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# Comment on "On spin-1 massive particles coupled to a Chern-Simons field"

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**Abstract**

In this comment we discuss some serious inconsistencies presented by Gomes, Malacarne and da Silva in their paper, Phys.Rev. D60 (1999) 125016 (hep-th/9908181).

**Key-Words:** Three-dimensions; Froissart-Martin bound; Chern-Simons.

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In the paper of Ref. [1], Gomes, Malacarne and da Silva, set up some conclusions about the dynamics and interactions between charged vector bosons ($\phi_\mu$) and the gauge field ($A_\mu$) in 3 dimensions. Besides, they also discuss the issue of 1-loop renormalizability. This comment is devoted to point out some inconsistencies in their misleading analysis; mainly, we criticize the way the authors heavily use the Ward identities to "ensure" 1-loop renormalizability for a model which is not even unitary at tree-level thanks to the violation of the Froissart-Martin bound.

According to the results previously worked out in the papers of Refs. [2–4], following a line initiated by [5], it is known that charged vector fields minimally (or non-minimally) coupled to a gauge field display severe problems in what concerns the quantum-mechanical consistency of the model. To be more specific: unitarity is jeopardized by complex massive vector fields, regardless the mass is introduced via a Proca or a Chern-Simons term, as we shall clarify below.

The authors of Ref. [1] claim that, even if a Proca term assigns mass to the charged vector field, the 1-loop renormalizability of the model is guaranteed by virtue of the identity of Eq.(16) in their paper. However, the use of such an identity in the calculation of 1-loop graphs such as vacuum-polarization and the 4-point function for the Chern-Simons field is not appropriate to reduce the superficial degree of divergence, for there is not reason to set the momenta associated to the matter-field lines in the 3-vertex equal to zero. Our remark is that there is no way to tame the ultraviolet divergences brought about by the Proca term. On the other hand, following the results of [2–4], the dynamical induction of a Proca term always takes place for topologically massive complex vector fields. The criterium that is neglected in the analysis of the work of Ref. [1] (the same criticism applies to the work by Bezerra de Mello and Mostepanenko [6]) is the lack of reference to the Froissart-Martin bound in 3 dimensions [7,8], which is of the type "$s\ \ln s$" for the total scattering squared amplitude in a Compton-like process. Though it is not very evident, the actually serious problem of the massive Proca complex vector field is that it leads to a clear violation of the Froissart-Martin unitarity bound in 3 dimensions, yielding an upper bound of the form "$s^2$" [2]. Had we started with a topologically massive complex vector field, unitarity would apparently be respected through the Froissart-Martin bound [7,8], since an upper bound of the type "$s^0$" [2] shows up for that case; nevertheless, a Proca term ($\phi^*_\mu\phi^\mu$) is always radiatively induced and a non-unitary bound "$s^2$" drops out [2–4].

Our comment sets out to raise the question whether it is sensible to consider the massive charged vector model beyond the tree-approximation, once, as stated above, the unitarity bound is clearly violated at that approximation. Usually, we draw our attention to the renormalizability and unitarity by taking into account power-counting, counter-terms, Ward identities and the positivity of the states in the Hilbert space. Though these are necessary requirements to be fulfilled, some additional criteria ought to be checked, such as the validity of the Froissart-Martin bound. The class of models discussed in Refs. [1,6] is a good warning example for what we have just mentioned: though the analysis of propagators and power-counting seems to point out to a healthy model in the case of Maxwell-Chern-Simons theory for the complex vector field, the induction of the Proca mass breaks the unitarity bound and we believe it is not sensible to go beyond tree-level, or, in short, to second-quantize such a model.

We should also stress that the introduction of a gauge-invariant non-minimal magnetic coupling, which in the Proca case is non-renormalizable, does not restore the Froissart-Martin bound in that case of Maxwell-Chern-Simons-Proca model for the charged vector field, as it was attained in Ref. [2].

To end our short comment, we conclude that, besides the lack of power-counting renormalizability, unitarity is the key ingredient to rule out the theory of massive charged vector fields coupled to a gauge field in 3 dimensions as a fundamental field theory, therefore, the results of Refs. [2,3] turn those of Ref. [1] useless.

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