DISCOVERING PRIMORDIAL MOMENTUM ANISOTROPY IN HIGH-ENERGY NUCLEAR COLLISIONS

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Elliptic flow (final-state momentum anisotropy) is a response to the initial ellipticity of the system.

\[ V_2 = \frac{1}{N} \int_{p_t} \frac{dN}{d^2p_t} e^{-i2\phi_p} \rightarrow V_2 \propto \mathcal{E} \]

- scalar modes (initial energy density):

\[ \mathcal{E}_2 = \frac{\langle x^2 - y^2 \rangle + i \langle 2xy \rangle}{\langle x^2 + y^2 \rangle} \]

- tensor modes (initial stress tensor):

\[ \mathcal{E}_p \equiv \frac{\langle T^{xx} - T^{yy} \rangle + i \langle 2T^{xy} \rangle}{\langle T^{xx} + T^{yy} \rangle} \]

[Teaney, Yan, 1010.1876]
[Sousa, Luzum, Noronha, 2002.12735]
WHAT IS THEIR ROLE? [Schenke, Shen, Tribedy, 1908.06212]

\[ Q_\varepsilon = \frac{\text{Re}\langle \varepsilon V_2^* \rangle}{\sqrt{\langle |\varepsilon|^2 \rangle \langle |V_2|^2 \rangle}} \]

- Q coefficient of linear correlation.

- \( E_2 \) is the dominant contribution to \( V_2 \) for \( dN/d\eta \geq 20 \).

THIS IS VERY WELL-KNOWN

- At low multiplicity, \( V_2 \) is instead in a stronger correlation with \( E_p \).

EXPERIMENTAL EVIDENCE STILL MISSING

What observable can reveal this transition and probe \( \varepsilon_p \)?
OUR FINDING

Introduce $\rho_2$, statistical correlation between event-by-event $<p_t>$ and event-by-event anisotropy at fixed multiplicity.

\[ \rho_2 \left( \varepsilon^2_p, \langle p_t \rangle \right) \]

Correlation with momentum anisotropy, $\varepsilon_p$, is positive. (expected in CGC picture)

Correlation with spatial anisotropy, $\varepsilon_2$, is negative. (expected in a small system)

Correlation with $\mathcal{U}_2$ will thus reveal the transition!

\[ \rho_2 \left( \mathcal{U}_2, \langle p_t \rangle \right) = \frac{\langle \mathcal{U}_2^2 \langle p_t \rangle \rangle - \langle \mathcal{U}_2 \rangle^2 \langle \langle p_t \rangle \rangle}{\sigma(\mathcal{U}_2^2) \sigma(\langle p_t \rangle)} \]

[Bozek, 1601.04513]

THE OBSERVABLE
Correlator goes from negative to positive as we decrease $dN/d\eta$. 

**RESULTS & PREDICTIONS**

**GENERIC PREDICTIONS FOR SMALL SYSTEMS (p-Au, d-Au, p-Pb)**
PREDICTIONS FOR PERIPHERAL A-A SYSTEMS.

Sign change around ~70% is generic in geometry-driven systems. [Schenke, Shen, Teaney, 2004.00690]

Initial momentum anisotropy yields:
- **Double sign change in Pb-Pb collisions @ LHC.**
- **No sign change in Au-Au collisions @ RHIC.** [consistent with preliminary STAR data]
With initial momentum anisotropy the cumulant stays negative!
BACKUP