general principle of relativity into a postulate for the description of nature. He demanded—and this actually on philosophical grounds—a formulation of natural laws such that the rotation of the earth against the fixed stars, for example, could be viewed with equal justice as a contrary revolution of the firmament about the earth. To discover Kant’s attitude to this view—which was just as possible in his own day—we must read the Metaphysical Foundations of Natural Science, where in the Observation following Principle I in the first chapter, and in Proposition 2 and the General Observation on Phenomenology in the fourth, he discusses the problem. Like Leibniz, Huygens and others, he there feels definitely called upon to maintain the relativity of all motion. But while Newton recognized that this was inconsistent with his mechanics, and so logically (though maybe not altogether cheerfully) postulated absolute motion for the latter, Kant seeks a way out by positing, in addition to the antithesis of relative and absolute, that of ‘true’ and ‘apparent’ motion.

In his Substanzbegriff und Funktionsbegriff (1910), Cassirer has already dealt with the question of the relativity of rotation. It is extremely notable with what acumen he then reviewed the consequences of the Machian view. For he says:

Thus here, and essence from the crit itself compelled. Cassirer is cert: thesis still provides interpretation of Eti indication of this, an (rightly or wrongly) was the principle that principle, be expected metaphysicians as L principle of the iden introduces it in the l upholding and enfor significance, it can, I to the ultimate grid whose ruthless appli view is correct, the c would then be seen, contingent one.

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Thus here, and in the developments preceding the passage cited, we find rejected in essence from the critical standpoint precisely those consequences to which science now finds itself compelled.

Cassirer is certainly correct in his view that confirmation of the Machian relativity thesis still provides in itself no compelling proof of the necessity for an empiricist interpretation of Einstein's theory — but it remains nevertheless an extremely significant indication of this, and not, I think, a misleading one. For the epistemological motive which, (rightly or wrongly) led Mach and Einstein to the postulate of the relativity of all motions, was the principle that differences in reality may be assumed only where there are differences that can, in principle, be experienced. This fundamental rule has often been enunciated, even by such metaphysicians as Leibniz, with whom it actually appears in two forms, namely as the principle of the identity of indiscernibles, and as the principle of observability (Cassirer also introduces it in the latter form), but it is still a large step from stating the rule to a consistent upholding and enforcement of it. Yet if the principle is recognized and evaluated in its true significance, it can, I believe, be elevated to the supreme principle of all empirical philosophy, to the ultimate guideline which must govern our attitude to every question of detail, and whose ruthless application to all special problems is an exceedingly fruitful procedure. If this view is correct, the connection of relativity theory with the empiricist theory of knowledge would then be seen, anyway, as an intimate, strictly factual, and not merely external or contingent one.

In the final chapter of his book, Cassirer stresses emphatically that the space and time of relativity theory are just the space and time of physics, not of reality as such, so that the space and time of psychology, say, stand contrasted to them as something of an altogether different kind. It is, in fact, of the greatest importance to be always clear about the fact that we can speak of space and time in totally different senses — and most important of all precisely for anyone who is ultimately interested in discerning the connection between these different senses. When I elsewhere set psychological space (and time), as the purely intuitive, in contrast to physical, as a purely conceptual construction, I was well aware that Kant defines 'intuition' in quite a different way. On this point I have been misunderstood by a succession of critics. Cassirer declares Kant's pure intuition to be a specific 'method of objectification', which indeed it is as well, but its nature is not exhausted by this. Kant certainly wanted to purge it of everything psychological — but I shall never be able to persuade myself that he succeeded. For no such success is possible, without employing the sole method which permits us to separate the purely conceptual elements of geometry from the psychologically intuitive, namely, the method of implicit definition, first framed in modern mathematics.

Without it we cannot even grasp the idea of a pure concept, or understand this in abstraction from all psychological elements. Kant's space of pure intuition therefore necessarily contains such elements as give the concept of space that content without which he would consider it 'empty'. He does indeed regard his space as identical with that of Newton (Cassirer is also of this opinion, which I have always shared myself; though Sellin, whom Cassirer otherwise quotes with approval, appears to contradict it); but Newtonian space, for Kant, is simply an intuitive one, not yet purified of the elements which we must still describe as psychological. So Kant's pure intuition — corresponding as it does to the received view of space and time — is a halfway house between the purely conceptual and the psychologically intuitive; and since I consider it one of the most important findings of the modern theory of exact science (Henri Poincaré having made an especial philosophical contribution on this point), that there simply is no such hybrid or halfway house, I have had on the one hand to deny the existence of a pure intuition like that of Kant and have ventured to speak of a confusion of the physical concept of space with its sensory representatives; while on the other hand I have had to declare that there is a core of truth to be found in the doctrine of purely subjective forms of
intuition, precisely insofar as they are still not wholly divested of psychological elements. So these views I am unable to abandon.

Pursuit of the changes of meaning in the terms 'space' and 'time' through the various fields of intellectual life gives Cassirer the opportunity to range his view of relativity theory in broad terms within a wider context, and to direct upon it, not only the light of the specialized critique of knowledge, but also the radiance of systematic philosophy. Thus the book concludes with a survey whose breadth conforms to the high level of the standpoint adopted. But we are left with the impression that this standpoint already transcends the region of critical philosophy proper, and that only in virtue of this has Cassirer succeeded in doing the degree of philosophical justice to the theory of relativity that is achieved in this intelligent and thoughtful book.

I gladly comply with the invitation of the Kant-Studien editors, to report in brief at this juncture on two other books about Einstein's theory, since the writings in question are such as to repay discussion. The first, written by Max Born, gives a brilliant, comprehensive account of Einstein's theory from the physicists' point of view. It fills in most appropriate fashion a very palatable gap in the Einstein literature, for while the layman's introductions to the theory so far available have confined themselves to bare essentials in the treatment of its basic physical concepts, in Born's book the theory appears for the first time without detachment from its natural background; on the contrary, great emphasis is explicitly laid upon its place in the system of physics, and the connections from which it has actually arisen are made clearly apparent. For the non-physicist it is of the greatest value to be initiated into these connections, since it is through them that the natural road to understanding leads. Born not only levels this road by avoiding all higher mathematics; even logarithms and trigonometrical functions are absent. But the main thing is, that the book is thorough and through the work of a philosophical mind. This is shown, not by the fact that Born interrupts the course of his exposition with philosophical glosses and asides, but in the high level of the viewpoints that determine the structure, and in the deep thought that is everywhere manifest in the treatment of the subject. It is shown above all, moreover, in the brief philosophical introduction, which strikes one as positively classical in the warmth and pregnancy with which it expounds the basic idea: that the absolute can be found only in the realm of the subjective, and that the thinking mind can penetrate into the sphere of objective validity only by sacrificing the absolute, in order to exchange it for knowledge of the relative. A fundamental insight indeed, which is not only evident in theoretical science, but also holds good, I am convinced, in practical philosophy as well.

The second work is the monograph Relativitätstheorie und Erkenntnis a priori by Hans Reichenbach (Berlin 1920). It undoubtedly represents a great advance in the logical interpretation of Einstein's theory. Using a sort of axiomatic method, Reichenbach probes, by a very acute and original analysis, into the logical foundations of relativity theory, and in so doing, by uncovering certain more hidden principles (he speaks, for example, of a 'principle of the approximable ideal', a 'principle of normal induction' etc.), he makes a valuable contribution to the logic of exact science as such. He reaches the conclusion that Einstein's theory is incompatible with the original doctrine of Kant, and proposes a transformation of the concept of the a priori, such that relativity theory will no longer contradict it, and the most important thesis of the Kantian philosophy will remain, as he thinks, intact. This thesis he professes to find in the insight that all knowledge becomes possible only through the logical presupposition of certain principles, which first constitute its object as such. Such principles he calls a priori, but dispenses with the mark of apodeictic; hence they are not necessary, and the progress of experience can provide motives for modifying them. "A priori means 'prior to knowledge', but not 'for all time', and not 'independently of experience'".57 In view of my earlier remarks, this strikes me as a total departure from the basis of th

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**Notes**

1. 'Kritische oder empir 96-111. Translation take
2. 'Die philosophische Be
5. *Einstein's Theory of Relativity* 1919
10. *This is also the true mean* 1920, p. 83.
15. *Die erkenntnistheoretische* published as supplement
16. On this point too, there basis of some remarks i
17. *Kritische oder empir 96-111. Translation take
18. 'Kritische oder empir 96-111. Translation take
21. I use the name, op. cit p
22. *[Engl. by J. Ellington, 1786.]*
23. I use the name, op. cit. 1
departure from the basis of the critical philosophy, and I should designate Reichenbach's *a priori* principles as conventions, in Poincaré's sense. Thus I cannot commend the author's terminology, but in substance I agree entirely with him on most of the essential points. Even in those questions about which he takes issue with me in the book, there is really no profound difference of opinion, as an elucidation of our positions by correspondence has subsequently disclosed. But for a reader averse to these positions, the book is still of value, for a piece of philosophy so marked out as this is by originality, clarity and acuteness of argument must offer him pleasure and profit, even when it provokes him to dissent.

**Notes**


7. Ibid.


13. Ibid. p. 67.


16. 'Die erkenntnistheoretische Bedeutung der Relativitätstheorie'. Dissertation, Kiel 1919, p. 37; also published as supplement (Bergzugsheft) no. 48 to *Kant-Studien*.

17. On this point too, there have been attempts to portray Kant as a predecessor of Einstein. On the basis of some remarks in Kant's first work, *Gedanken von der wahren Schätzung der lebendigen Kräfte*, Ilse Schneider observes (in *Das Raum-Zeitproblem bei Kant und Einstein*, Berlin 1921, p. 70): "Thus Kant is the first to point out the connection of geometry and physics, especially gravitation". But Kant's attempt to bring the three-dimensional character of space into relation with the formula of Newton's law of gravitation can by no stretch be regarded as a premonition of the unification of geometry and physics in the epistemological sense, and has, on the contrary, nothing at all to do with it. One might point here with equal justice to the Cartesian identification of substance and extension, which Cassirer also mentions (p. 60 [pp. 395 f.]), though without in fact exaggerating its true significance.


23. Ilse Schneider, op. cit. p. 14, cites the relevant passage in Kant with approval, since he makes him out to be an opponent of absolute motion; but she forgets that, precisely from the standpoint of relativity theory, these distinctions represent a monstrosity.
24 Engl. Substance and Function. Page references to German and English editions are given in the text. — Trans.
25 Substance and Function, pp. 230 ff. (pp. 170 ff.).
26 Substance and Function, p. 246 (pp. 185 ff.).
27 Einstein's Theory of Relativity, p. 97 (pp. 428 ff.).
28 Ibid., p. 37 (p. 380).
31 As can be seen, for example, from Selmen's remarks, op. cit. p. 40 [see note 5].
33 Op. cit. p. 16. The reference there is to time; but the arguments apply similarly to space.
35 Raum und Zeit, 3rd ed., 1920, p. 83 [Engl. present vol., no. 9, p. 262].
36 Die Relativitätstheorie Einsteins und ihre physikalischen Grundlagen, gemeinsamverständlich dargestellt, with 129 illustrations and a portrait, Berlin 1920.
37 Einstein's Theory of Relativity, p. 100.