Clustering Studies in Peripheral Collisions between Heavy Nuclei

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Fermionic systems may occur in a crystalline phase or exhibit quantum liquid properties [1]. However, finite nuclei transiently behave as clusters of protons and neutrons. At present, there is a strong interest in clustering phenomena, both experimental and theoretical [2]. While the origin of nuclear clustering is deeply connected with the effective nuclear interaction, the detailed mechanism of clustering remains elusive.

In this work, we studied the momentum distributions of projectile-like fragments from the reaction of an ^{40}Ar beam with a ^{64}Ni target at 15 MeV/nucleon, using experimental data obtained by our group with the MARS spectrometer at the Cyclotron Institute of Texas A&M University [3,4]. Here, we focused our attention to the products that correspond to the removal of an alpha particle cluster, ^{4}He.

As a first step, we compared the experimental momentum distributions with calculations performed with the Deep Inelastic Transfer model (DIT) [5] and the Constrained Molecular Dynamics model (CoMD) [6] followed by the de-excitation code GEMINI [7]. Further on, using the primary results of the CoMD calculations, an attempt was made to count the alpha-particles ejected during the reaction and the projectile-like and target-like nuclei that may have resulted from alpha particle pickup or removal. We observed that some of the parameters that we varied in the CoMD calculations, namely enhancement of the Pauli constraint, as well as the nuclear compressibility, have a significant effect on the calculated distributions and provide a rather good description of the cluster breakup and/or transfer.

We think that peripheral collisions of heavy ions offer the proper conditions (i.e., gentle excitation of the reaction partners) so that clustering may develop, and cluster transfer may be favored. We therefore believe that further studies will deepen our understanding of clustering in collisions in the Fermi energy regime (15-35 MeV/nucleon).

References:

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