Ideal-spin hydrodynamics on top of a rotating background

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Motivation and Background

noncentral heavy-ion collisions

- hot and dense matter created in the collision with large orbital angular momentum
- a nonvanishing polarization of Λ particles

do the spin degrees of freedom evolve *dynamically* in heavy-ion collisions?

$\longrightarrow$ derive **relaxation-type equations** for spin dofs for uncharged fluid in global equilibrium with non-vanishing thermal vorticity

Covariant spin hydrodynamics

$\longrightarrow$ We need a solution of hydrodynamics to feed into the spin equations

The **spin hydrodynamics equation** for an uncharged fluid are given by the consevation laws

- Conservation of energy-momentum $\partial_\mu T^{\mu\nu} = 0$,
- Conservation of total angular momentum $\partial_\lambda J^{\lambda\mu\nu} = 0$, where $J^{\lambda\mu\nu} := L^{\lambda\mu\nu} + \hbar S^{\lambda\mu\nu}$.

Note that $L^{\lambda\mu\nu} \equiv 2T^{\lambda[\nu}x^{\mu]}$!

$\longrightarrow$ only valid if Minkowski coordinates $x^\mu = (t, x, y, z)$ are chosen in flat spacetime!

$\longrightarrow$ **First step: covariance** of spin hydrodynamic equations

Ingredients

- **Ideal-spin fluid**
  - dissipative part in $T^{\mu\nu}$
  - ideal spin part: 24 original dofs reduce to 6

$$S^{\lambda\mu\nu} = Au^{\lambda}\Omega^{\mu\nu} + 2Bu^{\lambda}u_{\alpha}\Omega^{\alpha[\mu}u^{\nu]} + 2Cu^{\lambda}\Omega^{\alpha[\mu}\Delta^{\nu]}{}_{\alpha} + \\ + 2Du_{\alpha}\Omega^{\alpha[\mu}\Delta^{\nu]\lambda} + 2E\Delta^{\lambda}{}_{\alpha}\Omega^{\alpha[\mu}u^{\nu]}, \tag{1}$$

- Underlying microscopic description: **Kinetic theory**

$$T^{[\mu\nu]} = -\hbar^2\Gamma^{(\kappa)}u^{[\mu}\left(k^{\nu]} + \beta\dot{u}^{\nu]}\right) + \\ + \hbar^2\Gamma^{(\omega)}\varepsilon^{\mu\nu\rho\sigma}u_{\rho}\left(\omega_{\sigma} + \beta\Omega_{\sigma}\right) + \hbar^2\Pi^{\mu\nu}\,, \tag{2}$$

- **Rigidly rotating background**

$$\sigma_{\mu\nu} = 0, \quad \theta = 0, \quad \nabla_{\mu}\beta = -\beta a_{\mu}. \tag{3}$$

* $\{A, B, C, D, E\}$ are functions of ε or, equivalently, T

* $\Omega^{\mu\nu} = u^{[\mu}\kappa^{\nu]} + \epsilon^{\mu\nu\rho\sigma}u_{\rho}\omega_{\sigma}$