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Relativistic spin-magnetohydrodynamics

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Recent relativistic heavy-ion collision experiments have found evidence for the generation of strong magnetic field and global angular momentum. The numerical simulation of evolution of the QCD medium is based on either magnetohydrodynamics or spin-hydrodynamics for calculation of observables pertaining to magnetic field or global angular momentum, respectively. However, these two effects are not entirely separable due to the possible spin alignment of medium constituents in the presence of magnetic fields, similar to the Einstein-de Haas effect. Therefore a unified framework of "spin-magnetohydrodynamics"needs to be developed for precise calculation of experimental observables. Here we present the first formulation of this unified framework in a relativistic context.

Starting from the classical description of spin, a kinetic theory of massive spin-1/2 particles in the presence of a magnetic field is obtained in the small polarization limit. We use a relaxation time approximation for the collision kernel in the relativistic Boltzmann equation and obtain the correction to phase-space distribution function. Building on the kinetic description, we then formulate a non-resistive, relativistic dissipative spin-magnetohydrodynamics for a fluid, whose constituent particles are considered to be spin-polarizable but non-magnetizable. We find multiple novel transport coefficients and show that all dissipative currents i.e. particle diffusion, shear stress tensor, bulk viscous pressure and non-equilibrium spin-tensor contain coupling terms between spin and magnetic field.

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