Transport properties of Quarkyonic Matter

The goal of this internship is to explore how transport properties—diffusion, conductivity, viscosities—behave in Quarkyonic Matter, an exotic QCD phase expected at high baryon density and relatively low temperature. In Quarkyonic Matter, quarks fill a dense Fermi sea while excitations near the Fermi surface remain confined, leading to unusual collective dynamics. The project focuses on investigating transport properties in this dual quark–baryon regime and understanding how they differ from those of ordinary nuclear matter. Particular interest lies in studying fluctuation observables.
Quarkyonic Matter may appear in the core of neutron stars and in heavy-ion collisions at low beam energies. Transport coefficients impact cooling rates, collective flow, equilibration times and diffusion patterns—making them promising discriminants of this phase.

Objectives

- Build simplified hydrodynamic and kinetic models incorporating the features of Quarkyonic Matter.
- Compute or estimate transport coefficients: baryon and quark diffusion, thermal conductivity, shear and bulk viscosity.
- Compare to ordinary nuclear matter.
- Identify robust transport-related signatures that could distinguish Quarkyonic Matter in astrophysical or heavy-ion environments.

Possible approaches

- Hydrodynamics at high baryon density with a Quarkyonic Matter EoS.
- Baryon effective kinetic theory with quark saturation constraints.
- Linear response theory: Kubo formulas for diffusion and viscosity in a dual phase of quark and baryonic degrees of freedom.
- Numerical evaluation using C++/Python/Mathematica.

Student profile

- Master 2 student in particle or nuclear physics with a strong interest and ability in theoretical physics.
- Comfortable with statistical mechanics, kinetic theory or QFT at finite density.
- Good programming skills (Python/C++/Mathematica).
- Interest in neutron stars, heavy-ion physics and QCD matter.
- Curiosity, creativity, scientific rigor and independent working skills.

Contact

Please send a short CV, a statement of motivation and the transcript of grades to:
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Please arrange for a reference to be sent independently.