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Quantum Hall effect for quarks in chiral effective model

A net baryon density up to 2-6 times the nuclear saturation density and high magnetic fields are expected in the reaction zone of upcoming CBM/NICA experiments. Such densities are also likely in the core of massive neutron stars, possibly with mixed quark-hadron phases. The chiral effective model, based on the principles of chiral symmetry breaking and broken scale invariance, is employed to incorporate the in-medium effects of constituent quarks within hadrons. The classical and quantized versions of electrical conductivity and resistivity are studied in the relaxation time approximation framework of kinetic theory. Anisotropic electrical conductivity and resistivity tensors are investigated by considering cyclotron motion and Landau quantization. In the presence of strong magnetic fields, the Landau quantization of perpendicular momenta results in quantized anisotropic transport coefficients of the system. Two interesting macroscopic manifestations of Landau quantization are the Shubnikov-de Haas (SdH) oscillations and the Quantum Hall Effect (QHE) [1]. In this work, we explore the possibility of SdH/QHE type oscillations in low temperature and high magnetic field conditions present in the interior of the dense neutron stars, as well as in future facilities of CBM/NICA experiments. Finally, we also present a quantitative estimate of the same in the interior of a neutron star where the magnetic field varies as a function of the baryon density.

References

[1] Dey, J., Bandyopadhyay, A., Gupta, A., Pujari, N., & Ghosh, S. (2023). Electrical conductivity of strongly magnetized dense quark matter-possibility of quantum Hall effect. Nuclear Physics A, 1034, 122654.

Category

Theory

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