Comments on Sallhofers "Elementare Herleitung der Dirac-Gleichung"

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The transformation properties of the Dirac-equation derived by Sallhofer from electromagnetic principles are investigated.

In recent paper Sallhofer [1] has attempted a derivation of the Dirac equation starting from electrodynamics, or – to be more precise – an apparently non-covariant version of the Dirac equation has been obtained from a non-covariant formulation of classical electrodynamics. Sallhofer has argued that the well-known difficulties of relativistic quantum-electrodynamics can be avoided in this non-relativistic derivation.

It has to be remarked however, that the apparently non-covariant form of Maxwells' equations used in [1] are in fact fully Lorentz covariant not only in vacuo, but also in continuous media, if these media are treated in a covariant way. This has to be done by introducing 4-velocities, energy momentum tensors etc. in a covariant way, as shown e. g. by Schmutzer [2]. (This covariance is, however, of a rather formal nature only as long as no feedback of the field on the medium is allowed for.)

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Secondly, the relations

$$\psi_1 = i\,E_3\,,\ \ \psi_2 = i(E_2 + i\,E_3)$$
$$\psi_3 = H_3\,,\ \ \psi_1 = H_1 + i\,H_2 \qquad (1)$$

used by Sallhofer [1] (where it is Eq. (7)) between the electromagnetic fields $\boldsymbol{E}$ and $\boldsymbol{B}$ and the Dirac field ψ lead to a very peculiar behavior of the spinor field not only under Lorentz boosts (which the author wants to exclude) but also under rotations. The complex spinor ψ would undergo a transformation that is not complex-linear. Thus the usual [3] mass-spin assignment for the free electron and its kinematics break down completely in this derivation of the Dirac equation. Therefore it is also not obvious – to say the least – how the usual magnetic field effects on the electron can be dealt with in this derivation of the Dirac equation.

As a last point we should like to mention that it is by no means clear whether the mass of a Dirac particle can be regarded as part of the dielectric properties of the medium in which it moves, especially when other particles are present that are also described by Dirac's equation.

In conclusion we remark that it is certainly a difficult task to give a radically new approach to Dirac's equation, since such a derivation should reproduce all the successful predictions of older versions of the theory, allow for all relevant generalizations and lead to improved results where the old theory might encounter difficulties. Not all these requirements are met by Sallhofers derivation of the Dirac equation. Especially the author's claim that the new derivation avoids all problems with relativity cannot be maintained, since the Eq. (4) of his paper [1] are covariant, as has been pointed out above.

[1] H. Sallhofer, Z. Naturforsch. **33 a**, 1378 (1978).
[2] E. Schmutzer, Relativistische Physik, Verlag Teubner, Wien 1968.
[3] See, e. g., R. Sexl, and H. Urbantke, Relativität, Gruppen, Teilchen, Springer, Wien 1976 (1982).

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