High-energy collision study reveals new insights into quark-gluon plasma

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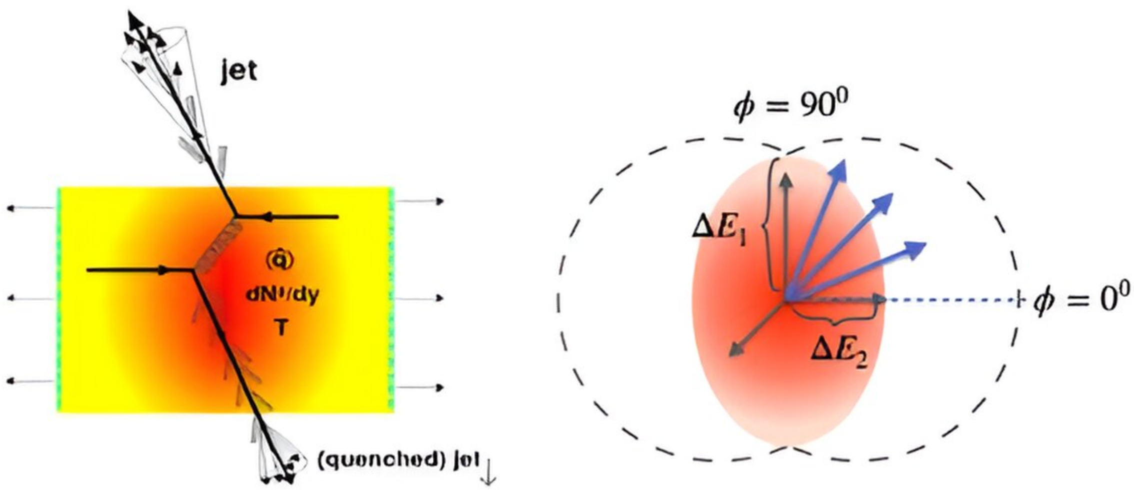


The suppression and azimuthal anisotropy of the high transverse momentum (pT) hadrons are both consequences of jet quenching or energy loss. Credit: Han-Zhong Zhang

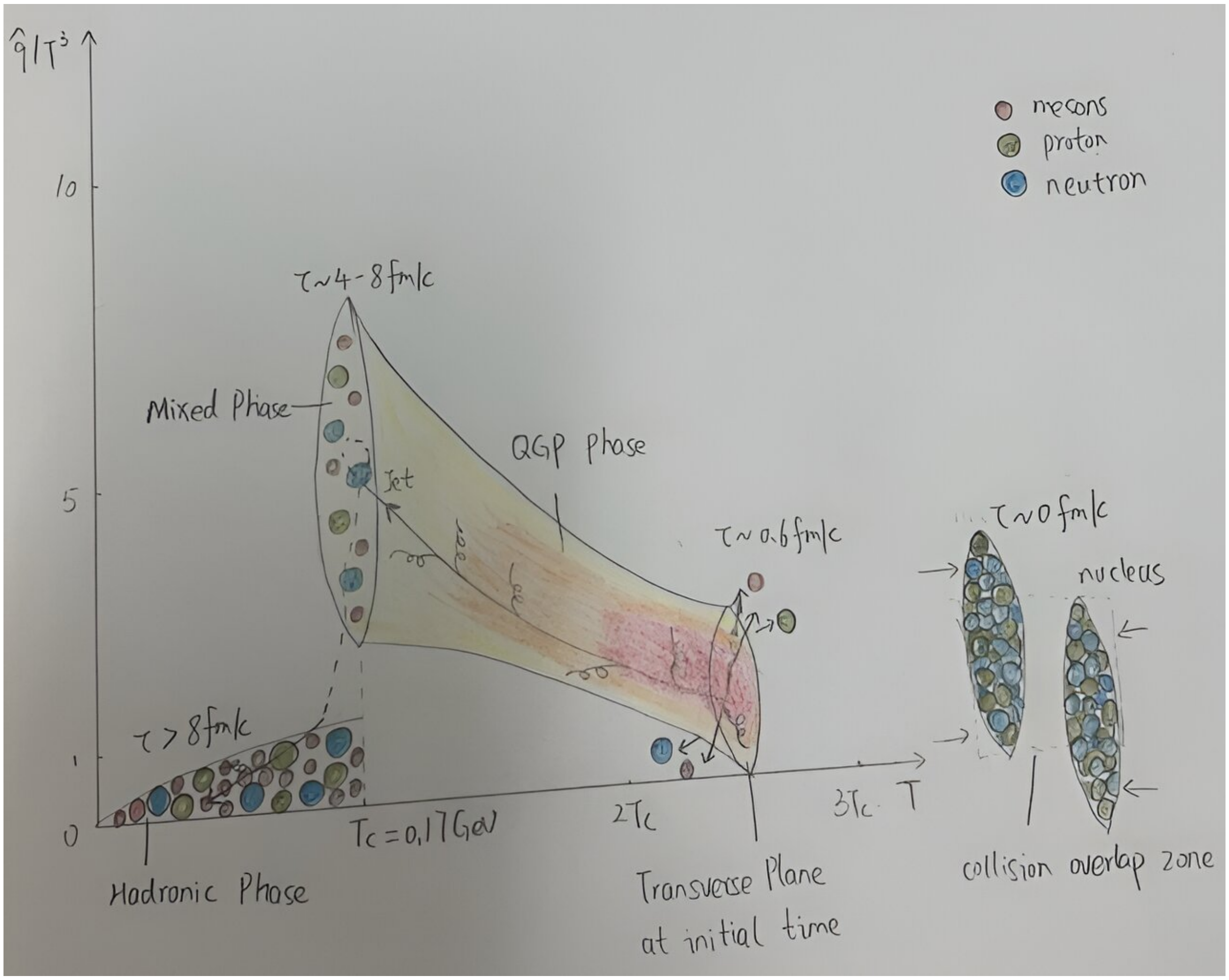
In high-energy physics, researchers have unveiled how high-energy partons lose energy in nucleus-nucleus collisions, an essential process in studying quark-gluon plasma (QGP). This finding could enhance our knowledge of the early universe moments after the Big Bang.

The study reveals that the jet transport coefficient over temperature cubed, a critical factor in parton energy loss in QGP, decreases with increasing medium temperature. This discovery, supported by a significant enhancement of the elliptic flow parameter ($v_2(p_T)$) for large transverse momentum (p_T) hadrons, provides a more in-depth understanding of jet quenching in high-energy collisions.

The research is published in the journal *Nuclear Science and Techniques*.

High-energy collisions create a hot, dense state of matter known as the QGP. As partons pass through this medium, they lose energy. This process, known as jet quenching, leads to the suppression of high p_T hadrons, measured by the nuclear modification factor ($R_{AA}(p_T)$), and the azimuthal anisotropy, measured by the $v_2(p_T)$.

The team used a next-to-leading-order perturbative QCD parton model to analyze data from the Relativistic Heavy-Ion Collider (RHIC) and the Large Hadron Collider (LHC). By fitting their models to the experimental data, they found that the jet transport coefficient's scaled value ($q^/T^3$) decreases with temperature. This novel approach provides a more accurate description of how jets lose energy in these extreme conditions.



Relativistic heavy-ion collisions produce a high density of partons with strong final-state interactions and lead to the formation of the quark-gluon plasma (QGP). Credit: Han-Zhong Zhang

"This discovery helps us understand the behavior of partons in the quark-gluon plasma more accurately," says Prof. Han-Zhong Zhang, the corresponding author. "It shows that partons lose more energy near the critical temperature, which could explain the enhanced azimuthal anisotropy observed in high-energy collisions."

The findings suggest that as partons travel through the QGP, they lose more energy near the transition from QGP to the hadron phase, strengthening the azimuthal anisotropy by approximately 10% at RHIC and LHC.

"In the future, we hope to refine our model and enrich the information on $\hat{q}$, allowing us to better describe $R_{AA}(p_T)$ and $v_2(p_T)$ simultaneously for both RHIC and LHC energies," Prof. Zhang says.

This study advances high-energy nuclear physics, providing deeper insights into jet energy loss in high-energy collisions. These findings could enhance our understanding of the quark-gluon plasma and pave the way for future research into the fundamental properties of matter under extreme conditions.

This research is a collaborative effort between South China Normal University and Central China Normal University.

More information: Man Xie et al, The medium-temperature dependence of jet transport coefficient in high-energy nucleus–nucleus collisions, *Nuclear Science and Techniques* (2024). DOI: 10.1007/s41365-024-01492-4

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