letters

▶ Pagels wrote that, according to the Copenhagen interpretation of quantum mechanics, "reality is partially created by the observer." I suggested in my review that this is not an accurate statement of the expressed views of Bohr and Heisenberg. I tried to characterize these views briefly but did not comment on them.

▶ It seems to me that even a brief history of an idea should not omit mention of its inventor.

In spite of my reservations about Pagels' book, I agree with Sistino that it is important for scientists to "inform the general public of the value and the fascination of physics." I commend Pagels for his efforts, and hope that the success of his book will inspire others to follow his example.

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1/83

Einstein's light postulate

I was pleased to see the translation of the speech given by Einstein in Japan in 1922 in the August issue (page 45). But it is rather doubtful that this brief speech "throws some light on the current controversy as to whether or not he [Einstein] was aware of the Michelson–Morley experiment, when he proposed the special theory of relativity in 1905," as the translator of the speech, Yoshimasa A. Ono, suggests. The speech is too brief and anecdotal in character to fulfill this function. But there are many careful studies of this topic. One of the new and more interesting is a paper written by Elie Zahar from the London school of Sir Karl Popper and Imre Lakatos, "Why did Einstein's Programme supersede Lorentz's?," which has been published in *Method and Appraisal in the Physical Sciences* (Cambridge U. P., 1976). Apart from methodological considerations, the paper is mainly devoted to very deep historical and logical analysis of the genesis of special relativity theory. The speech by Einstein presented in PHYSICS TODAY does not seem to contradict Zahar's conclusions.

Briefly, Zahar's point of view on the genesis of special relativity is that the formulation of 1905 was derived only from two postulates: (P1) Relativity Postulate and (P2) Light Postulate. The important role Einstein gave to (P2) inspired inductivists to regard the null result of the Michelson–Morley experiment as an axiom of special relativity. However, such a diagnosis disagrees both with logic and history. From the logical point of view, it is not possible to claim that an observational statement of the null result of the

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Michelson–Morley experiment implies the speed of light is universally constant in all inertial frames.

History also bears witness against the inductivistic position. If we read carefully the text of the speech from 1922 and take into account the words of Robert S. Shankland [American Journal of Physics 31, 47 (1963)]: "When I asked him [Einstein] how he had learned of the Michelson–Morley experiment, he told me that he had became aware of it through the writings of H. A. Lorentz, but only after 1905 had it come to his attention," we see there is no immediate connection between the Michelson–Morley null result, or similar experiments, and P2.

According to Zahar, the invariance of c could already be deduced from the Lorentz theory before 1905. But even the Lorentz system was not constructed to explain the Michelson–Morley result. All the formal apparatus developed by Lorentz, very useful for Einstein, had nothing to do with the Michelson–Morley experiment. The Lorentz transformation was originally only a mathematical tool. Namely, the Lorentz transformation appeared to reduce the form of the equation of electron motion in electric and magnetic fields from an arbitrary moving frame of reference to the frame at rest with respect to ether.

In a paper in 1895 Lorentz tried to give a physical interpretation of his own transformation. One step in that direction was the Lorentz–Fitzgerald contraction hypothesis. Another one was the Theory of Corresponding States. The final form of the latter theory given by Lorentz in 1904 (the paper unknown for Einstein before 1905) might be turned into a theory observationally equivalent to special relativity: from a formal point of view, Einstein differs from Lorentz in that he regards the "effective" Lorentzian variables in a moving frame of reference as the real ones and presumes only the Lorentz transformation as that which relates inertial frames.

Zahar claims that "it was not Michelson, the experimentalist, but Lorentz, the theoretician, who played a considerable role in the genesis of Special Relativity." The new heuristic point of view taken by Lorentz as well as mathematical tools developed by Lorentz taught Einstein to deal with the formalism of electrodynamics of moving bodies.

Independently of questions related to the Michelson–Morley experiment, one can ask why P2 is one of the two axioms of SRT and not for example P3 "The Maxwell–Lorentz equations express a law of nature." Of course, the latter was Einstein's starting point, historically and epistemologically. Moreover, the formulation of P2 is in disagreement with Einstein's heuristic requirement of coherence.

Zahar resolves the question as follows: P2 is the weaker formulation than P3; it is implied by conjunction of P1 and P3. The postulates P1 and P2 are sufficient to generate a new kinematics and to derive the Lorentz transformation; Einstein probably did not want to make his space–time theory dependent on a macroscopic theory (Maxwell electrodynamics).

The above remarks are only a brief digest of the very deep study given by Zahar. He treats not only the foundations of special relativity but also the foundations of the general theory. His work deserves to be better known among physicists.

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THE TRANSLATOR COMMENTS: Contrary to T. Grabińska's comment, my intention in translating Einstein's lecture at Kyoto in 1922 is fulfilled; this speech has indeed thrown some light on the current controversy as to whether or not Einstein was aware of the Michelson–Morley experiment when he proposed the special theory of relativity in 1905. The letter of Grabińska is one example of a proof.

Since my paper is essentially a translation of Einstein's lecture with an introduction explaining the background matter of the lecture, I did not try to discuss how the Michelson–Morley experiment influenced Einstein's thought in developing the special theory of relativity. In dealing with the point mentioned above, Einstein's recollection in 1922 at Kyoto should be taken into account.

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Systems of units

Having received my *Physics Vade Mecum*, it was with pleasure that I noticed the imperial system of units has at last been reduced to 4 pages of conversion tables. I received my university education using imperial units backed up with cgs, mks and even made-up units to try and achieve consistency within each system. Now that Australia is one of many countries that have adopted the SI system of units, I find it convenient not to buy books that are cluttered with data and formulae in units other than SI units. SI units are so simple and consistent that problems of distinguishing between force and mass and deciding on what length unit is required for a particular calculation no longer exist—except in American textbooks (even though I understand the US is adopting the SI system).

It was thus with disappointment that I noticed cgs units intruding into the *Physics Vade Mecum*. It was with shock I noticed centimeters appearing nearly everywhere in the book. The SI system has a preferred ratio of 10^3 between units with different prefixes, and so cm is not a preferred unit. Neither are dynes, bars, or even hp appearing on page 64 with rpm. The unit of surface density oz/yd^2 appearing on page 65 would have to result in acoustics appearing to be witchcraft rather than physics if only because the unit appears to be so antiquated.

May I suggest that in any future *Vade Mecums* the editor should adopt one system of units, namely SI, saving space and confusion with a much more useful publication.

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THE AUTHOR COMMENTS: We appreciate David Eden's view that it would be very nice if there were only one system of units. We could then do away with conversions and conversion tables altogether, saving space and confusion, as he points out.

We considered the question of units very seriously when we were composing the *Vade Mecum*. The problem is that only a fraction of the physicists who write in the AIP journals use SI units. In fact, in *Physical Review* and *Physical Review Letters*, the most important journals read by physicists, SI units are rarely used. It isn't even true that cgs units are universal. Theorists prefer natural units, $\hbar = c = 1$.

It seemed to us that physicists will use the units they are most comfortable with and that will best express the sense of magnitude they are trying to convey. We decided that our handbook would be most useful if it were written using the language and units prevailing at this time. Each editor made the choice appropriate to his own field. The advantage of this became apparent when it came to reproducing the tables of data which the *Vade Mecum* has in abundance. We saved the labor of converting the tables and the pain of introducing errors.

As a matter of fact, we felt we had gone as far as we dared in the *Vade Mecum* to advance the cause of SI units. In many cases, we went to extra space and trouble to give expressions in both cgs and SI units side by side. An effort was made to include the prescription for conversion to SI units in the table headings.

Those who favor SI units should credit David Lide of the National Bureau of Standards, Chairman of the *Vade Mecum* Committee, for having pushed us as far as we went in this