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Imprint of alpha-clustering on nucleon-nucleon correlations in relativistic light ion collisions

This study investigates the influence of α-cluster structures in relativistic light nuclear collisions. Using a cluster framework, the characteristics of the nucleonic configurations of ^{16} O and ^{20} Ne are extracted as predicted by various \textit{ab initio} models, including Nuclear Lattice Effective Field Theory (NLEFT), Variational Monte Carlo (VMC), and the Projected Generator Coordinate Method (PGCM). Additionally, I analyze configurations derived from a three-parameter Fermi (3pF) density function. The investigation focuses on the effects of cluster parameters on two-point correlators using a rotor model for symmetric collisions (^{16}O+^{16}O and ^{20}Ne+^{20}Ne) and asymmetric collisions (^{208}Pb+^{16}O and ^{208}Pb+^{20}Ne). The cluster parameters are determined by minimizing the \textit{chi-square} statistic to align the nucleon distributions with those predicted by the mentioned theories. The results reveal that perturbative calculations effectively capture the structural features of these nuclei, while comparisons with Monte Carlo simulations validate these findings. Furthermore, The analysis reveals distinct cluster geometries: VMC suggests tetrahedral shapes, while NLEFT, PGCM, and 3pF indicate irregular triangular pyramids. Notably, NLEFT shows a bowling pin-like α cluster structure for ^{20}Ne. The study also identifies constraints on cluster parameters in the ground and excited oxygen states, with a gradual increase in $\varepsilon_2\{2\}$ for excited states. Accurate modeling of asymmetric collisions requires a range of nucleons from heavy spherical nuclei, leading to weighted correlators in perturbative calculations. I demonstrate consistency between perturbative calculations and Monte Carlo models, with analytical calculations providing more insights into asymmetric than symmetric collisions.

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