

Quark–Gluon Plasma Jet Leaves a Wake

Back-to-back jets produced during heavy-ion collisions reveal a plasma property predicted by quantum chromodynamics.

By **Rachel Berkowitz**

For a few microseconds after the big bang, quarks and gluons had too much thermal energy to bind together into the hadrons that make up today's ordinary matter. Instead, they formed a quark–gluon plasma. To study the conditions that prevailed in the early Universe, physicists recreate quark–gluon plasma via heavy-ion collisions in particle accelerators. New measurements by the CMS Collaboration at CERN's Large Hadron Collider (LHC) now provide an unambiguous observation of a long-sought phenomenon in this medium: the wake formed by a jet of nascent hadrons [1].

When beams of heavy ions are smashed together, they produce a hot, dense soup of quarks and gluons. Within 10^{-22} seconds, the plasma condenses into kaons, pions, and other ordinary hadrons. Early in some collisions, pairs of quarks or gluons scatter from each other with sufficient momenta that they shoot through the hot medium and emerge as collimated streams of particles, or jets. To conserve momentum, pairs of jets shoot out in opposite directions. As these back-to-back jets

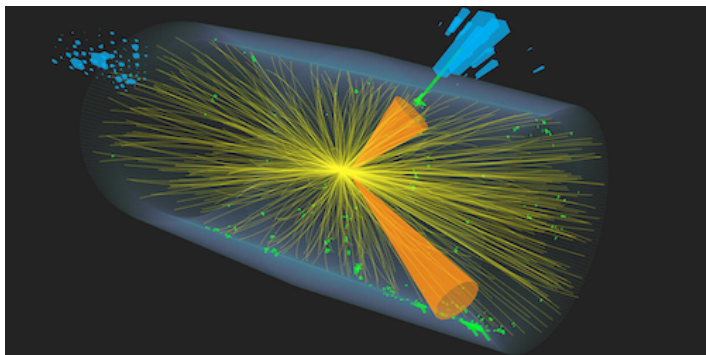
traverse plasma that has yet to condense, they interact with it. Calculations suggest that these interactions must deplete particles behind a jet's leading edge in a potentially observable signature called a diffusion wake.

To hunt for these wakes, researchers at the LHC smashed beams of lead ions together. They also smashed together proton beams, which are not expected to form quark–gluon plasma. As observed by the CMS Detector, the lead–lead collisions had a depleted particle yield in the direction opposite the leading jet, at more than 5-sigma significance with respect to the proton–proton collisions. The observed effect, the researchers say, firmly establishes the presence of a wake in the plasma. It also enables comparisons between model predictions with and without jet–medium interactions and opens the prospect of distinguishing between possible mechanisms for how particles lose energy and respond to the medium as they travel through the plasma.

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REFERENCES

1. A. Hayrapetyan *et al.* (CMS Collaboration), "Observation of the jet diffusion wake using dijets in heavy-ion collisions," *Phys. Rev. Lett.* **137**, 071902 (2026).



Credit: CMS Collaboration/CERN