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COMMENTS ON THE NOTE OF MR. PAUL EHRENFEST: "THE TRANSLATORY MOTION OF DEFORMABLE ELECTRONS AND THE AREA LAW"

[1]

by A. Einstein

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The article referred to above contains the following remarks:

"In the formulation in which Mr. Einstein published it, Lorentzian
[2] relativistic electrodynamics is rather generally viewed as a complete system. Accordingly, it must also be able to provide purely deductively an answer to
[3] the question posed by transferring Abraham's problem from the rigid electron to the deformable one: Granted that there exists a deformable electron that
[4] has some nonspherical and nonellipsoidal form when at rest. According to Mr. Einstein, this electron undergoes the well-known Lorentz contraction during uniform translation. Well then, is it possible for this electron to undergo
[5] force-free uniform translation in every direction, or is it not?"

Concerning this I have the following comments:

1. The principle of relativity, or, more exactly, the principle of relativity together with the principle of the constancy of velocity of light, is not to be conceived as a "complete system," in fact, not as a system at all, but merely as a heuristic principle which, when considered by itself, contains only statements about rigid bodies, clocks, and light signals. It is only by requiring relations between otherwise seemingly unrelated laws that
[6] the theory of relativity provides additional statements.

For example, the theory of the motion of electrons arises in the following way. One postulates the Maxwell equations for vacuum for a system of space-time coordinates. By applying the space-time transformation derived by means of the system of relativity, one finds the transformation equations for the electric and magnetic forces. Using the latter, and applying the space-time transformation once again, one arrives at the law for the acceleration of an electron moving at arbitrary speed from the law for the acceleration of the
[7] slowly moving electron (which is assumed or obtained from experience). Thus, we are not dealing here at all with a "system" in which the individual laws are implicitly contained and from which they can be found by deduction alone,

but only with a principle that (similar to the second law of the theory of heat) permits the reduction of certain laws to others. [8]

2. Previously, when one did not rely on the principle of relativity, but instead tried to obtain the laws of motion of electrons by electrodynamic methods, one found it necessary to make more definite assumptions on the distribution of electricity so that the problem is not an undetermined one. The electricity was thought of as being distributed over a (rigid) framework. [9] It should be noted that the laws that govern the motion of such a structure cannot be derived from electrodynamics alone. After all, the framework is nothing other than the introduction of forces which balance the electrodynamic ones. If we view the framework as a rigid body (i.e., one not deformable by external forces), the problem of the motion of the electron can be solved deductively without arbitrariness only if the dynamics of the rigid body is known with sufficient accuracy. [10]

If the theory of relativity is correct, we are still far from the latter goal. For the time being, we only have the kinematics of parallel translation and an expression for the kinetic energy of a body in parallel translation, provided the latter does not interact with other bodies[1]; for the rest, both the dynamics and the kinematics of a rigid body have at present to be considered as unknown for the case under consideration.

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[1]I will soon show in an article that the latter restriction is essential. [11]

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