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Dirac algorithm and counting of degrees of freedom for the complete Maxwell-Proca theory in flat spacetime

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Recently, theories based on multiple vector fields have been proposed, involving not only the dynamical character, as commonly demanded, but also the interaction between them; however, it is a topic that has not brought enough attention in the construction of alternative theories of gravity until a few years ago. Furthermore, in the construction of theories with multiple fields, the interactions between the involved fields are restricted or just allowed between fields of the same type. Due to the lack of knowledge of a theory that introduces the interactions between massive and massless fields of spin one, the complete Maxwell-Proca theory was recently proposed. In this theory not only the dynamics of the Maxwell and Proca fields are included, as previously stated, but also the interactions between them. Nevertheless, it is important to keep in mind that such a procedure must guarantee the absence of instabilities and remove the non-physical degrees of freedom that can be introduced due to interactions between the fields. This is the reason why the aplication of the Dirac algorithm in the complete Maxwell-Proca theory is imperative to guarantee the propagation of the appropriate number of degrees of freedom and, from this, to find the conditions to be imposed on the theory to achieve the consistent description with a physical system. We emphasize that the theory is built on Minkowski spacetime and its description is valid for any number of interacting Maxwell and Proca fields.

Author: HERNÁNDEZ, Jessica (Universidad Industrial de Santander)

Co-authors: GÓMEZ, Gabriel; RODRIGUEZ GARCIA, Yeinzon (UAN & UIS (Colombia))

Presenter: HERNÁNDEZ, Jessica (Universidad Industrial de Santander)

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