National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Holographic QCD in a Magnetic Background
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Venue	: MC-126
Date and Time	: 25 Jun 2025 (4:00 PM)

Abstract : In high-energy noncentral heavy-ion collisions, an extremely strong magnetic field is expected to be generated, which can significantly influence the dynamics of the quark-gluon plasma (QGP), a strongly coupled state of matter governed by quantum chromodynamics (QCD). However, the nonperturbative nature of QCD poses serious challenges for conventional computational methods such as lattice QCD. In this thesis, we employ bottom-up holographic models, based on the gauge/gravity duality, to systematically investigate the effects of external magnetic fields on various nonperturbative aspects of QCD. Specifically, we construct and analyze Einstein-Maxwell-dilaton (EMD) and Einstein-Born-Infeld-dilaton (EBID) gravity based holographic models to explore several QCD observables in magnetized backgrounds. Our studies of quark-antiquark free energy, entropy, entropic force, and dissociation time within the EMD model reveal how magnetic fields modify quarkonium bound states, suggestive of the inverse magnetic catalysis behavior near the deconfinement transition. To account for quark internal structure under the magnetic field, we further formulate a dynamical EBID holographic model. Within this model, we study quarkonia melting, compute quark number susceptibility, and anisotropic diffusion coefficients, finding nontrivial magnetic field and temperature dependence that reflects key transport characteristics of QGP. Additionally, we probe the entanglement structure of QCD phases in the presence of a magnetic field through various holographic entanglement measures, including holographic entanglement entropy, mutual information, entanglement wedge cross-section, and entanglement negativity. These analyses uncover novel anisotropic effects induced by the magnetic field, both in confined and deconfined phases. Overall, this thesis provides a comprehensive holographic framework to study magnetized QCD, offering valuable insights into real-time dynamics, transport properties, and quantum entanglement of QCD phases in a magnetic background. These findings contribute to a deeper understanding of strongly coupled gauge theories in extreme conditions.