Polarization in heavy-ion collisions via local initial energy deposition

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Jet quenching and polarization

High energy density region (Hot bullet)

Unknows:
- How relate $u_x$ and $p_x$
- What should be the total energy of the hot bullet
Smooth IC + Hot spot carrying momentum

\[ T_{\mu\nu} = \frac{1}{V} p^{\mu} p^{\nu} = \frac{1}{V} \begin{pmatrix} E & p_x & 0 & 0 \\ p_x & p_x^2/E & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \]

Then solve \( T_{\mu\nu} u_{\nu} = \epsilon u^\mu \)

\[ M_{\text{eff}} = \sqrt{E^2 - p_x^2} \]

\[ \epsilon = \frac{1}{V} M_{\text{eff}}^2 = \frac{1}{V} 30 \text{ GeV}; \]

\[ u^x = \frac{p_x}{M_{\text{eff}}} = 1.27; \quad u^\tau = \sqrt{1 + (u^x)^2} \]
Vorticity evolution in (3+1)D viscous hydrodynamics
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R-observable: \( R^\hat{j}(\hat{p}) = \frac{\hat{P} \cdot (\hat{j} \times \hat{p})}{|\hat{j} \times \hat{p}|} \)

- \( p\mu = -\frac{1}{8m} \varepsilon^{\mu \nu \rho \sigma} p_{\sigma} \int d\Sigma^\lambda p_{\lambda} (1-n_F) \omega_{\nu \rho} \int d\Sigma^\lambda p_{\lambda} n_F \)

- \( n_F = \frac{1}{1+\exp(\beta p_{\mu} - \mu Q/T)} \)

- Strength of \( R_j \) is heavily dependent of shear viscosity
  - Position of peak changes very little (in the limit of the grid)

- Ideal hydro and \( \frac{\eta}{S} = 0.01 \) are very similar

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Conclusion

• If a hard parton deposits (part of) its energy and momentum and thermalizes with the medium, it will generate a vortex ring.

• This can be quantified by the ring observable $R_j(p) = \frac{\hat{p} \cdot (j \times \hat{p})}{|j \times \hat{p}|}$

• It shows strong sensitivity to medium shear viscosity.
THANKS

Processes: # 2017/05685-2  
# 2019/05700-7