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Peer Review

Review of: "Deriving the Electron Anomalous Magnetic Moment from Classical Field Angular Momentum"

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The authors pursue an interesting idea, to derive the electron's anomalous magnetic moment from classical fields. This is certainly not a trivial matter. The authors carefully state that their work is not intended to replace the results of previous quantum field theory derivations.

There are, however, a number of weak points in the manuscript. The basic idea is to invoke the angular momentum of the electromagnetic field, L, which is then combined with the electron's spin-only moment to form the anomalous magnetic moment. Even though the authors point out that they make several approximations, which is indeed appropriate, several steps in the derivation are weakly founded and require further elucidation.

The first approximation is to model the charge of the electron as a thin torus on a massive particle. There is, of course, no justification that this can be done, but one can assume this to look next at where the assumption would lead to.

The derivation that leads to equation (11) is fuzzy. The quantity rho in Eq. (6) is not defined. Where is the 3-dimensional integral in Eq. (11)?

Once there is an equation that connects L_z and the vector potential, there are many further assumptions that lead to Eq. (18). It is not evident that these are all defendable, but let us assume that they are approximations. A step that is, however, not sufficiently motivated is then made after Eq. (18), to rewrite hbar/2 as S_z. The problem here is that hbar appears in many expressions, and it is not justified to rewrite hbar as 2S_z.

In the last part of the manuscript, there is an ambiguity regarding the Lande factor and how one should add the spin and orbital moments to obtain the anomalous spin moment of the electron. Eq. (22) adds

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first spin and orbital angular momenta and then multiplies with a Lande factor of 2, it seems. This would then be the wrong Lande factor for the orbital part? At least a motivation for this procedure should be given.

The authors describe their work as “bridging classical electrodynamics and quantum field theory.” From our current understanding, it would be more appropriate to view their formulation as a semiclassical interpretation connecting the two frameworks, rather than as a direct bridge between them.

Some further remarks: the orbital angular momentum of the electromagnetic field (the L given in the abstract) can be derived from Dirac theory. It has also been shown that there is an interaction term in Dirac theory that has the form \sigma \cdot L (see Mondal et al, PRB 92, 100402(R) (2015)), which looks like a spin-orbit coupling, but with the angular momentum of the electromagnetic field. This can be rewritten as the interaction of the electron's spin with an effective optical field. Perhaps the authors can deduce a way to rewrite this part as an effective spin interacting with a magnetic field. Notably, however, a big distinction is that the fields that the authors consider are self-induced, whereas in the Dirac theory derivation these are external fields.

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Declarations

Potential competing interests: No potential competing interests to declare.