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Causal second order magnetohydrodynamics from kinetic theory using RTA approximation

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The magnetic field seems to play a significant role in shaping and working the visible universe. It gives rise to a lot of non-trivial and anomalous behavior in the system in which they are present, extending from the effects seen in condensed matter physics in Dirac and Weyl semi-metals to large cosmological objects like in neutron stars or black holes. The strength of the magnetic field in natural systems can be as low as 10^{-5}T for that of the Earth to as high as 10^{11} T in the Magnetars. But the strongest magnetic field on the Earth is manmade and is produced in high-energy heavy-ion collision experiments at RHIC or LHC. The magnitude of the magnetic field produced here is 3 to 4 orders larger than that produced in Magnetars[1]. In a heavy-ion collision, a strongly coupled Quark-Gluon Plasma(QGP) is formed and its space-time evolution can be described using viscous hydrodynamics formulation. The presence of a strong transient electromagnetic field in the initial stages of heavy-ion collisions indicates that the dynamics of the QGP can be better understood using the RMHD (Relativistic Magnetohydrodynamics) formulation. The RMHD framework describes the system of any relativistic charged fluid and its interaction with the electromagnetic field and the governing laws for fluid and electromagnetic fields need to be solved in a self-consistent manner. There are a few underlying microscopic theories by which these studies can be done; the kinetic theory is one of them. In our current work[2,3], we use the relativistic Boltzmann equation in the relaxation time approximation for the collision kernel. Here, we have formulated the second-order causal evolution equations for the viscous stresses, e.g., bulk, diffusion, and shear stresses, along with the calculation of relevant transport coefficients for both ideal and resistive MHD. We have also computed anisotropic components of the electrical conductivity. These formulations can serve as an input to numerical studies. Last but not least, we have given δf (slight deviation from the equilibrium distribution function), which can be readily applied to the Cooper-Frye prescription for calculating particle spectra in phenomenological studies.

1.{Event-by-event fluctuations of magnetic and electric fields in heavy ion collisions},Bzdak, Adam and Skokov, Vladimir.
2. {"Relativistic resistive dissipative magnetohydrodynamics from the relaxation time approximation"}, Panda, Ankit Kumar and Dash, Ashutosh and Biswas, Rajesh and Roy, Victor,
3."Relativistic non-resistive viscous magnetohydrodynamics from the kinetic theory: a relaxation time approach",
Panda, Ankit Kumar and Dash, Ashutosh and Biswas, Rajesh and Roy, Victor,

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