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The unexpected uses of a bowling pin: exploiting Ne-20 isotopes for precision characterizations of collectivity in small systems

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Whether or not femto-scale droplets of quark-gluon plasma (QGP) are formed in so-called small systems at high-energy colliders is a pressing question in the phenomenology of the strong interaction. For proton-proton or proton-nucleus collisions the answer is inconclusive due to the large theoretical uncertainties plaguing the description of these processes. While upcoming data on collisions of O-16 nuclei may mitigate these uncertainties in the near future, here we demonstrate the unique possibilities offered by complementing OO data with collisions of Ne-20 ions. We couple both NLEFT and PGCM ab initio descriptions of the structure of Ne-20 and O-16 to hydrodynamic simulations of OO and NeNe collisions at high energy. We isolate the imprints of the bowling-pin shape of Ne-20 on the collective flow of hadrons, which can be used to perform quantitative tests of the hydrodynamic QGP paradigm. In particular, we predict that the elliptic flow of NeNe collisions is enhanced by as much as 1.170(8)(30) for NLEFT and 1.139(6)(39) for PGCM relative to OO collisions for the 1% most central events. At the same time, theoretical uncertainties largely cancel when studying relative variations of observables between two systems. This demonstrates a method based on experiments with two light-ion species for precision characterizations of the collective dynamics and its emergence in a small system.

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