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Exploring the alpha cluster structure of nuclei using the thick target inverse kinematics technique for multiple alpha decays

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The alpha cluster structure of nuclei with an equal number of protons and neutrons (alpha conjugate nuclei) was proposed in the 1968 by Ikeda et al. [1] to explain some excited states not reproduced by the shell model. Since then many studies have been performed and now the alpha clustering in light nuclei is well established [2]. However further investigation is required to fully understand the clusterization in medium light and heavy nuclei. In particular states analogous to the Hoyle state, in which the nucleus is described by a cluster of n alpha particles, have not yet been unambiguously identified in nuclei larger than ^{12}C.

We investigated the reaction ^{20}Ne+α using the Thick Target Inverse Kinematics (TTIK) technique [3]. This technique is particularly suited for this study because it allows exploration of a large range of incident energies in the same experiment. Moreover, in the inverse kinematics, the reaction products are focused at forward angles and can be detected with detectors covering a relatively small portion of the solid angle in the forward direction.

^{20}Ne beams of energy 3.7 AMeV and 11 AMeV were delivered by the K150 cyclotron at Texas A&M University. The reaction chamber was filled with ^{4}He gas at a pressure sufficient to stop the beam at 10 to 4 centimeters from the detectors (10.3 and 50 PSI respectively). In this way we could detect particles emitted at zero degrees. The energy of the light reaction products was measured by three silicon detector telescopes placed at a radial distance of 48 cm from the entrance window. Each telescope consisted of two 5x5 cm^2 Micron Semiconductors DC quadrant detectors (Design G). The time of flight of the detected particles was also measured relative to the cyclotron radiofrequency. A monitor detector was used to measure the intensity of the incident beam.

For the first time the TTIK method was used to study multiple α-particle decays and single α-particle emission. New results will be shown on the elastic resonant α scattering, as well as on inelastic processes leading to high excitation energy systems decaying by multiple α-particle emission. According to the Ikeda picture ^{24}Mg can be described as ^{20}Ne + α, ^{16}O + 2α, ^{12}C + 3α or a cluster of 6 α particles. Each configuration is expected to be observable at excitation energies around the corresponding threshold values. We observed alpha particle multiplicities up to 3, when the ^{20}Ne beam energy was 3.7 AMeV, while at 11 AMeV we observed alpha particle multiplicities up to 6.

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