

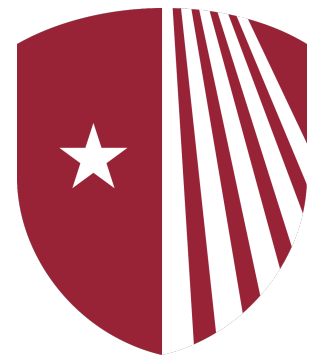
Shear viscosity of rotating, hot, and dense spin-half fermionic systems using Kubo formalism

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Collaborators: Sarthak Satapathy, Pushpa Panday, Salman Ahamad Khan, Debarshi Dey

Rajeev Singh

Stony Brook University
NISER



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Motivation & Ingredients

Motivation: Derive shear viscosity using Kubo formalism and study the impact of finite rotation on shear viscosity in a fermion-dominated medium subject to high angular velocity?

The metric tensor in a rotating setting at an angular velocity Ω is

$$g_{\mu\nu} = \begin{pmatrix} 1 - (x^2 + y^2) \Omega^2 & y\Omega & -x\Omega & 0 \\ y\Omega & -1 & 0 & 0 \\ -x\Omega & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}.$$

And, in curved spacetime the energy-momentum tensor is expressed as

$$T^{\mu\nu} = \frac{i}{4} \left(\bar{\psi} \tilde{\gamma}^\mu \tilde{D}^\nu \psi + \bar{\psi} \tilde{\gamma}^\nu \tilde{D}^\mu \psi \right) + \text{h.c.},$$

where ψ and $\bar{\psi}$ are the Dirac field operator and its conjugate, respectively, and h.c denotes the Hermitian conjugate. In a uniformly rotating frame, \tilde{D}^μ is

$$\tilde{D}_\mu = \left(\partial_t - i \frac{\Omega \Sigma_3}{2}, -\partial_x, -\partial_y, -\partial_z \right),$$

where $\Sigma_3 = (i/2) [\gamma^1, \gamma^2]$. The spacetime dependent gamma matrices $\tilde{\gamma}^\mu$ in tetrad system are

$$\begin{aligned} \tilde{\gamma}^0 &= \gamma^0, & \tilde{\gamma}_0 &= \gamma^0 - x\Omega\gamma^2 + y\Omega\gamma^1, & \tilde{\gamma}^1 &= \gamma^1 + y\Omega\gamma^0, & \tilde{\gamma}_1 &= -\gamma^1, \\ \tilde{\gamma}^2 &= \gamma^2 - x\Omega\gamma^0, & \tilde{\gamma}_2 &= -\gamma^2, & \tilde{\gamma}^3 &= \gamma^3, & \tilde{\gamma}_3 &= -\gamma^3, \end{aligned}$$

where γ^μ are the gamma matrices in Minkowski space. The final piece is the Kubo formula for shear viscosity

$$\eta = -\frac{1}{10} \lim_{q_0 \rightarrow 0} \frac{\rho_\eta(q_0)}{q_0},$$

Effect of angular velocity on shear

$$\eta(T, \mu, \Omega) = \frac{1}{240} \int \frac{d^3p}{(2\pi)^3} \left(\frac{1}{4E_p^2 \Gamma T} \right) \times \left\{ \left\{ 160p_z^4 + 4p_\perp^2 \Omega^2 + (\Omega - E_p - 3p_z) \Omega^3 + 8p_\perp^2 p_z (\Omega - 4E_p) + 32p_z^3 (\Omega + 5E_p) - 8p_z^2 \Omega (2E_p + 3\Omega) \right\} \mathcal{N}_{\pm\mu, \mp\Omega/2} \right. \\ \left. + \left\{ 160p_z^4 + 4p_\perp^2 \Omega^2 + (\Omega - E_p - 3p_z) \Omega^3 + 8p_\perp^2 p_z (\Omega - 4E_p) + 32p_z^3 (\Omega - 5E_p) - 8p_z^2 \Omega (2E_p - 3\Omega) \right\} \mathcal{N}_{\pm\mu, \pm\Omega/2} \right\}$$

