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Creation of quark−gluon plasma droplets with three distinct geometries

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Experimental studies of the collisions of heavy nuclei at relativistic energies have established the properties of the quark−gluon plasma (QGP), a state of hot, dense nuclear matter in which quarks and gluons are not bound into hadrons. In this state, matter behaves as a nearly inviscid fluid that efficiently translates initial spatial anisotropies into correlated momentum anisotropies among the particles produced, creating a common velocity field pattern known as collective flow. In recent years, comparable momentum anisotropies have been measured in small-system proton−proton (p+p) and proton−nucleus (p+A) collisions, despite expectations that the volume and lifetime of the medium produced would be too small to form a QGP. Here we report on the observation of elliptic and triangular flow patterns of charged particles produced in proton−gold (p+Au), deuteron−gold (d+Au) and helium−gold (3He+Au) collisions at a nucleon−nucleon centre-of-mass energy sqrt(s_NN)=200 GeV. The unique combination of three distinct initial geometries and two flow patterns provides unprecedented model discrimination. Hydrodynamical models, which include the formation of a short-lived QGP droplet, provide the best simultaneous description of these measurements.

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