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Signature of a possible α-cluster state in $N = Z$ doubly-magic ^{56}Ni

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Abstract An inelastic α-scattering experiment on the unstable $N = Z$, doubly-magic ^{56}Ni nucleus was performed in inverse kinematics at an incident energy of 50 A.MeV at GANIL. High multiplicity for α-particle emission was observed within the limited phase-space of the experimental setup. This observation cannot be explained by means of the statistical-decay model. The ideal classical gas model at kT = 0.4 MeV reproduces fairly well the experimental momentum distribution and the observed multiplicity of α particles corresponds to an excitation energy around 96 MeV. The method of distributed $m\alpha$-decay ensembles is in agreement with the experimental results if we assume that the α-gas state in ^{56}Ni exists at around 113^{+15}_{-17} MeV. These results suggest that there may exist an exotic state consisting of many α particles at the excitation energy of 113^{+15}_{-17} MeV.

1 Introduction

The study of α clusters in nuclei is a very interesting field of research in nuclear physics. The main highlight of the α-cluster studies is the Hoyle state (0_2^+) in ^{12}C at 7.65 MeV. This resonance state, above the 3α threshold, is the doorway for the abundance of ^{12}C in the universe through the nucleosynthesis process [1], which resulted with life on earth. In the 1960s, Ikeda et al. [2] predicted that α-cluster states should exist closely above the particle-emission thresholds in light nuclei. In finite nuclei, the α-cluster state may exist in excited states with a dilute density composed of a weakly interacting gas of α particles [3,4], where the degrees of freedom of the individual nucleons are no longer crucial [5]. Cluster structures in nuclei have been discussed in a wide range of theoretical models, such as, resonating group methods (RGM) [6], generator coordinate methods (GCM) [7], self-consistent mean-field theory framework [8,9], *ab-initio* calculations [10], Tohsaki–Horiuchi–Schuck–Röpke wave

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