

EXPLORING ^8Be : HOW TWIN RESONANCES SHAPE ASTROPHYSICAL NUCLEAR REACTIONS

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Abstract

The light nucleus ^8Be provides a remarkable testing ground for understanding how nuclear structure and reaction dynamics are intertwined. Its excitation spectrum contains a rich sequence of resonances that strongly influence low-energy reactions involving ^7Li , ^7Be , and ^6Li , nuclei that play an important role in primordial and stellar nucleosynthesis.

We investigate these resonances and the associated nuclear reactions within a microscopic many-channel cluster model. The approach treats several competing cluster configurations of ^8Be within a unified framework and explicitly accounts for cluster polarization, allowing for interaction-induced changes in the internal structure of the clusters. Particular attention is given to the so-called twin positive-parity resonances with $J^\pi = 1^+, 2^+, 3^+$, and 4^+ , which appear as pairs of nearby states with the same spin and parity.

Our calculations show that the formation and properties of these twin resonances are closely connected with the coupling between different reaction channels and are highly sensitive to cluster polarization. A particularly illustrative example is provided by the 2^+ states below the $p + ^7\text{Li}$ threshold, which emerge as Feshbach-type resonances generated through the coupling of open and closed channels.

We further demonstrate how this resonance structure manifests itself in low-energy reactions such as $^7\text{Li}(p, \alpha)^4\text{He}$, $^7\text{Be}(n, \alpha)^4\text{He}$, and $^7\text{Be}(n, p)^7\text{Li}$. The calculated astrophysical S-factors reproduce the main experimental trends and reveal which ^8Be resonances dominate the reactions at astrophysically relevant energies.

These results illustrate how a microscopic description of nuclear clustering can connect the spectroscopy of an unstable nucleus with reaction observables, providing a unified picture of the role played by ^8Be resonances in low-energy nuclear astrophysics.