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Regularization methods in four-point interaction theories: handling magnetic field and chiral imbalance effects

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Content

In heavy-ion collisions (HIC), different environments such as strong magnetic fields and chirally imbalanced media can be realized. In the former case, strong magnetic fields are expected to be generated perpendicular to the reaction plane in noncentral HIC experiments conducted at BNL (RHIC) and the LHC (ALICE). Under such conditions, several aspects of quantum chromodynamics (QCD) can be explored, including the phase diagram, meson masses, and decay properties. In the latter case, a chirally imbalanced medium may arise when C and CP symmetries are locally violated on an event-by-event basis in HIC. According to the Adler–Bell–Jackiw anomaly, such violations can induce an asymmetry between right- and left-handed fermions, modeled through the chiral chemical potential, a thermodynamic parameter that enables theoretical studies of QCD under chiral imbalance. However, the inclusion of magnetic fields and/or a chiral chemical potential in effective QCD models is not free of subtleties. In this lecture, we revisit the motivations and methods underlying the magnetic-field-independent regularization (MFIR) and the medium separation scheme (MSS), which separate vacuum and medium contributions (e.g., from magnetic fields or chiral imbalance) to avoid unphysical artifacts. Their implementation within the two-flavor Nambu–Jona-Lasinio (NJL) model will be discussed, along with a comparison of selected results from the literature.

Primary author(s) : Dr. TAVARES, William (UERJ)

Presenter(s) : Dr. TAVARES, William (UERJ)