Contribution ID: **64** Type: **Poster**

Three-body description of ^{12}C: From the hyperspherical formulation to the algebraic cluster model and its application to alpha+^{12}C inelastic scattering

Alpha clustering in ^{12}C , as well as the nature of the Hoyle state (which plays a fundamental role in nucleosynthesis), have become long-standing issues. Microscopic theories [1] sustain three-alpha cluster configurations for the ^{12}C nucleus, a fact which supports the use of cluster [2] and algebraic [3] methods. These approaches, although simpler, are particularly suitable for the description of reaction observables.

First, we have studied the structure of ^{12}C by solving the problem of three identical S=0 bosons within the hyperspherical formalism. For this purpose, we have employed the pseudostate method in a transformed harmonic oscillator basis [4]. In this scheme, we compute radii and electromagnetic transition amplitudes. By studying the spatial distribution of the system in terms of Jacobi coordinates, we find equilateral triangle configurations for the 0^+,2^+ bound states. In the case of the 0^+ Hoyle state, the probability exhibits a complex structure (already reported in [2,5]). However, the mean value is also consistent with the equilateral ratio, indicating that the triangular symmetry is still valid. This gives a robust basis to algebraic models of three alpha particles.

We then construct densities and transition densities in ^{12}C by using the algebraic picture by Iachello and Bijker [3,6]. The ground-state band is associated with the fully symmetric representation of D_{3h} with zero quanta of excitation, while the Hoyle band is characterized as a vibrational "breathing mode". The different size associated to the g.s. and Hoyle bands, as well as the reported transition amplitudes, can be described by fixing a small set of parameters. From these transition densities, we compute form-factors for the alpha+^{12}C scattering following a double-folding procedure. Coupled-channel calculations using these ingredients are in progress.

1) PRL98(2007)032501
2) PRC87(2013)054615
3) NPA966(2017)158
4) PRC94(2016)054622
5) PRC90(2014)061604
6) PRL112(2014)152501

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Session Classification: POSTER SESSION