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Spin Hydrodynamics in Belinfante form and local spin polarization

We discuss a puzzle in relativistic spin hydrodynamics; in the previous formulation the spin source from the antisymmetric part of the canonical energy-momentum tensor (EMT) is crucial. The Belinfante improved EMT is pseudo-gauge transformed from the canonical EMT and is usually a physically sensible choice especially when gauge fields are coupled as in magnetohydrodynamics, but the Belinfante EMT has no antisymmetric part. We find that pseudo-transformed entropy currents are physically inequivalent in nonequilibrium situations. We also identify a current induced by the spin vorticity read from the Belinfante symmetric EMT We then implement the (3+1) dimensional viscous hydrodynamic model to study the spin polarizations from these sources with a small chemical potential and ignorance of electromagnetic fields \modDY{by adopting an equation of state different from those in other recent studies}. Although the shear correction alone upon local polarization results in the sign and azimuthal-angle dependence more consistent with experimental observations, as also discovered in other recent studies, it is mostly suppressed by the contributions from thermal vorticity and other terms that yield an opposite trend. It is found that the total local spin polarization could be very sensitive to the equation of states, the ratio of shear viscosity over entropy density, and freezeout temperature.

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