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Investigation of the cluster structures in light nuclei through photon flow in O+O collisions at LHC energies

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In relativistic nuclear collisions, spatial anisotropies characterized by initial eccentricity, triangularity, and higher-order eccentricities arise from the geometry of the collision and fluctuations in the initial energy density distribution. These spatial anisotropies subsequently manifest as momentum anisotropies in the final-state particles through the collective expansion of the hot and dense medium produced in such collisions. The presence of cluster structures in light nuclei, such as ^{7}Be, ^{9}Be, ^{12}C, and ^{16}O, induces nuclear deformities, resulting in significant spatial anisotropies in the overlap region when collided at relativistic energies.

A recent proposal for dedicated ^{16}O-^{16}O collision runs at 7 TeV at the LHC has opened up the opportunity for experimental verification of cluster structures at such energies and investigation of α-cluster structures in light nuclei by examining final state observables in relativistic nuclear collisions. Moreover, the system size of ^{16}O-^{16}O collisions is comparable to high-multiplicity proton-proton (pp) and peripheral lead-lead (Pb-Pb) collisions which provides a unique opportunity to investigate the origins of collective behavior in small collision systems.

In this work, we investigate the initial state produced in collisions of α-clustered oxygen nuclei at 7 TeV assuming tetrahedral structures. We use GLISSANDO initial conditions and study the resulting flow observables for photons within the framework of the MUSIC hydrodynamics model and state-of-the-art rate of photon production. Our study compares these results with those from unclustered ^{16}O-^{16}O collisions, revealing significant qualitative and quantitative differences in photon observables between the two cases.

We demonstrate that photon observables in ^{16}O-^{16}O collisions can serve as a valuable probe for investigating the nucleon-level geometry as well as the initial state produced in relativistic nuclear collisions.

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