Stueckelberg massive electromagnetism in curved spacetime: Hadamard renormalization of the stress-energy tensor and the Casimir effect

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Abstract

We discuss Stueckelberg massive electromagnetism on an arbitrary four-dimensional curved spacetime (gauge invariance of the classical theory and covariant quantization; wave equations for the massive spin-1 field A_μ, for the auxiliary Stueckelberg scalar field Φ and for the ghost fields C and C^*; Ward identities; Hadamard representation of the various Feynman propagators and covariant Taylor series expansions of the corresponding coefficients). This permits us to construct, for a Hadamard quantum state, the expectation value of the renormalized stress-energy tensor associated with the Stueckelberg theory. We provide two alternative but equivalent expressions for this result. The first one is obtained by removing the contribution of the "Stueckelberg ghost" Φ and only involves state-dependent and geometrical quantities associated with the massive vector field A_μ. The other one involves contributions coming from both the massive vector field and the auxiliary Stueckelberg scalar field, and it has been constructed in such a way that, in the zero-mass limit, the massive vector field contribution reduces smoothly to the result obtained from Maxwell's theory. As an application of our results, we consider the Casimir effect outside a perfectly conducting medium with a plane boundary. We discuss the results obtained using Stueckelberg but also de Broglie-Proca electromagnetism and we consider the zero-mass limit of the vacuum energy in both theories. We finally compare the de Broglie-Proca and Stueckelberg formalisms and highlight the advantages of the Stueckelberg point of view, even if, in our opinion, the de Broglie-Proca and Stueckelberg approaches of massive electromagnetism are two faces of the same field theory.

This work is related to a published work [2] done in collaboration with Antoine Folacci.

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2. A. Belokogne and A. Folacci, "Stueckelberg massive electromagnetism in curved spacetime: Hadamard renormalization of the stress-energy tensor and the Casimir effect", Phys. Rev. D **93**, 044063 (2016), arXiv:1512.06326 [gr-qc].