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Measurement of the Hoyle state radius using double excitation inelastic scattering

The second 0_2^+ state of ^{12}C at an excitation energy of 7.654 MeV, known as the Hoyle state [1], is crucial for understanding how ^{12}C is formed in stellar nucleosynthesis. Despite extensive studies, the Hoyle state characteristics remain a challenging topic for nuclear structure theories: many theoretical models predict very different radii and spatial arrangements of this state [2,3].

Experimentally, only few attempts have been made in order to measure the radius of the Hoyle state, mostly using inelastic scattering angular cross sections. The most frequently cited study reported a 0.5 fm larger Hoyle state radius than the ground state radius [4] from ^{12}C + ^{12}C diffusion at 121.5 MeV. However, the extraction of the Hoyle state radius was based on a simple diffusion model and relied on strong assumptions. Moreover, the cross section was measured at large angles, leading to the first minimum expected at a smaller angle being missed.

To get rid of these limitations, a new experiment was conducted at GANIL in 2025 to measure the Hoyle state radius by comparing single- and double- excitation in ^{12}C + ^{12}C inelastic scattering using the multi-detector FAZIA [5]. This comparative analysis eliminates many of the assumptions that were previously required, allowing for more accurate comparisons with modern scattering theory that incorporates realistic nuclear potentials.

In this talk, I will present this new experiment as well as the first results.

References :

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