

# Jet Quenching in Relativistic Heavy Ion Collisions at the LHC: Unveiling the Secrets of the Quark-Gluon Plasma

Deep inside the heart of heavy ion collisions at the Large Hadron Collider (LHC), a primordial soup of quarks and gluons, known as the quark-gluon plasma (QGP), is created. This exotic state of matter, which existed in the first few microseconds after the Big Bang, holds the key to understanding the fundamental forces that govern the universe.

Jets, streams of highly energetic particles produced in the collisions, serve as a valuable probe to investigate the properties of the QGP. By studying how jets are modified as they traverse the hot, dense medium, scientists can glean insights into the transport coefficients and other characteristics of the plasma.

In the absence of a QGP, jets would emerge from the collision point with their full energy intact. However, when they pass through the QGP, they experience a phenomenon known as jet quenching. The interactions between the jet particles and the constituents of the plasma lead to energy loss and the broadening of the jet.



## Jet Quenching in Relativistic Heavy Ion Collisions at the LHC (Springer Theses) by Hugh Blair-Smith

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The extent of jet quenching is sensitive to the properties of the QGP. A strongly interacting QGP, characterized by a large transport coefficient, will cause significant jet quenching. Conversely, a weakly interacting QGP will result in less quenching. By measuring the degree of jet quenching, scientists can infer the transport coefficients and other properties of the QGP.

Jet quenching has been extensively studied at the LHC in heavy ion collisions involving lead and proton nuclei. Various experimental techniques have been employed to measure jet properties, including:

- **High-granularity calorimeters:** These detectors measure the energy deposited by jets, providing information about their energy loss and broadening.
- **Tracking detectors:** These detectors reconstruct the trajectories of charged particles within jets, allowing for precise measurements of jet kinematics.
- **Vertex detectors:** These detectors identify the collision point and provide information about the initial geometry of the collision.

Experimental results have consistently shown that jets are significantly quenched in heavy ion collisions compared to proton-proton collisions. The

magnitude of the quenching depends on the jet energy and the centrality of the collision (i.e., the impact parameter).

Theoretical models have been developed to describe jet quenching in the QGP. These models incorporate various mechanisms for energy loss, such as:

- **Collisional energy loss:** Jets lose energy through elastic and inelastic collisions with the constituents of the QGP.
- **Radiative energy loss:** Jets emit gluons as they traverse the QGP, leading to further energy loss.
- **Path length effects:** The length of the jet's path through the QGP affects the amount of quenching.

Model calculations have been successful in reproducing the experimental data and have provided valuable insights into the transport coefficients and other properties of the QGP.

Jet quenching studies at the LHC have played a crucial role in advancing our understanding of quantum chromodynamics (QCD), the theory that describes the strong interactions between quarks and gluons. By probing the properties of the QGP, these studies have provided insights into:

- **Confinement and deconfinement:** Jet quenching provides direct evidence for the transition from confined hadronic matter to deconfined QGP.
- **Chiral symmetry:** The QGP is expected to exhibit chiral symmetry breaking, a property that cannot be probed in ordinary matter. Jet

quenching studies can shed light on this symmetry breaking.

- **Transport coefficients:** Jet quenching measurements constrain the transport coefficients of the QGP, providing valuable information about its hydrodynamic properties.

Jet quenching in relativistic heavy ion collisions at the LHC has been a powerful tool for investigating the properties of the quark-gluon plasma. Experimental studies have provided detailed measurements of jet quenching, which have been successfully interpreted by theoretical models. These studies have significantly advanced our understanding of QCD and the fundamental forces that govern the universe.

As the LHC continues to operate, future experiments will further enhance our knowledge of the QGP. High-luminosity upgrades will enable more precise measurements of jet quenching, leading to deeper insights into the properties of this exotic state of matter.



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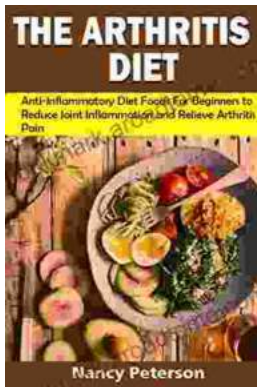
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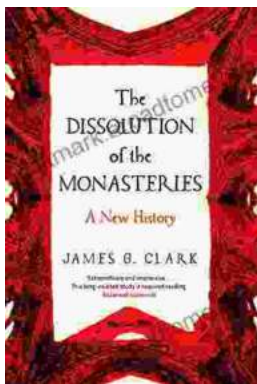
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