Contribution ID: **960** Type: **Oral presentation**

Relativistic spin hydrodynamics with torsion and linear response theory for spin relaxation

Wednesday, April 6, 2022 11:10 AM (20 minutes)

Using the second law of local thermodynamics and the first-order Palatini formalism, we formulate relativistic spin hydrodynamics for quantum field theories with Dirac fermions, such as QED and QCD, in a torsionful curved background. We work in a regime where spin density, which is assumed to relax much slower than other non-hydrodynamic modes, is treated as an independent degree of freedom in an extended hydrodynamic description. Spin hydrodynamics in our approach contains only three non-hydrodynamic modes corresponding to a spin vector, whose relaxation time is controlled by a new transport coefficient: the rotational viscosity. We study linear response theory and observe an interesting mode mixing phenomenon between the transverse shear and the spin density modes. We propose several field-theoretical ways to compute the spin relaxation time and the rotational viscosity, via the Green-Kubo formula based on retarded correlation functions.

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Session Classification: Parallel Session T02: Chirality, vorticity and spin polarization

Track Classification: Chirality, vorticity and spin polarization