Early-Stage Shear Viscosity far from Equilibrium via Holography

Flash Talk

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Far from Equilibrium in Bulk and Boundary → s

- Viscosity: Crucial property of QCD matter.
- BUT: Off-equilibrium behavior differs from static one.

⇒ Calculate the effective $\eta/s$ for non-equilibrium systems.

• Sudden energy deposition @ boundary ↔ Rapid mass infall (Reissner-Nordström Vaidya spacetime).

• Holographic equation of state → time-dependent $s$. 
System Response to Perturbations $\rightarrow \eta$

- **Bulk**: Evolution of the geometry perturbation $h_{mn}$.
- **Boundary**: Damped oscillations of $\langle T^{\mu\nu} \rangle$.

**Linear response**:

$$\langle T^{xy}(t_2) \rangle_h = \int d\tau \ G^{xy,xy}_R(\tau, t_2) \ h^{(0)}_{xy}(\tau) = G^{xy,xy}_R(t_p, t_2)$$

$$= \delta(\tau - t_p)$$

- **Wigner transformation** $\rightarrow$ **Kubo formula** $\rightarrow$ time-dependent $\eta$. 
Initial stage modeled by temperature rise

\( T = 155 \text{ MeV} \rightarrow T = 310 \text{ MeV} \)

over \( \Delta t = 0.3 \text{ fm} \).

⇒ First holographic non-equilibrium calculation of \( \eta/s \) via the retarded Green's function.

⇒ Off-equilibrium effects drastically change the effective viscosity/entropy ratio in the early stage.

⇒ Impact on hydrodynamics and on the extraction of viscosity from data.