Contribution ID: **53** Type: **Oral talk**

Formulating relativistic hydrodynamics with spin polarization

Tuesday, 25 June 2019 12:10 (25 minutes)

Recently, there have been significant experimental progresses in observing and controlling spin-dependent bulk quantities in broad areas in physics such as relativistic heavy-ion collisions and spintronics. Although hydrodynamics is one of the most powerful theoretical frameworks to describe such macroscopic bulk quantities, its extension to a spinful fluid has not been fully developed, especially for relativistic systems. In this study, we formulate dissipative relativistic hydrodynamics with a dynamical spin degree of freedom based on the phenomenological entropy-current analysis [1]. With the help of the first and second laws of local thermodynamics, we constrain the possible constitutive relations for a relativistic spinful fluid. In addition, we perform the linear-mode analysis on the top of global thermal equilibrium, and clarify that spin density gives a non-hydrodynamic diffusive mode with a finite lifetime. This diffusive behavior is a consequence of the mutual convertibility between spin and orbital angular momentum.

[1] K. Hattori, M. Hongo, X.-G. Huang, M. Matsuo, H. Taya, "Fate of spin polarization in a relativistic fluid: An entropy-current analysis," arXiv:1901.06615

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Session Classification: Session 6