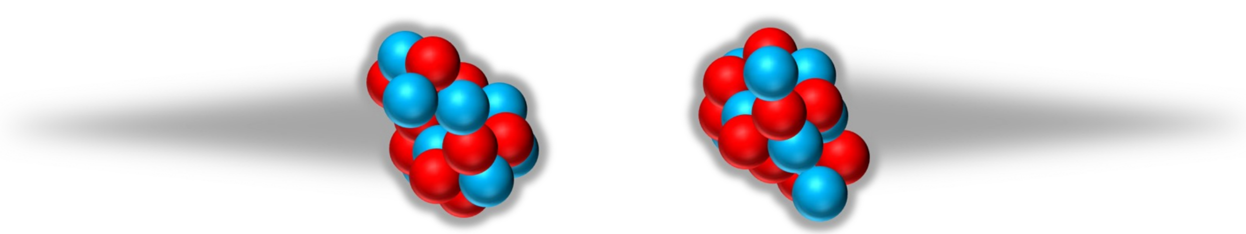
Using nuclear shapes to study collectivity in light ion collisions

Objectives

- Physicists are searching for signs that even the smallest high-energy nuclear collisions can create a hot, dense state of matter known as the quark-gluon plasma (QGP).
- The authors of this work make predictions for collisions of two different light nuclei: oxygen-16 (^{16}O) and neon-20 (^{20}Ne). Unlike ^{16}O, ^{20}Ne has an unusual “bowling-pin” nuclear shape.
- Using nuclear structure calculations and hydrodynamic simulations, the team showed that the unusual ^{20}Ne shape leaves a distinct fingerprint in the flow of particles after collisions.
- Comparing ^{16}O and ^{20}Ne collisions cancels out many uncertainties, making it possible to probe collective QGP behavior with higher precision.

Impact

- This work provided important theoretical motivation for the ^{20}Ne-^{20}Ne collisions run at the Large Hadron Collider (LHC) in July 2025.
- The “bowling-pin” nuclear shape geometry of ^{20}Ne amplifies the anisotropic hydrodynamic flow, while ^{16}O provides a baseline.
- By comparing the two, scientists can disentangle nuclear geometry effects from other sources of uncertainty.
- This opens a new path for studies of QGP and strengthens the bridge between nuclear structure theory and high-energy nuclear physics.
- The new LHC results on ^{20}Ne-^{20}Ne and ^{16}O-^{16}O collisions appear to confirm several key predictions made in this work.



Neon-20 nuclei have an elongated “bowling-pin” shape. Collisions of these nuclei create distinct particle flow signals that reveal the role of nuclear geometry.

Accomplishments

- “Exploiting ^{20}Ne Isotopes for Precision Characterizations of Collectivity in Small Systems”, Giacalone et al., Phys. Rev. Lett. 135, 012302 (2025).