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Stochastic Magnetic Fluctuations in Quantum Field Theory: From Fermionic Propagation to Electromagnetic Observables

Abstract

In physical scenarios such as relativistic heavy-ion collisions, magnetic fields are not necessarily uniform or constant but exhibit both spatial and temporal variations. These fluctuations can influence the dynamics of quantum fields and modify the response of the medium in which they propagate. This work presents a literature review of five interconnected theoretical studies [1–5] investigating the influence of stochastic magnetic fluctuations on fermionic propagation, gauge-field dynamics, spectral properties, and electromagnetic observables. The review also addresses the limitations of these theoretical models and some open questions for future research. In these studies, the fluctuating magnetic field can be incorporated into quantum field theory through the replica method and other superstatistical methods [1,2]. By studying its contributions to fermionic propagation using the Schwinger propagator, it was found that magnetic noise induces corrections that renormalize the effective charge of fermions and modify their propagation velocity [1]. Furthermore, the interaction between this modified fermionic field and the gauge field generates corrections in the photon sector, producing anisotropic modifications in photon propagation and fluctuation-induced effective masses [3]. By incorporating the fermionic and photon propagators in this medium, it was possible to determine modifications to the fermion self-energy and spectral properties [4]. Finally, these microscopic effects also manifest in electromagnetic observables, particularly in the production of photons and dilepton pairs, whose emission rates and angular distributions are modified [5].

References

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Academic position of the presenting author

Undergraduate Student

Primary authors: Mr LÓPEZ CASTRILLÓN, Sebastián (Universidad del Valle); Ms MUÑOZ VELASCO , Isabella (Universidad del Valle); Dr CASTAÑO YEPES , Jorge David (Universidad del Valle)

Presenters: Mr LÓPEZ CASTRILLÓN, Sebastián (Universidad del Valle); Ms MUÑOZ VELASCO , Isabella (Universidad del Valle)

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