FUNDAMENTAL ERRORS OF THEORETICAL PHYSICS
A CRITICAL REVIEW

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Science depends on the mutual criticism of scientists. A branch of science aiming at making progress must not only tolerate criticism; it must also create conditions under which criticism can be discussed and will be considered. Theoretical physics failed to achieve that in the last century. *Gravity* is the most obvious of all physical forces, but no theoretical physicist can explain it within the presently prevailing theories[1]. Yet theoretical physicists behave, almost unanimously, as if their theories held the final explanation of everything.

That development had been caused by a mistaken approach, confusing mathematics and physics. Since the times of Huygens (1629-1695) and Newton (1643-1727), the progress of physical theory had shown in a wonderfully increasing precision of calculations and measurements. That seemed to encourage the view, still widely held at the beginning of the 20th Century, that the rules of mathematics must be elements of nature itself; that observing mathematical rules is a physical property of light and matter therefore. In the following decades however, due to the ground-breaking works of Whitehead, Russell, Tarski and Popper, it gradually became apparent that mathematics is not part of nature but a *creation* of man. It cannot *explain* the regularities of nature, and can *describe* them correctly *only if they exist*. That should have given rise to a general review of established physical theories, but it never came. Theoretical physics lost contact with the the theory of science and with the progress made in that field. It thus lost contact also with reality.

I. QUANTUM THEORY

The results of that development show already in Quantum Theory[2]. It raises a fundamental problem that was never discussed in theoretical physics. Max Planck, the founder of the theory, assumed the quantum to be an ultimate, smallest, and therefore indivisible unit of nature. Einstein, in his light quantum hypothesis, also presupposed its being indivisible. But neither Planck nor Einstein ever gave reasons for that assumption. The allegation may seem incredible, but we will see that the history of Quantum Theory confirms it.

1.

Planck published his theory in 1900 and received the Nobel Prize in Physics for it in 1919. He was trying to find a mathematical formula describing the distribution of the energy of light at the heating of a black body. At the turn of the 19th Century many physicists considered that spectrum the ideal case of radiation energy, uninfluenced by the properties of any individual material. One believed an 'ideal' black body to reflect no rays at all, but to absorb all impinging radiation. Although such bodies do not exist in nature and are anything but 'normal' therefore, their spectrum was nevertheless labeled 'normal spectrum' for that reason. Physicists were particularly interested in changes of that spectrum at the heating such a black body. For getting as near as possible to the ideal, experimenters did not use a real black body but a cavity enclosed by black walls with only a small hole letting radiation escape and permitting obervation.

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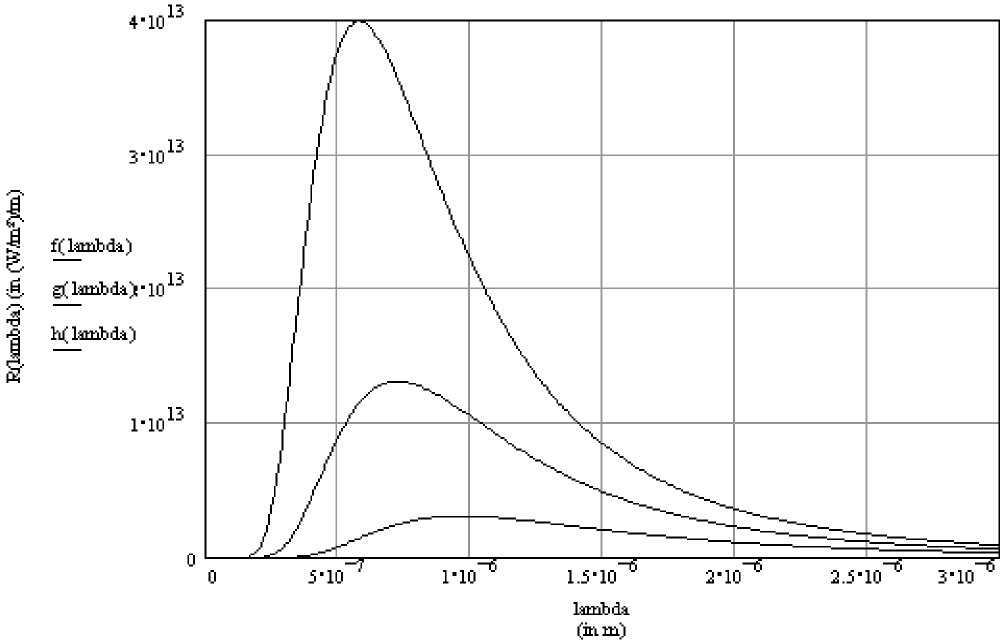
[1] That seems to be generally recognized; see, for instance, Richard P. Feynman, *QED – The Strange Theory of Light and Matter*, Kap. 5; Leon Lederman, *The God Particle*, Kap. 3; Stephen Hawking, *A Brief History of Time*, Kap. 8.

[2] For the following see also my *Einstein, Popper and the Crisis of Theoretical Physics* (2015), pp. 183ff. – This paper summarizes the physical results reached in that book.



(*Fig. 1*: Spectral distribution of black radiation intensity at different temperatures)

Figure 1 shows the distribution of radiation energy of such a black body at different temperatures[3]. The abscissa (x-coordinate) shows the frequencies. The ordinate (y-coordinate) shows the intensity of radiation energy; and the different curves show examples of the distribution of radiation energy at different temperatures, each curve standing for one temperature[4]. They therefore show the results of experimental measurements known at the time.

Max Planck was trying to find a formula for calculating the energy distribution shown in those curves. Several had already been proposed in his time. The one developed by Wilhelm Wien gave good results at high frequencies whereas the so-called Rayleigh-Jeans formula gave better results at low frequencies[5]. By interpolation of those two formulae and introducing the constant of nature *h*, Planck succeeded in developing the radiation formula now bearing his name[6]. According to modern textbooks, it is an exact representation of the curves shown in *Figure 1*. Its meaning need not interest us any further at this point, but in that context Planck introduced his constant *h*, which he named 'quantum of effect' and calculated at $h = 6.548 \times 10^{-27}$ *erg* x *sec*[7].

(*a*) Planck first presented his theory to a larger audience on December 14, 1900[8]. The following quotation from his paper throws some light on the background of the problem he was trying to solve:

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[3] Quoted from Gerthsen/Vogel, *Physik*, 17.ed. [1993], p. 543.
[4] The lowest curve shows results at 1000° K, the middle curve at 1500° K and the top curve at 2000° K.
[5] Rayleigh had already published his formula at this time, but according to Agassi (*Radiation Theory and the Quantum Revolution* [1993], p.100) Planck did not know it. He was starting from a formula developed by Kurlbaum and Rubens (Hermann, *Max Pla*nck in. *Die Großen Physiker*, [1997] vol. II, p. 147 f.).
[6] The formula is $u_\nu d\nu = \frac{8\pi h\nu^3}{c^3} \cdot \frac{d\nu}{e^{h\nu/k\vartheta} - 1}$. In Planck´s notation, *u* stands for the density of energy in space and ν for the proper frequency of a ‚resonator' (see the main text following). The expression $u_\nu d\nu$ therefore stands for the density of energy in space *u* described by the ordinate referring to the differential quotient (limiting value) of the frequency ν of the abscissa.
[7] Max Planck, *Vorträge und Erinnerungen*, p. 26. Due to a change of units *h* is now calculated at $h = 6{,}626 \times 10^{-34}$ Js.
[8] For the following see also my *Einstein, Popper and the Crisis of Theoretical Physics* (1915), p.183ff.

> 'Gentlemen, when some weeks ago I had the honour to draw your attention to a new ,formula which seemed to me to be suited to express the law of the distribution of radiation energy over the whole range of the normal spectrum, I mentioned already then that in my opinion, the usefulness of that equation was not based only on *the apparently close agreement* of the few numbers, which I could then communicate, *with the available experimental data,* but mainly on the simple structure of the formula and especially on the fact that it gave a very simple logarithmic expression for the dependence of the entropy of an irradiated monochromatic vibrating resonator on its vibrational energy. …
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> Since the entropy of a resonator is thus determined by the way in which energy is distributed at one time over many resonators, I suspected one should evaluate this quantity in the electromagnetic radiation *by introducing probability considerations*, … This suspicion has been confirmed; *I have been able to derive deductively an expression for the entropy of a monochromatically vibrating resonator and thus for the energy distribution in a stationary radiation state, that is, in the normal spectrum*. … .
>
> I do not wish to give today this deduction – which is based on the laws of electromagnetic radiation, thermodynamics and probability calculus – systematically in all details, but rather to explain as clearly as possible the real core of the theory. This can be done most easily by describing to you a new, completely elementary treatment through which one can evaluate – without knowing anything about a spectral formula or about any theory – the distribution of a given amount of energy over the different colours of the normal spectrum *using one constant of nature only* and after that the value of the temeperature of this energy radiation using a second constant of nature.' (My italics).[9]

This text shows in outline the task Planck had set himself. He had already found his formula of radiation, and had compared it with the results of experiments known at the time. That was why he spoke of 'the apparently close agreement … with the available experimental data'. Their results were also known therefore, but he was still searching for a deductive foundation. The passages in italics show that.

The problem that got in his way on that quest was the problem of entropy, that is the fact that in any conversion of radiation and mechanical energy there will always be a small part that cannot be converted. The exact proportion of that part was unknown, and entropy could not serve as a mathematical operand therefore. That, in turn, prevented an exact calculation of radiation energy. Seen from the angle of mathematics, entropy was an unknown operand, to be determined only by introducing other equations.

The text shows also Planck´s approach to that problem. He wanted to determine the size of entropy 'by introducing probability considerations'; and his radiation formula was to be deduced by 'using one constant of nature only'.

Planck gave no other reason. His text shows, however, that he was neither content with having already found his radiation formula nor with its having been confirmed by experiments. Still less did he look for practical applications because that would have meant adapting the 'ideal' conditions, which he had assumed, to those of bodies existing in reality. He wanted more. The formula was not only to be confirmed empirically but also to be founded deductively. Without deduction it seemed worthless to him because only deduction could raise it to the rank of 'exact science'[10]. The fact that his deduction depended on *ad hoc* introducing a new constant serving only to make results fit did not bother him. On the contrary, his conviction of the necessity of deductive reasoning was so firm that he believed the constant *h* to be prescribed by nature itself just because, and *only* because, deduction would have been impossible without it.

In none of his works did Max Planck give any further reason. Even five years later, presumably therefore after careful consideration, he presented the constant *h* in his *Lectures on the Theory of Heat Radiation* as a pleasant surprise to to his readers in the following words:

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[9] Max Planck, *On the Theory of the Energy Distribution Law of the Normal Spectrum,* Verhandlungen der Deutschen Physikalischen Gesellschaft No. 17 (1900), p. 237 ff.(translation quoted from *The Old Quantum Theory*, ed. by D. ter Haar, Pergamon Press, 1967, p. 82).

[10] See also Planck´s lecture on *Sinn und Grenzen der Exakten Wissenschaft* (1942).

> 'It can hardly be doubted that in processes of oscillation at a center of emission the constant *h plays a certain role* to the understanding of which from the angle of thermodynamics our theory *gave no further clu*es up to now. Nevertheless the thermodynamics of radiation will have reached a completely satisfactory conclusion only if the constant *h* has been *understood in its full universal significance*.' (My translation and italics).

That was the only explanation Planck ever gave for introducing the constant *h*.

In other words, *he himself knew nothing*. That was in 1906, more than five years after the first publication of his Quantum Theory, and even after Einstein had published his light quantum hypothesis, which we will consider further down. He had a vague notion that the constant *h* still had to be 'understood in its full universal significance', but he himself had not even an inkling of that significance because his theory 'gave no further clues' up to then. Yet he stood unswervingly by his belief that the constant *h* must be a 'universal constant' because calculation would have been impossible without it. Hence, it would also have been impossible to express in mathematical formulae the results of then known measurements.

Seen before that background, the fact that his radiation formula had already found empirical confirmation appeared secondary to Planck. He mentioned it only in passing in the introduction of his paper. Further down he even said:

> 'It would of course be very complicated really to carry out the calculations mentioned although it would surely be not without interest to test in a simple case the degree of approximation to truth to be reached that way.'

He could hardly have expressed more clearly that experiments were 'not without interest' to him, but no more than that. They certainly did not give rise to making 'complicated' calculations.

(*b*) The passage last quoted even indicates that Planck saw an 'approximation to truth' not in his theory but in the experiments made for testing it. Theory, so we will have to understand him at this point, was not an approximation to truth; it *was* truth itself. Only theory was 'exact science', everything else was mere 'opinion'. His axiomatic understanding of science presupposed that a physical theory had been deduced from indubitable premises in accordance with the strict rules of mathematics. Experiments could help, at best, in finding such theories. They were mere indicators, assisting the weak human mind in its search for correct deduction. An experiment could approximate truth only if it confirmed the theory, which had been found deductively. He presupposed, assuming that to be self-evident, that it must confirm a theory which had been deduced correctly. Under no circumstances could it call in question, or even refute, a theory that had been founded deductively. The notion that the outcome of an experiment might overthrow a theory as completely as Copernicus and Kepler had overthrown Ptolemaic theory must have been alien to him.

Seen from today´s perspective it is hardly possible anymore to imagine the world of thought in which Planck lived. It might become easier if we consider what he regarded as physical experiments. Planck was one of the first academic teachers of physics to work only theoretically from the beginning of his career. He probably lacked the practical view to some extent, and could never quite free himself from the fascination of geometry, not even when considering physical experiments. In the passage last quoted the text in italics indicates that to him experiments seem to have consisted in 'carrying out calculations'. They were like drawing on paper geometrical figures according to the rules of geometry. The pencil must be thin, the ruler straight, and the compass must have sharp points. Given such conditions, careful handling of the instruments would yield good approximations to geometric figures without quite reaching their ideal. That would also explain why Max Planck thought it important to carry out experiments under 'ideal' conditions. An experiment could be meaningful only if it met such conditions. And if it did, then it was bound to confirm the theory that had been found deductively. Primacy belonged to theory in his view. Experiments were but secondary confirmations.

2.

We now turn to the further development of Quantum Theory. Only five years after Planck had officially launched his theory on December 14, 1900, Einstein took the next major step in its development. His paper *Concerning an Heuristic Point of View Toward the Emission and Transformation of Light* (1905) stated his light quantum hypothesis for which he later received the Nobel Prize for 1921[11]. Other than his theory of relativity, it gained acceptance only with difficulty. Resistance seems to have come not least from Planck himself[12].

On closer consideration that was hardly surprising because Einstein had radically changed the meaning of the quantum hypothesis by the way in which he made use of it in his own theory. Planck never addressed that change directly to my knowledge, but he must have felt it, and it must have worried him at heart. Einstein´s light quantum hypothesis of 1905 was in fact the first profound revolution in the history of quantum theory, even if that remained unnoticed at the time. No theoretical physicist seems to have realised that Einstein had already given up again the premises on which Max Planck had based his theory in 1900.

(*a*) Planck had calculated his constant at $h = 6.548 \times 10^{-27}$ *erg* x *sec*, therefore as a 'product of energy and time'[13]. It had no physical properties of its own in his view, but was an abstract mathematical operand, serving for describing physical processes. He himself had coined the term 'quantum of action'[14]. The name was important to him because it indicated that the constant *h* was independent of specific applications. That was why he wrote:

> 'I want to denominate this (*scil.* the natural constant *h*) as the "elementary quantum of action" or as the "element of action" because it is of the same dimension as the quantity to which the principle of smallest effect owes its name.' (My translation)[15].

The abstract quality of Planck´s constant has implications which we must consider in detail.

In our time almost every physicist will take for granted that the quantum is indivisible. Even with non-physicists that almost is common knowledge; to many it is all they believe to know of quantum theory. They probably assume that its indivisibility had been carefully established by Planck himself. For, it seems a matter of course that a discovery as fundamental as that of a last, indivisible entity of nature must have been based on thorough investigation. How else could one rely on the existence of so fundamental an entity?

Yet no confirmation is to be found for that assumption in Planck´s writings, not even the slightest! The allegation may sound incredible, but I can only request those doubting it to check its accuracy by reading Planck´s texts. There is no other way of proving it because there is nothing in those texts that I could quote for doing so. The fact that Planck never gave reasons for the indivisibility of the constant *h* is of utmost importance for assessing the whole devlopment of theoretical physics in the 20th Century. Closer consideration shows that even to search for a justification of the indivisibility of *h* would have been almost directly against Planck´s beliefs. The

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11 Albert Einstein, *Über einen die Erzeugung und Umwandlung des Lichts betreffenden heuristischen Gesichtspunkt*, Annalen der Physik vol. 17 (1905), p. 132 ff. (*Concerning an Heuristic Point of View Toward the Emission and Transformation of Light*, American Journal of Physics, v. 33, n. 5, May 1965). The quotation following in the main text is from p. 133.

12 Fölsing, *Albert Einstein - Eine Biographie*, p. 170; Hermann, *Max Planck* in *Die Großen Physiker*, vol. II p. 149.

13 Max Planck, *Vorträge und Erinnerungen*, p. 26.

14 As mentioned above, Planck´s German term was 'Wirkungsquantum'. Literally translated that would be 'quantum of effect'.

15 Max Planck, *Vorlesungen über die Theorie der Wärmestrahlung*, p. 154.

only sentence coming anywhere near to *arguing* for the indivisibility of *h* that I found in his writings reads like this[16].

> 'The fact that the constant *h* is introduced as a *certain finite quantity* is characteristic of the whole theory here developed. If one would assume *h* infinitely small, one would come to a law of radiation resulting as a *special case* from the general one (cp. the Rayleigh law ...).' (My translation; my italics).

It shows that in Planck´s understanding the abstract aspect came first. The constant *h* had to be a 'certain finite quantity' because only in that case could his equation be expressing a universal law, whereas assuming *h* to be infinitely small would have implied a continuous increase or decrease, and the equation would then have applied only to the 'special case' of the Rayleigh law. That was why he introduced the quantum of action as a 'constant of nature' and repeatedly added the epithet 'elementary'[17]. Nature itself must have prescribed it, so he must have believed, because it was mathematically indispensable for reconciling with each other Wien´s equation and the Rayleigh-Jeans formula. Had *h* been variable, then his formula would have described only a 'special case'. And because only a constant would express a universal law of nature, he believed it to be elementary. The circularity of that reasoning did not worry him. Being an adherent of the axiomatic method, he believed starting from fixed basic truths to be inevitable. Without them, so he must have thought, there could be no 'exact science'. And if one had to start from them, then they must be part of nature itself.

From Planck´s point of view, as I understand him, the problem was about a methodological principle. In his notion the constant *h* had to be indivisible because it had to be a constant. The question of whether it was *empirically* indivisible never presented itself. It could not present itself because he did not consider the constant *h* an empirical entity but an abstract quantity, resulting from mathematical necessity. Its elementary quality was no result of observable physical effects, but of the fact that deducing the radiation formula would be impossible without it. If he had been searching for a justification of its indivisibility, then he would have been contradicting his own beliefs by expressing doubts he did not harbour.

Least of all would Planck have resorted to experiments. They would have presupposed physical effects that could be tested, and he avoided allegations of that kind. Theory was his domain, and experiments seemed secondary compared to that. The best they could achieve from his point of view were approximations to truth. But his natural constant *h* was to be a universal constant for purely mathematical reasons, and it had to be applicable to all other physical quantities. That was why he never used the term 'quantum of energy' his writings, but only that of a 'quantum of action'. And never, in any of his writings, did he speak of '*quanta* of action' because being an abstract, a mathematical constant could not exist in several specimens.

(*b*) Einstein did not give up Max Planck´s approach explicitly in his paper on the light quantum hypothesis, but he set aside its meaning from the outset. At its very beginning he proposed to treat the quantum, hypothetically, as something existing in reality, and then to consider how far that hypothesis would carry. That was the fundamental shift in the conceptual content of quantum theory, which jumbled up everything.

The following brief sections from the introduction to Einstein´s to paper are symptomatic. He wrote there:

> 'According to the Maxwellian theory, energy is to be considered a continuous spatial function in the case of all purely electromagnetic phenomena including light, while the energy of a ponderable object should, according to the present conceptions of physicists, be represented as a sum carried over the atoms and electrons. The energy of a ponderable body cannot be

[16] *Vorlesungen über die Theorie der Wärmestrahlung*, p. 156.
[17] *Vorlesungen über die Theorie der Wärmestrahlung*, p. 154, 156, 162,

> subdivided into arbitrarily many or arbitrarily small parts, while the energy of a beam of light from a point source (according to the Maxwellian theory of light or, more generally, according to any wave theory) is continuously spread (over) an ever increasing volume.
> …
> It seems to me that the observations associated with blackbody radiation, fluorescence, the production of cathode rays by ultraviolet light, and other related phenomena connected with the emission or transformation of light are more readily understood if one *assumes* that the energy of light is discontinuously distributed in space. In accordance with *the assumption to be considered here*, the energy of a light ray spreading out from a point source is not continuously distributed over an increasing space but consists of a finite number of *energy quanta which are localized at points in space, which move without dividing, and which can only be produced and absorbed as complete units.* (My italics)[18].

There are two aspects of this passage, which must interest us here, one methodological, the other conceptual. Keeping them apart will be important.

First about method. Einstein said he was proposing an 'assumption'. He assumed 'that the energy of light is discontinuously distributed in space'. He did not start from a truth believed to be certain but, on the contrary, from a mere hypothesis. Its justification was to be examined only afterwards by its results.

Planck and Einstein were writing at almost at the same time as we saw, but from the point of view of methodology the difference between them was remarkable. Planck had already found his radiation formula, but considered it unsatisfactory as long as it stood on empirical findings alone. That was why he searched for a way of deducing it *from other axioms* and assumed the constant *h* to be one of them. Einstein, by contrast, refrained from basing his hypothesis on any reasons at all. He only relied on the power of persuasion of the deductions that would *follow* from it. His heuristic method thus seems to mark him as a modern proponent of critically rational science in the sense of Popper´s theory, a scientist taking up new hypotheses unprejudiced, and criticizing them only subsequently at the hands of experience.

That remarkable progress, however, was undone again forthwith by Einstein´s conceptual inconsistency. He converted Planck´s abstract 'quantum of action' into a plurality of 'quanta of energy'. In his understanding they stood for amounts of energy 'localized at points of space', and they could even 'move without dividing'. They had properties belonging only to real things. Thus, whereas Planck´s constant *h* stood for an abstract quantity, Einstein´s quantum of energy clearly stood for an empirical entity[19].

What follows from this shift of meaning? Logical mistakes happen not only at the level of abstract concepts or rules of logic. In fact, they rarely happen at that level, especially after the invention of computers that make no mistakes at the level of the binary code. In real life, logical mistakes mostly arise from situations where some conceptual content had been allocated to some term and the allocation was not upheld in the further course. The process of connecting some concept with a specific meaning thus creates a source of error to which scientists must pay careful attention, especially when expressing their ideas in mathematical formulae. The application of the rules of logic consists *only* in allocating to the words or signs occurring in language or in mathematics some specific meaning which we want them to convey in some context, and in *retaining* that meaning in that context. Apart from being at the level of the mind, this process of connecting

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[18] Einstein, *Über einen die Erzeugung und Umwandlung des Lichts betreffenden heuristischen Gesichtspunkt,* p. 132. - The quotation is from the official translation in American Journal of Physics (v. 33, n. 5, May 1965, *Concerning an Heuristic Point of View Toward the Emission and Transformation of Light*), but at the end of the first sentence I have added the word '(over)' which seems to have been omitted. In that sentence, Einstein´s German text has the word 'Summe,' which should correctly be translated by 'sum'. Translating it by 'volume' in the official translation in fact is better than Einsteins original, but it no longer shows that he was not keeping apart mathematics and physics.

[19] This shows also at the end of his paper, where Einstein spoke of 'light quanta'. He began his discussion of Planck´s theory by speaking of 'Elementarquanta' (p. 136), then of 'movable points of any kind' (p. 141), then proposed that light might consist of 'energy quanta' that are independent of one another (p. 143), and ended up by speaking of 'light quanta' that could be absorbed or cause ionisation of molecules (p. 148).

words with a meaning is not very different from sticking a label on a glass of jam. We ourselves connect words such as 'quantum', or abstracts such as *x, y, z,* with sets of facts, for example by denoting the velocity of light by *c*, or energy by *e,* or Planck´s constant by *h*. That is what gives them their meaning. They stand as symbols for something not identical with themselves. With every application of that kind we leave the field of 'pure' mathematics, or of 'formal' logic. And by doing so we create a source of error not existing before.

Einstein repeatedly made mistakes of that type. Even in the case of quantum theory he used identical expressions in different meanings within one context. He shifted the meaning of his concepts without declaring that, and took back half of that shift the next moment, making things even worse thereby.

In his light quantum theory he converted Planck´s singular abstract 'quantum of action' to a plurality of 'energy quanta which are localized at points in space', and which could even 'move without dividing', thereby transforming it from an abstract quantity into an empirical entity. Yet he retained *part* of Planck´s original meaning by continuing to assume that his newly introduced 'energy quanta' could 'only be … absorbed as complete units'.

Einstein thus *in fact introduced the indivisibility of his 'quanta of energy' without stating any reason for that, and even though no one else before him had ever given any reason for their being indivisible.* Planck never discussed indivisibility as we saw. In his view the quantum of *action*, standing for a product of energy and time[20], was an elementary constant of nature, its indivisibility needing no further justification therefore. Einstein seems not to have noticed that however. At any rate he did not introduce his assertion that the quanta of energy could 'only be … absorbed as complete units' as a hypothesis to be tested by experiment. Instead, he gave the impression as if they still were the same entities as the one introduced by Planck. He must have believed that Planck had deductively justified the indivisiblity of his quantum of action.

That belief would have been mistaken. If Planck had defined his natural constant *h* as standing for a quantity of real energy, therefore as an empirical entity, then he would have had to explain from the outset why he assumed it to be indivisible. Why, after all, should there be a limit to the smallness of energy impulses? Had not Maxwell´s theory started from exactly the opposite assumption that energy will increase or decrease continuously and can be divided infinitely? Yet, even if there were a limit to divisibility, why should it be at $h = 6.548 \cdot 10^{-27} erg \cdot sec$? All that could hardly be explained to anyone at first glance. Considerable efforts would at least have been needed for making it credible to physicists or other readers, and the probability of convincing a majority of scientists would have been low.

It never came to that however. Due to his axiomatic understanding of science, Planck never thought it necessary to state any reasons at all for the indivisibility of *h*. And Einstein, in the introduction of his paper, summarily and without any explanation, presupposed the quantum to be indivisible, and not to be *designating* an abstract quantity of energy, but *being* energy itself. He confused language and reality, or mathematics and physics, at this point, and thereby invalidated all other conclusions drawn from his hypothesis of the existence of a quantum of energy. In Einstein´s theory, Planck´s *calculatory* entity of the fundamental constant *h* became the *physical* entity of a concentration of energy, which he assumed to be the smallest possible in nature. Without any justification he denaturized Planck´s 'quantum of action' into a plurality of 'quanta of energy', and that was not all. Einstein´s energy quanta even could move about in space, as the text last quoted shows. They were nothing but light particles. At the end of his paper he himself even spoke of 'light quanta'[21], indicating thereby that they were the 'photons' of modern terminology. At bottom, his light quantum hypothesis thus meant returning to Newton´s particle theory of light which had been given up in the 19th Century because several physical phenomena of light could be explained satisfactorily only through a wave theory relying on the ether hypothesis.

[20] Planck, *Vorlesungen über die Theorie der Wärmestrahlung*, p. 153, 154; *Vorträge und Erinnerungen*, p. 26.
[21] Pp. 144-147

(*c*) From the point of view of scientific method, there would have been no objection to resuming the particle theory of light, provided Einstein had done it openly and explicitly. Qualified discussions of conflicting theories of physics are the very motor of science. An open dispute between adherents of the wave theory of light relying on the ether hypothesis, and those proposing a new variety of Newton´s particle theory of light might have been very stimulating.

Einstein´s denaturation of quantum theory was neither explicit nor open however. The shift of meaning from which he started in his new theory, was well hidden in premises he assumed to be true without explaining them. He probably never noticed that with his light quantum hypothesis he already had left again the ground on which Planck had built his theory. In his paper '*Concerning an Heuristic Point of View Toward the Emission and Transformation of Light* (1905), he mentioned Planck´s natural constant *h* not even once. Accordingly, the size of the quantum of action, which Planck had calculated at $h = 6.548 \cdot 10^{-27} erg \cdot sec$, appeared nowhere in that paper. That could hardly have escaped Planck´s notice, but he seems to have been unable to articulate his qualms and to communicate them to others.

We thus face the amazing fact that from Max Planck´s first presentation of the quantum hypothesis in 1900 to the present day *no one ever established the indivisibility of the quantum*. Planck himself had not established it because he believed his quantum of *action* to be an elementary quantity based on mathematical deduction. Einstein, however, believed justifying indivisibility to be unnecessary because he relied on Planck´s deduction, which did not exist. Nevertheless he shifted the meaning of the concept 'quantum' by transforming Planck´s *abstract* quantity into a plurality of *physical* entities, which he then named 'quanta of energy' and treated as such.

Experimental investigation would have been of utmost importance therefore. But Einstein did not notice the shift of conceptual meaning he had caused, and others followed him uncritically. The hypothesis of the quantum being indivisible thus evaded discussion for more than a century.

II. The Theory of Relativity

Einstein´s Theory of Relativity was another of the fundamental errors of theoretical physics[22]. Non-physicists usually not even pretend being able to understand it, but most physicists hold it to be true beyond question, or at least the Special Theory. Finding one willing to explain it to others is next to impossible however.

There is a simple explanation to that situation. *Nobody* can understand the Theory of Relativity, not even the Special Theory, because it rests on a mathematical mistake that remained undiscovered in a whole century. This mistake can be *proved* in the strictest sense of that word.

1.

Einstein first published his Special Theory of Relativity in 1905 in his paper *On the Electrodynamics of Moving Bodies*[23]. At its beginning, he explained that a physical theory starting from the concept of 'absolute rest' must lead to asymmetries when applied to moving bodies. He convincingly based that on empirical examples, and then assumed that 'the same laws of electrodynamics and optics will be valid in all frames of reference for which the equations of mechanics hold good'. Then he raised this 'conjecture' (the purport of which he called the 'Principle of Relativity') to the status of a 'postulate' and introduced also another 'postulate' consisting in the assumption

[22] For the following see also my *Einstein, Popper and the Crisis of Theoretical Physics* (2015), pp. 215ff.
[23] Albert Einstein, *Zur Elektrodynamik bewegter Körper* (On the Electrodynamics of Moving Bodies), Annalen der Physik vol. 17 [1905], p. 891 ff. The translation used here is from '*The Principle of Relativity* published by Methuen & Co. (1923).

> 'that light is always propagated in empty space with a definite velocity *c* which is independent of the state of motion of the emitting body.'

Its usual label is now 'principle of the constancy of the speed of light'. In § 1 of his paper Einstein then defined the simultaneousness of two events happening at points *A* and *B* of a system of coordinates with 'clocks' at those points. He began by saying:

> 'In order to render our presentation more precise and to distinguish this system of co-ordinates verbally from others which will be introduced hereafter, we call it the "stationary system."

His ensuing definition of 'simultaneousness' thus *explicitly* referred to the points of space of a system *at rest*. That will be important because Einstein later transferred that definition to a moving system although he had introduced it only for the stationary system. At first, still discussing the system at rest, he continued like this:

> 'But it is not possible without further assumption to compare, in respect of time, an event at A with an event at B. We have so far defined only an "A time" and a "B time." We have not defined a common "time" for A and B, for the latter cannot be defined at all unless we establish *by definition* that the "time" required by light to travel from A to B equals the "time" it requires to travel from B to A. Let a ray of light start at the "A time" t_A from A towards B, let it at the "B time" t_B be reflected at B in the direction of A, and arrive again at A at the "A time" t'_A. In accordance with definition the two clocks synchronize if

(1) $$t_B - t_A = t'_A - t_B$$

. . .

> In agreement with experience we further assume the quantity

(2) $$\frac{2\overline{AB}}{t'_A - t_A} = V$$

> to be a universal constant—the velocity of light in empty space.'

(*a*) Einstein´s mathematical mistake begins in equation (2), the definition of *V*, standing for the speed of light in empty space. Its denominator ($t'_A - t_A$) denotes the *time* light takes on its way from *A* to *B* and back to *A*. Its numerator ($2\overline{AB}$) however, expressing the *distance* of transport, does not refer to the distance from *A* to *B* and back to *A* but *doubles* the distance from *A* to *B*.

Einstein must have assumed the ways from *A* to *B* and back to *A* to be equal, but that would be correct only in a system at rest. In a moving system it is not true because light takes *time* on its way, and the system is moving during that time. That has nothing to do with the constancy of the speed of light but only with the distance it travels. The following diagram shows that the ways of light in a stationary system are different from those in moving system.

A_1	Position (1): stationary system	B_1

↔ Way of light signal in the stationary system (both ways) ↔

A_2	Position (2): moving system at reflection of light in B_2	B_2

→ Way of light signal from A_1 to B_2 in the moving system →

A_3	Position (3): moving system at return of light signal to A_3	B_3

← Way of light signal from B_2 to A_3, moving system ←

The way of the light signal from A_1 to B_2 is longer than that on its return from B_2 to A_3. Even if the speed of light in a vacuum really were constant, independent of the motion of its source, Einstein´s equation (1) still would not apply to a moving system.

Einstein must have overlooked that. His definitions of 'simultaneousness' and of the speed of light in equations (1) and (2) explicitly referred to the system *at rest*, as we saw. Nevertheless, in the next section of his paper, § 2 headed '*On the Relativity of Lengths and Times*', he transferred those definitions unchanged to a moving system *AB* at the ends of which there were again to be clocks. *V* still stood for the speed of light, and *v* stood for the velocity of the moving system. He wrote there:

> 'We imagine further that with 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*. Let a ray of light depart from *A* at the time t_A, let it be reflected at *B* at the time t_B, and reach *A* again at the time t'_A. *Taking into consideration the principle of the constancy of the velocity of light* we find that
>
> (3) $$t_B - t_A = \frac{r_{AB}}{V - v}$$ and
>
> (4) $$t'_A - t_B = \frac{r_{AB}}{V + v},$$
>
> *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.
>
> So we see that we cannot attach any "absolute" signification to the concept of simultaneousness, but that two events which, viewed from a system of co-ordinates, are simultaneous, can no longer be looked upon as simultaneous events when envisaged from a system which is in motion relatively to that system.' (My italics).

This text shows that Einstein did not act unintentionally when he transferred the definitions he had made in equations (1) and (2) *AB* to the moving system. On the contrary, he even gave specific reasons for that transfer. By referring to 'the criterion established in § 1 for the synchronization of two clocks', he *explicitly* pointed to equation (1). His 'taking into consideration the principle of the constancy of the velocity of light' could only mean that this principle was to apply also to the moving system. Otherwise that statement would have been meaningless.

Any doubts remaining after that will be removed by a footnote on page 896 of Einstein´s paper which he made for explaining equations (3) and (4)[24]. It reads like this (with my italics for text put in quotation marks by Einstein):

> '*Zeit* bedeutet hier *Zeit des ruhenden Systems* und zugleich *Zeigerstellung der bewegten Uhr, welche sich an dem Orte, von welchem die Rede ist, befindet*'.
>
> In English: '*Time here* stands for *time of the system at rest* and also for the *position of the hands of the moving clock which is at the place under discussion*'.

He could have expressed himself more clearly of course[25]. Nevertheless the words 'und zugleich' ('and also') leave no doubt that the meaning of *t* and *t´* in his formulae (3) and (4) was to be the same as that in the system at rest, which is that of equation (1). He also explicitly said he was

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[24] Some English translations of the paper do not have that footnote.

[25] Giving the same meaning to the terms 'time' and the 'hands of a clock' confuses time with an instrument for measuring it. Einstein´s paper may have been the origin of that mistake which modern textbooks still repeat.

applying this identical concept to the system at rest *and* to the moving system. Otherwise his equations (3) and (4) would have been undefined.

(*b*) In this compressed presentation the self-contradiction in Einstein´s reasoning is obvious[26]. The expressions on the left sides of (3) and (4) are the same as those on both sides of (1). By the rules of algebra we can therefore insert the right sides of (3) and (4) in (1), which gets us

(5)
$$\frac{r_{AB}}{V-v}=\frac{r_{AB}}{V+v}$$

Eliminating the identical numerators on both sides reduces that to

(6a,b) $V - v = V + v$ or $+v = -v$

That *proves* the self-contradiction in Einstein´s Theory of Relativity.

(*c*) Einstein´s mistake consisted in not heeding his own definition of the speed of light V in equation (2) when he denoted 'the length of the moving rod measured in the stationary system' by the sign r_{AB} in equations (3) and (4). The sign r_{AB} expresses the same as expression $\overline{AB}$ in equation (2). Einstein only used different signs for denoting the same meaning in the moving system and in the system at rest. However, the numerator of equation (2) doubles the distance $2\overline{AB}$ from A to B whereas its denominator $t'_A - t_A$ measures the speed of transport by the time taken by light on its way from A to B *and back to A*. His definition of V in equation (2) therefore actually defined the speed of light not as a *constant* velocity but as an *average* velocity on different tracks and in opposite directions. In a system at rest, that makes no difference, but in a moving system it is crucial. The above diagram shows that.

This self-contradiction brings down Einstein´s Special Theory of Relativity and also his General Theory of Relativity, which was but an extension of the Special Theory, intended to make it applicable not only to constant motion on straight lines but also to accelerated or decelerated motion on curved lines. He had based it on the same premises as his Special Theory, hence also on the same self-contradiction. The breakdown of his Special Theory therefore invalidates also all inferences drawn from the General Theory. If we assume contradicting premises to be true in spite of their being contradictory, then we can draw from them with seeming logical correctness *any conclusion whatever*. That is universally accepted, in logic as well as in mathematics. It can even be *proved* in the strictest sense of that word [27]. All conclusions drawn from the Theory of Relativity, Special or General, are random therefore.

2.

Against this, some theoretical physicists try to argue that in the meantime so many experiments have confirmed the results of the Theory of Relativity that the question of its theoretical foundation has become irrelevant. They claim the state of evidence to be so obvious that there is no point anymore in calling the theory itself into question. Some will even contend that the Theory of Relativity is permanently being applied in the navigation of satellites and missiles, and that it has proved to be indispensable there. I have often heard allegations of that kind, but rarely seen them in writing.

a) The experiment made by Hafele and Keating is one of the rare exceptions. In 1971, those U.S. physicists let four highly precise Cesium clocks travel round the earth in fast aeroplanes, two each

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[26] For details see also my *Einstein, Popper and the Crisis of Theoretical Physics* (2015), p. 235-247.
[27] Karl Popper, *What is Dialektic?* (*Conjectures and Refutations* [1963], pp. 312ff.).

in eastern and western direction, and then compared them with reference clocks of identical construction that had always agreed with them before the flights[28].

It turned out that the indications of the clocks that had moved were in fact different from those remaining stationary. That seemed to agree with the Special Theory. But the predicted delay showed only in eastern direction whereas the clocks travelling westward had been accelerated. The Theory of Relativity, however, claims that compared to the system at rest the time of the moving system will always be decelerated, independent of the direction of motion. In his paper, Einstein had stated that in the following words:

> 'If one of two synchronous clocks at *A* is moved in a closed curve with constant velocity util it treturns to *A*, the journey lasting t seconds, then by the clock which has remained at rest the travelled clock at its arrival at *A* will be ½ tv^2/c^2 second *slow*. Thence we conclude that a balance clock at the equator must go *more slowly*, by a very small amount, than a precisely similar clock situated at one of the poles under otherwise identical conditions.'[29] (My italics).

An acceleration of time clearly was incompatible with Einstein´s own understanding of his theory. Hafele/Keating nevertheless saw things differently. They wrote[30]:

> 'Consider a view of the (rotating) earth as it would be perceived by *an inertial observer looking down on the North Pole from a great distance*. A clock that is stationary on the surface at the equator has a speed $R\Omega$ relative to nonrotating space, and hence runs slow relative to *hypothetical coordinate clocks of this space* in the ratio $1- R^2\Omega^2/2c^2$, where R is the earth´s radius and Ω its angular speed. On the other hand, a flying clock circumnavigating the equator near the surface in the equatorial plane with a ground speed v has a coordinate speed $R\Omega + v$, and hence runs slow with a corresponding time rate $1- (R\,\Omega + v)^2/2c^2$. Therefore, if τ and τ_0 are the respective times recorded by the flying and *ground reference clocks* during a complete circumnavigation, their time difference, to a first approximation, is given by $\tau-\tau_0 = (2R\,\Omega v + v^2)\,\tau_0/2c^2$. Consequently, a circumnavigation in the direction of the earth´s rotation (westward, $v>0$) should produce a time loss, while one against the earth´s rotation (eastward, $v<0$) should produce a time gain for the flying clock if $v \sim R\,\Omega$.' (My italics).

(*b*) The logical mistake in that reasoning is obvious. When deriving their formula for calculating time dilation, Hafele/Keating had assumed the perspective of 'an inertial observer looking down on the North Pole from a great distance'. My italics show that. The observer himself was to be at rest therefore, because otherwise he would not have been 'inertial'. In their experiment however, Hafele/Keating did not comapare the airborne clocks with an inertial observer but with 'ground reference clocks', resting near the equator and therefore *rotating with the earth*. In both directions, the transport took more than 24 hours in flight for one circumnavigation. The rotational speed of the earth´s surface was higher than the speed of the planes over ground. Even the planes *flying* eastwards were *rotating* westwards therefore. Relative to the 'inertial observer looking down on the North Pole from a great distance' their speed could have been negative ($v < 0$) only if the observer himself had been spinning on the prolongation of the pole axis, but in that case he would not have been 'inertial'. The calculations made by Hafele/Keating were fallacious because they did not take into account the speed of the stationary clocks caused by the earth´s rotation.

That is not the only mistake they made. The more fundamental question is what their experiment had to do with the theory of relativity. Clocks *are* not time but instruments for measuring it. A clock going fast or slow goes wrong. If a stationary clock correctly compares the position of the sun to that of the earth but runs differently after orbiting the earth, then something

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[28] J.C. Hafele/R.E. Keating, 'Around-the-World Atomic Clocks: Predicted Relativistic Time Gains', S. 166; dieselben 'Around-the-World Atomic Clocks: Observed Relativistic Time Gains', S. 168.
[29] Einstein, *On the Electrodynamics of Moving Bodies*, end of § 4.
[30] Hafele, *Around-the-World Atomic Clocks: Predicted Relativistic Time Gains*, Science vol.177 (1972), p. 166.

must have happened to the clock on that orbit.[31]. The next question must be why it changed[32]. Hafele/Keating never asked themselvs that question. Yet this does nor prevent modern authors from quoting their experiment as beautifully having comfirmed the theory of relativity[33].

(*c*) Let us now look at things from the angle of theory. Can it be true that the Theory of Relativity has been confirmed by experiments? Is it possible that it is permanently being applied in the navigation of satellites and missiles, and that it has proved to be indispensable there? How can a theory be confirmed empirically if it rests on a self-contradiction?

Mathematicians and logicians generally acknowledge that from contradicting premises *any inference whatever* can be drawn with seeming consistency. Even if the procedure of inference was correct, the result will nevertheless be invalid. In his paper *What is Dialectic*, Karl Popper put that like this:

> 'If two contradicting statements are admitted, any statement whatever must be admitted; for from a couple of contradicting statements any statement whatever can be validly inferred.' [34]

He even *proved* that, and nobody contradicted him. All inferences drawn from contradicting premises are invalid and therefore random.

If we assume the Theory of Relativity to be true in spite of its self-contradiction, then that would thus raise the question whether the rules of logic and mathematics apply also to experimental physics. Einstein´s Theory of Relativity probably was the most mathematical theory ever proposed for solving a problem of physics. But how can a theory claim to empirical truth if it relies on mathematics but accepts a mathematical self-contradiction? If the allegation were true that the Theory of Relativity is permanently being applied in the navigation of satellites, and that it has proved to be indispensable there, then we would have to distinguish its empirical confirmations from the random results inferred from its contradicting premises. But how are we to do that? And how can we *observe* the 'proper time' of a satellite?

A thought experiment may help to explain the problem. Let a missile take off from the prime meridian at Greenwich on some random day but precisely at the moment when the sun is at the apex of its path there. By the definition of Greenwich Mean Time that would be 12.00 *h* sharp. The missile is to be equipped with propulsion systems which we control from the earth. We let it make a fast journey through space and return to Greenwich where it falls into the Thames again precisely on the prime meridian and precisely when the sun is at its apex there. Greenwich Mean Time now is 12.00 *h* sharp again, but according to the Special Theory the 'proper time' of the missile would have to be different. How can we establish that? The clocks in the emissile might have been exposed to the same effect as those in the Hafele/Keating experiment. Can we establish the relativity of time just by observing the missile? Or would we not at least need a unit of measurement for observing and describing the difference between Greenwich Mean Time and the 'proper time' of the missile? In the long history of relativity nobody ever answered those questions.

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[31] The same confusion of time and the instrument used for measuring it shows also in A. P. French´s discussion of time dilation (A. P. French, *Special Relativity*, ed. 1997, p. 101-104). French there reports of an experiment using mesons as an instrument for measuring time and yielding different results at the top of Mount Washington than at sea level. Before attributing that to a difference of time measured by comparing the position of the earth to that of the sun he would have had to make sure therefore that their behaviour on the top of Mount Washington would be *the same* as that at sea level.

[32] In the Hafele/Keating experiment the most obvious explanation seems to be that ether wind had caused the effect. In *Section III*, we will see that moving against the direction of the earth´s rotation will increase the velocity of matter relative to ether. - In French´s experiment (see previous note) the difference of altitude may have caused the mesons to behave differently. Under the assumptions made in *Section III* that is to be expected.

[33] Jürgen Brandes, Die relativistischen Paradoxien und Thesen zuRaum und Zeit (1995), p. 38; Hubert Goenner, Einsteins Relativitätstheorien (1997), p. 46.

[34] Karl Popper, *Conjectures and Refutations* (1963), p. 317,

3.

The Theory of Relativity has been refuted theoretically and empirically. It rested on a mathematical self-contradiction, but Einstein´s fundamental error lay not at the level of mathematics but at a deeper level, showing best in what he did *not* discuss in his papers. His omissions, for once, deserve more attention than his actual statements at this point. For seeing that, we must consider not only his paper *On the Electrodynamics of Moving Bodies* but also that *Concerning an Heuristic Point of View Toward the Emission and Transformation of Light* for which he received the Nobel Prize in 1922[35].

(*a*) Both papers were on the theory of light, which had relied on the ether hypothesis since the times of Huygens (1629-1695) and Newton (1643-1727). Einstein, however, wanted to show that 'the introduction of a "luminiferous ether" (would) prove to be superfluous' [36]. A responsible-minded scientist would have paid special attention to the phenomena of light in that situation. It had been Roemer´s discovery of the finite speed of light (1675), after all, which convinced so many scientists of later centuries that light must have a carrier, and that the ether hypothesis must therefore be true. Further discoveries, among them those of polarization and of interference, had given even more power of persuasion to that hypothesis.

Nothing like that happened however. Einstein had not mentioned those phenomena in his paper *Concerning an Heuristic Point of View Toward the Emission and Transformation of Light*, and he not even hinted at them in his paper *On the Electrodynamics of Moving Bodies*. He neither explained how light could propagate through a vacuum without a carrier, nor did he mention Young´s double slit experiment which had led to the discovery of light interference, nor the phenomenon of polarisation, also understandable only through a wave theory of light. Huygens´ and Faraday´s attempts at explaining light in analogy to sound got no mention. All the important discoveries of the 19th Century relating to light and radiation were left unexplained in those papers.

(*b*) Evading the most important counter-arguments in a scientific treatise would normally be considered non-serious in any science. Anyone wanting to protect Einstein from that accusation can only refer to his understanding of science, which must have been different from that prevailing in our days. I, at least, could name no other excuse for leaving unmentioned *all* the counter arguments known at the time. This one, however, shows also his limitations.

When Einstein wrote his famous papers in 1905, he was a young scientist aged 26 years. One of his teachers at the Polytechnikum in Zürich may have put him on the wrong track. At any rate, he must have lost himself completely in the clutter of mathematical theorems and physical theories of his time, and his contact with the empirical side of physics must more or less have broken down. Many young scientists pass through such stages in their development. The odd aspect of Einstein´s case is that other theoretical physicists did not notice his mistakes, and, instead of criticizing him, styled him a genius.

It was the spirit of those times that would have it like that. Geniality was the pet of the age, believed to be given not by learning and imagination but by nature itself, though only to the elect. One did not know then that in empirical science discoveries consist in introducing new information in the shape of hypotheses 'explaining the known by the unknown'[37]. Karl Popper was to show only decades later that an empirical explanation must consist in introducing empirical information going beyond that to be explained. The *explicandum* must be known because otherwise we could not be looking for an explanation of it; and the *explicans* must be unknown, at least to the persons we are addressing, because otherwise they would need no explanation. That is why explanations

[35] Albert Einstein, *Über einen die Erzeugung und Umwandlung des Lichts betreffenden heuristischen Gesichtspunkt*, Annalen der Physik vol. 17 (1905), p. 132 ff. (*Concerning an Heuristic Point of View Toward the Emission and Transformation of Light*, American Journal of Physics, v. 33, n. 5, May 1965).
[36] Those were his words in the introduction of *Zur Elektrodynamik bewegter Körper* (On the Electrodynamics of Moving Bodies).
[37] Karl Popper, *Realism and the Aim of Science* (1983), p. 132.

cannot be gained by mere mathematical or logical deduction from the known *explicandum*, and it also is why computers can neither explain anything nor make discoveries 'explaining the known by the unknown'.

(*c*) All this is a matter of course in our time, or at least it should be so, but Einstein lived in a different age. He did not even try to *explain* the constancy of the speed of light, which he presupposed. Nor did he try to explain the phenomena of polarization and interference, because explaining them would have required introducing new hypotheses such as the ether hypothesis. It would have clashed with his understanding of physics as an 'exact science'.

I think anyone looking for *explanations* in Einstein´s papers would have misunderstood him. All he tried to achieve in those papers was setting up mathematical approaches for correctly *describing* the phenomena of light. He had realized that Maxwell´s equations lead to ‚asymmetries' when used for describing within one system of coordinates several physical bodies moving realtive to each other[38]. And he must have believed that the solution of this problem could only consist in treating the constant of 'time' as a variable, and treating the variable of the 'speed of light' as a constant. And since he could not establish those assumptions deductivly, he raised them to the rank of 'postulates'. They were the axioms on which he based his theory. He did not draw the line between the non-empirical method of logic and mathematics and the empirical method of trial and error in empirical science.

Einstein must have thought he could solve the problems of the speed of light by purely mathematical means. He must have believed nature to be *per se* following the rules of mathematics, mathematics being an element of nature therefore, and integrated in it as it were. His famous words 'God does no throw dice' indicate that. Besides, we met similar views with Max Planck in *Part I* of this essay. They, too, were elements of the spirit of those times, and they were the reason why Einstein assumed the speed of light to be a constant. They also were the reason why he did not distinguish between descriptions and explanations. Two short quotations from his paper on *Geometry and Experience* show that. He wrote there[39]:

> 'But if we conceive Euclidean geometry as the science of the possibilities of the relative placing of actual rigid bodies and accordingly interpret it as a physical science, and d*o not abstract from its original empirical content*, *the logical parallelism of geometry and theoretical physics is complete*.'
>
> …
>
> 'Our experience up to date justifies us in feeling sure that in Nature is actualized the ideal of mathematical simplicity. It is my conviction that pure mathematical construction enables us to discover the concepts and the laws connecting them which give us the key to the understanding of the phenomena of Nature. Experience can of course guide us in our choice of serviceable mathematical concepts; it cannot possibly be the source from which they are derived; experience of course remains the sole criterion of the serviceability of a mathematical construction for physics, but the truly creative principle resides in mathematics. *In a certain sense, therefore, I hold it to be true that pure thought is competent to comprehend the real*, as the ancients dreamed.' (My italics).

The words in italics show that Einstein believed in an 'original empirical content' of geometry, and in a 'logical parallelism of geometry and theoretical physics'. He did not see that logic, algebra and geometry are not at the level of physical reality but part of human *language*, although the development of non-Euclidean geometries in the 19th Century had once more shown that the standard for gauging geometry is not truth but expediency.

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[38] Einstein *Zur Elektrodynamik bewegter Körper*, p. 891.

[39] Albert Einstein, *On the Method of Theoretical Physics*, Philosophy of Science, Vol. 1, No. 2, (Apr., 1934), pp. 163ff., 165,167.

The so-called 'rules of logic' consist in connecting with a meaning some of the most simple and therefore most important words of our language, words like 'is', 'and', 'or', 'only', 'all', 'no', 'not', 'if ... then', 'true', 'false' &c. The same holds for the rules of mathematics. They only replace by shorter signs some of the longer verbal expressions of our language[40]. This process of connecting words or signs with a meaning is also a personal decision. We make it, and we communicate to others, for instance by saying or writing 'in this context *c* stands for *speed of light*' or '*:* stands for *divided by*', or by drawing a line along a ruler and calling it 'straight line'. All mathematical and geometrical methods are *creations of the human mind* thus, very useful, but unfortunately creating also new sources of error. We may lose sight of the meaning we once gave to some sign, and that may influence the results of our deductions. Einstein often fell victim to that danger. Even the few sentences just quoted show that he did not clearly draw the line between empirics and mathematics. The reason must have been in his understanding of mathematics.

If Einstein believed mathematics to be an element of nature itself, then, from his point of view, it would seem logical also to believe that if he had properly described some physical phenomenon in terms of mathematics, then he had also explained it thereby. He seems never to have said so explicitly. Assuming that belief would also explain, however, why on the one hand he claimed that 'the introduction of a "luminiferous ether" (would) prove to be superfluous'[41], and on the other hand he not even mentioned in his papers those phenomena of light which had convinced so many experimental physicists of the existence of ether in previous centuries. I could imagine no other explanation for that omission, and this one would at least explain the logical mistakes in Einstein´s Theory of Relativity.

III. The Attractive Force of Matter

The greatest fundamental error of theoretical physics is also its oldest. It is in trying to explain gravity as a *force of attraction*. As an approach, it is understandable because human beings experience the world through their sensory faculties, and therefore tend to consider themselves the center of everything, particularly in childhood. Since antiquity that encouraged the view that the Earth must be at the center of the universe, and that gravity must therefore be a force of attraction. From the point of view of epistemology however, this approach does not lead anywhere because the force of attraction is itself in need of an explanation, and no physicist has been able to find one so far.

The real miracle was in the fact that Copernicus succeeded in overcoming this geocentric approach at least partly by placing the Sun in the center of the universe and banishing the Earth to a place among the planets. However, even in the Copernican system, gravity remained a force of attraction, and that was the error. If we ever are to succeed in explaining 'by the unknown' also gravity itself, then we must overcome the geocentric approach altogether[42]. All attempts at explaining gravity as a force of attraction have failed. The only way out of that deadlock is by accepting that this force is not inherent in matter, but is an external force, acting *on* matter, and therefore coming from outside. Many have tried this approach too, of course, Newton himself being among the first, but none succeeded[43]. Yet there still is a way left open for improving on those older approaches.

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[40] Alfred Tarski, *Introduction to Logic and to the Methodology of the Deductive Sciences*, pp. 18ff: C. v. Mettenheim, *Einstein, Popper and the Crisis of Theoretical Physics* (2015), p. 108ff

[41] Introduction of Albert Einstein, *Zur Elektrodynamik bewegter Körper* (On the Electrodynamics of Moving Bodies), Annalen der Physik vol. 17 [1905], p. 891 ff.

[42] For 'explaining the known by the unknown' see Popper, *Realism and the Aim of Science* (1983), p. 132. I quoted that in *Part I, Section 2.*

[43] For Newton, see his letter to Boyle of Feb. 28, 1678, quoted by Florian Cajori in Appendix to *Sir Isaac Newton´s Mathematical Principles of Natural Philosophy and his System of the World*, vol. II, p. 675.

1.

There is a close link between gravity and matter. If we want to understand gravity, we must begin by trying to understand matter.

Present theory assumes matter to consist of atoms. Their history began when philosophers of antiquity wondered how a body could change and yet remain the same. The idea that matter consists of particles that can change without the body losing its identity seemed to solve that problem, but it soon led to the next one, this time ending in an antinomy. For all that was known at the time, every physical body could be split in smaller parts, but it seemed inconceivable that this process could go on forever. The philosophers of antiquity pondered deeply over this, and thought that, surely, there must be an end to splitting somewhere, and a point reached where no further division is possible. Democritos (460-370 b.C.) seems to have first seen that. Together with Leucippos he is believed to be the founder af the atom theory of antiquity, which gave to that last and indivisible particle of matter the name ‚ατομοσ', the indivisible. The atoms of present theory thus bear their name unjustly. Not only are they anything but indivisible; they also have long forgone any claim to being the ultimate components of matter.

The atomic theory resulting from those approaches relied also on another principle however, the principle of *simplicity*. Its aim was finding simple explanations of physical phenomena because only they can satisfy our need for understanding nature.

That led to the theory of elements. Empedocles (495-430 b.C.) had assumed the world to be composed of four of them, Earth, Water, Air and Fire. Aristotle (384-322 b.C.) added to them Ether as the 'quintessence', and there matters rested until Descartes (1596-1650) reduced the number of elements to only three[44]. The discoveries, made in 17th and 18th Centuries, of chemical elements with different properties but not further reducible themselves, were a setback for atomic theory therefore. But when Dalton discovered that every element is composed of 'ultimate particles' (1808), and Mendelejew and Meyer developed the periodic system of elements (1868/69), the outlines of a new and even simpler system seemed already to be getting in sight again.

That new system, however, was called in question before it had been fully developed when Michael Faraday´s discovery of electrolysis (1834) showed the necessity of distinguishing between elements and their electrical charge. That gave Lorentz the inspiration for his theory of the electron (1895), attributing the chemical properties of the elements to the atomic nucleus and the electrical charge to the electrons.

At first, one believed electrons to be randomly distributed within the atom, somewhat like the raisins in a plumpudding, or, alternatively, like springs fixed to its surface, passing on through their elasticity the electrical charge to neighbouring atoms. That was why literature of that time sometimes spoke of 'resonators'[45]. Empirical criteria for deciding between those theories were not in sight however, and when Ernest Rutherford proposed to visualize the atom like a miniature edition of our solar system (1911), he thrust into a theoretical vacuum as it were. His theory owed its breakthrough chiefly to its elegance. The planetary model of the atom is not only vivid. It also satisfies the principle of simplicity by repeating the order of our universe at the level of microphysics. In our days almost every theoretical physicist will probably believe matter to be composed of atoms consisting of a nucleus and one or more electrons orbiting it.

Nevertheless that theory, too, got into difficulties when Otto Hahn and Fitz Strassmann discovered that the atom ist not indivisible but can be split in smaller parts with physical and chemical properties different from those of the original nucleus (1938)[46]. Since then, more and more particles were discovered of which the nucleus and its surrounding hull are believed to be composed. Little remains of the once so simple planetary model of the atom. Going by the view prevailing in our time, the atom is composed of so many different particles, and different states of

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[44] René Descartes, *Traité de la Lumière*, Kap. V,(*Œuvres,* Livrairie Philosophique j. Virin (1996), vol. XI p. 1 ff., 23 ff.).
[45] For instance Max Planck, *On the Theory of the Energy Distribution Law of the Normal Spectrum,* Verhandlungen der Deutschen Physikalischen Gesellschaft No. 17 (quoted above in *Part II, 1a.*).
[46] Their former colleague Lise Meitner had already left Germany at that time due to the perscution of Jews there.

particles, that there is no question of simplicity any more. Yet gravity still remains unexplained, and apparently most theoretical physicists even agree on that[47].

From the point of view of the theory of science, there can be no objection therefore against replacing the planetary model of the atom by a simpler theory. If theoretical physics is ever to make progress again, then it will have to find a new approach to the theory of matter and to the problem of explainig gravity.

2.

Anyone searching for explanations of physical effects in this difficult situation must consider a physical principle called 'principle of locality'. Its purport is that physical effects can only be explaind by the *immediate* action of one object on another object. Descartes probably was the first to state that principle, and he made considerable efforts to observe it in his own works[48]. In our time however, there seem to be physicists who call it into question and consider it a problem[49].

If we observe the principles of Karl Popper´s methodological nominalism, then no such problem exisits[50]. From the nominalist point of view, science is not about finding the 'real', or the 'true' meaning of words or concepts. Accordingly, the problem of physical explanations is not in finding out what 'physical' really means, or what a physical explanation 'really is', or whether, for example, physical effects can be explained by psychological or by transcendent phenomena. The only question is for what kinds of explanation we use the epithet 'physical' if we want to express ourselves clearly. I consider the principle of locality an appropriate epithet for distinguishing physical explanations from other kinds of explanations. That is why in this paper I use the term 'physical explanation' only for explanations that explain physical effects by the immediate action of one object on another object.

The concept 'explanation' may also need our attention however. *Explanations* consist of two parts, the *explicandum* and the *explicans*. We saw that in *Part II, 3b* of this essay, but I must recall it here because it will be important for what follows. The information contained in the *explicandum* must be known because otherwise we would not be searching for an explanation of it. And the *explicans* must give us additional information. If the explanation is to be a discovery, then that information must be *new*. Any empirical explanation deserving the name 'discovery' must therefore consist in explaining 'the kown by the unknown'[51]. It must be invented. Only after someone invented it can we try to test its truth in experiments.

(*a*) All this applies also to gravity. Aristotle had tried to explain it as being the 'essence' of matter, which he assumed to consist in its tendency to approach the center of the earth, whereas the essence of air was to consist in its tendency to move away from that center. That was no physical explanation in the sense just stated because it gave no additional physical information but simply presupposed as being known what it pretended to explain. Nevertheless it shaped the worldview of physics for millennia. In the Ptolemaic system the earth continued to be considered the center of the cosmos and also the center of gravitation. Copernicus banished her to a place among the planets, but Newton still described gravity as a force of attraction and listed it among the 'centripetal forces'[52]. Not even he could explain it however, although he saw the difference between descriptions and explanations very clearly. That is why he left the problem of explaining gravity 'to

[47] See, for instance, Richard P. Feynman, *QED – The Strange Theory of Light and Matter*, German translation p.171; Leon Lederman, *The God Particle* (1993), German translation p.9, 528, 530; Stephen Hawking, *A Brief History of Time* (1988), p. 70, 157.

[48] According to Huygens, Descartes treated matters of physics better than anyone had treated them before him (Christiaan Huygens, *Traité de la Lumière* [1690], p.7 f.).

[49] Aspect, Grangier, Roger, *Experimental Realization of Einstein-Podolsky-Rosen-Bohm* Gedankenexperiment*: A New Violation of Bell´s Inequalities*, Phys.Rev.Lett. 49 (1982), p. 91.

[50] Karl Popper, *The Open Society and its Enemies*, vol. 2, Chapter 11, section II (pp. 9-21).

[51] Popper, ‚Realism and the Aim of Science' (1983), S. 132; see also my *Popper versus Einstein'*, p. 105 f.

[52] Cajori, *Sir Isaac Newton´s Mathematical Principles of Natural Philosophy and his System of the World*, vol. I, p.2.

the consideration of (his) readers.'[53] His outstanding achievements in other fields silenced any criticism that might have been forthcoming.

Another feature that shaped the worldview of physics for millennia was in the ancient ether hypothesis. It was not about gravity at first, but concerned only the theory of light because one could not imagine how light could travel from one place to another without some medium transporting it. Both Huygens and Newton, the greatest physicists of their time, therefore assumed some invisible substance to be filling the universe and surrounding all celestial bodies, and gave it the name 'ether'. Only Einstein and his followers believed the theory of light could do without the ether hypothesis[54].

In post-Newtonian times, some physicists tried to use the ether hypothesis also for explaining gravity. Matthew Edwards collected those theories in the volume *Pushing Gravity* some years ago[55]. They have several features in common. All of them believed matter and ether to be different substances, and assumed ether somehow to be pushing matter in the direction of the center of gravity. And none of them tried to explain other physical phenomena besides those of light and of gravity. That makes them suspects of being mere *ad hoc*-hypotheses.

We need not go into more details here because a better approach is possible, an approach that will satisfy the principle of locality and will explain not only the phenomena of light and of gravity but several others as well. I have described this approach elsewhere[56]. It resembles the theories of *Pushing Gravity* in some aspects but differs from them in others. The most important difference is that it does not assume matter and ether to be different substances, but assumes them to be *different states of the same substance*, as, for instance, steam and ice are different states of water.

The results of present atomic theory can hardly be reconciled with this approach, yet they support it in a way. For, whatever else one may think of those results: they show at least that modern atomic theory has given up the principle of searching for simple explanations. The components of which it assumes matter to consist include so many varieties that there can be no question of simplicity any more. And it still assumes motion to exist at the level of the ultimate components of matter, even where nothing seems to be moving. But if all those different particles, states of particles and families of particles did really exist, then present atomic theory could not satisfy our need for a simple and comprehensible theory of matter. We would then have to find a new theory at a deeper level, a theory that would have to include also the explanation of gravity. Returning to ether theory will open that approach.

(*b*) The ether hypothesis I am suggesting here assumes ether to be filling the whole universe, and to be in permanent motion. Most adherents of ether theory would probably agree with it up to that point[57]. My theory, however, assumes that the motion of ether does not come from inside the universe but from its *periphery*, and that it *decelerates* as ether approaches the respective center of matter.

These assumptions may seem far-fetched or even contradictory at first sight because Newtonian theory describes the effects of gravity as an *acceleration* of matter. Closer consideration will show, however, that they are plausible and necessary if we return to ether theory. They will enable us to explain gravity by the immediate action of one object on another object, therefore in accordance with the principle of locality and without giving up any of the descriptive part of

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[53] Quoted from Cajori, *Sir Isaac Newton´s Mathematical Principles of Natural Philosophy and his System of the World*, vol. II, p. 633f.

[54] See the quotation from the Introduction Einstein´s *Zur Elektrodynamik bewegter Körper* (On the Electrodynamics of Moving Bodies), Annalen der Physik vol. 17 [1905], p. 891 ff. at the end of *Part I*, above.

[55] Matthew R. Edwards, *Pushing Gravity, New Perspectives on Le Sage´s Theory of Gravitation* (2002). - Duncan Shaw´s paper *The cause of gravity – a concept* (Physics Essays 25, 1 [2012], p. 66 ff.) is the only later publication known to me and taking that approach. The text applies also to that publication.

[56] Christoph v. Mettenheim, ‚Popper *versus* Einstein' (1998), pp. 111-195; *Einstein, Popper and the Crisis of Theoretical Physics* (2015), pp. 279-316.

[57] Since the Michelson-Morley experiments no physicist seems to assume anymore that the earth is moving through an ether that is stationary.

Newtonian theory. They also open approaches to explaining by physical action not only gravity itself but several other important physical phenomena as well.

If ether is filling the universe, it must be *elastic*. Without elasticity, a universe filled with ether would have to be a static block in which motion would be impossible. Ether must also consist of *particles* moving relative to one another. If it were a homogenous substance, then we would first have to explain how motion could be possible within that substance although it is homogenous. Only a theory assuming ether to consist of elastic particles can solve that problem.

Those two qualities of ether, particles and elasticity, entail several implications. Elasticity implies motion, and motion implies time. Any elastic reaction of an ether particle to an impulse must take place with a tiny delay of time; otherwise it would not be motion in the physical sense. A delay of time, however, implies also a loss of energy because it disturbs the rhythm of elastic resonances. At the level of matter we can observe that in the device usually called 'Newton´s cradle' although naming it 'Huygens´ cradle' would be more appropriate.

Figure 2, explainig entropy: Elastic reactions imply motion, and therefore take time. The ball on the left will hit the second ball, the impulse will travel through the neighboring balls due to their elasticity. The time interval will disturb the order of resonances beetween elastic reactions. At first, only the last ball on the right will bounce off whereas the ones in between remain almost stationary. Eventually, however, the time delay between reactions will cause total disorder and loss of kinetic energy.

At the level of ether, assuming elastic ether particles thus explains not only *inertia* but also the phenomenon of *entropy*, and even the *deceleration* of ether itself.

The ether hypothesis must also assume that the velocity of ether will adapt itself to that of the earth´s atmosphere because observations point in that direction[58]. On the one hand we observe other celestial bodies moving at high velocities relative to the earth. On the other hand Michelson and Morley could never discover any influence of the earth´s motion on the velocity of light in their famous experiments[59]. If ether exists at all therefore, then it must be in motion, but adapting that motion to that of the earth´s atmosphere as it approaches. Up to this point all adherents of ether theory would probably still agree.

The fact that my theory assumes the motion of ether to be coming from outside may seem far-fetched at first glance, but that is no reason for feeling uneasy about it. The only conceivable reason would be that it conflicts with the the ancient tradition of geocentric theories. Assuming the motion of ether to be coming from outside makes it less familiar than other theories such as, for instance, Big Bang theory, but not more than that. It does not explain the origin of that external motion which it assumes, but neither does Big Bang theory explain the cause of the original explosion which it presupposes. It cannot even explain all the rotation, which we observe in our planetary system and in other galaxies, whereas the omnipresence of that rotation supports the hypothesis of the motion of ether coming from outside.

Rotation even gives rise to further interesting speculations. The universe might have originated in a head-on collision of two ether streams flowing in opposite directions. That would create torsional impulses at every point of collision which is not precisely head-on, and would

[58] According to A. P. French, (*Special Relativity* [1968], p. 45), Augustin Jean Fresnel assumed that already in 1818.
[59] Bernard Jaffe (*Michelson and the Speed of Light*, S. 76), quotes Michelson as having said: 'The hypothesis of a *stationary* ether is erroneous' (Jaffe´s italics).

therefore result in creating rotating systems at the level of ether. In the further course, that would result in rotating material systems and ultimately even in the rotation of galaxies, maybe even of the whole universe. We must leave it at that however, in order not to lose sight of our goal of explaining gravity.

3.

The few assumptions just made, of the motion of ether to be coming from the *periphery* of the universe and to be *decelerating* as it approaches the respective center of matter, will permit to explain gravity. The explanation will be simple in so far as it does not presuppose any further hypotheses beyond those just mentioned, and in so far as it repeats at the sub-material level the order of galaxies which we observe in the universe. It will not be simple in so far as it requires some power of imagination. That should not be held against it, however, because the explanation of gravity would hardly have remained undiscovered so long if it were simple.

(*a*) For understanding that explanation we now consider a single material particle moving about in the universe and, for any reason whatever, entering the gravitational field of the earth. That *material* particle is no closed body in our new theory, but consists of even smaller ether particles. We can imagine it as a tiny vortex of ether particles, rotating around a common axis like a tiny whirlwind. This rotating order is what our limited sensory faculties perceive as matter, and it explains the stability of matter, lasting as long as that whirlwind lasts.

When entering the gravitational field of the earth, that material particle will at first be surrounded by chaotic ether particles belonging to no system or to less ordered systems that have not yet arranged themselves to material systems. What is going to happen? A whirlwind will remain stable for some time until external influences cause it to collapse. Our material particle also meets with external influences in the shape of other ether particles in their immaterial state. Due to its rotation however, the order of our *material* particle will be more stable than that of the chaotic ether particles surrounding it, because the ether particles of which it consists meet with resistance from other ether particles only on the outside of the vortex, but not on the inside. *The cause of the stability of our material particle therefore is in its rotating order. All particles have the same direction, and therefore lose less energy through collisions than the chaotic particles surrounding the material vortex.*

We now assume the front of that material particle to meet with the resistance of unordered and therefore immaterial ether particles. Since its own stability is stronger than theirs is, it will have a tendency to maintain its velocity. It will lose some of that velocity in collisions with other ether particles, but not to the same extent as the chaotic ether particles surrounding it. And since the impulse of its motion is still coming from the periphery of the universe, and therefore from the outside of the material particle, it is being pushed from behind and will penetrate the chaotic ether until it meets with resistance that is stronger than its inner stability. *The explanation of gravity therefore is that the impulse of motion, which common theory ascribes to the attractive force of the earth, in fact comes from outside, and that rotating systems, due to their inner harmony, have greater forces of stability than random systems, and therefore 'overtake' them as it were.*

This explanation applies not only to the motion of matter relative to the surrounding chaotic ether but also to motion within matter itself. There, too, some systems are more organized and therefore more stable than others. Solid bodies are more stable than fluids, and fluids are more stable than gasses. That is why solid bodies can penetrate fluids and gasses until they collide with other solid bodies, for instance when hitting the surface of the earth.

(*b*) This theory explains not only gravity itself but also several other physical phenomena that remain unexplained at present. At least it opens approaches to explaining them.

That concerns not only the transportation of light, which would remain unexplained without a transporting medium. Present theory, which tries to get along without ether, also has no explanations for the transparency of glass, or for the effects of catalysers, or for those of of homeopathic medicines, whereas the principle of resonance between elastic ether particles at least opens approaches to explaining them. That same principle also opens approaches to explaining thunderstorms through ether streams of different frequencies adapting their wavelengths to new harmonious resonances in electrical discharges. And it can give a simple answer to the question of longitudinal or transersal waves. If we assume colliding ether particles to create impulses that will be transported through the elasticity of adjacent particles, then it is only natural to assume every collision to cause not only a contraction of particles in the direction of their motion but also an extension in tranversal direction, which will then result in the emission of similar but weaker impulses in that direction.

The most important effect needing explanation, however, is in the rotation of matter which we observe wherever we look, here on earth, in our planetary system and in the galaxies of the universe. Present physical theory offers no explanation for that phenomenon. It not even offers an explanation for the earth´s rotation. If the universe had really originated in a gigantic explosion, as Big Bang theory assumes, then that might explain why celestial bodies are in motion, but it would not explain their arranging themselves in rotating systems.

Assuming matter to consist of elastic ether in the shape of tiny vortices permits a simple and plausible explanation of that phenomenon. We believe to know that the inertia of matter corresponds to multiplying mass by velocity. If a ball is moving on a straight line and at the same time rotating on a transversal axis, then part of its mass is moving in the direction of that motion on a straight line and the other part against that direction. Its inertia will therefore be stronger on the 'fast' side than on the 'slow' side, and will press the motion of ball into a curve with its outer side being the 'fast' side and its inner side the 'slow' side. Newton saw that effect, and billard players, tennis players and golfers know it[60]. The same effect must exist also in the vortices of which material ether is composed because the impeding forces of the surrounding chaotic ether will be *proportionally* weaker on the 'fast' side and stronger on the 'slow' side. That quite naturally explains the spiral shape of vortices, and it also explains why material units will tend to arrange themselves in the order of rotating systems. They meet with less resistance in the order of those systems.

(*c*) Finally, we must face the question whether we can test this theory empirically. I think that will be possible.

The hypothesis that light decelerates as it approaches matter may serve as a starting point. I have already suggested two experiments by which we could put it to the test. One of them would consist in measuring the speed of light at different altitudes here on earth[61]. The other would rely on the principle employed by the Danish astronomer Roemer in 1675 when discovering the finite speed of light. He was using Jupiter´s moons as 'clocks' in that experiment, by comparing their positions at the moment when Jupiter was nearest to the earth to those at his remotest position. His measurements revealed that they varied in a rhythm of exactly six months, therefore in a rhythm not explicable by the orbits of Jupiter´s moons but only by the earth´s orbit around the sun, and therefore by the duration of light transport at greater or smaller distances. If the velocity of light *decelerates* as it approaches the earth, as my theory assumes, then measurements made at intervals of three months, or 90°, ought to show also differences in the speed of light itself.

We might leave it at that, however, because the most interesting experiment has already begun. It is in the fusion reactor ITER, presently being constructed in the south of France. That reactor is to repeat here on earth the fusion of hydrogen into helium assumed to be going on in the sun, and to use it for creating energy one day. Older versions of the ITER website correctly pointed out that the conditions of gravity prevailing on the sun cannot be simulated here on earth. That also means, however, that the conditions of *pressure* prevailing on the sun cannot be simulated

[60] For Newton, see his letter to Boyle of Feb. 28, 1678, quoted by Florian Cajori in Appendix to *Sir Isaac Newton´s Mathematical Principles of Natural Philosophy and his System of the World*, vol. II, p. 675.
[61] Michelsons experiments were made under different aspects but some of them seemed to indicate that terrestrial measurements the velocity of light depend on altitude. Cp. Jaffe *Michelson and the Speed of Light* (1971), p. 164ff.

here on earth because they would destroy the reactor. From the point of view of a theory assuming incompressible particles that aspect may seem negligible. But if matter itself consists of tiny *vortices* of *elastic ether*, then the difference of pressure on the sun and here on the earth should be decisive. That is why I do not expect the ITER experiment to succeed. But whatever its outcome may be: theoretical physics, at any rate, will only make progress again if theoretical physicists learn to accept that mathematics is not an element of nature but part of human language; it is created by man.