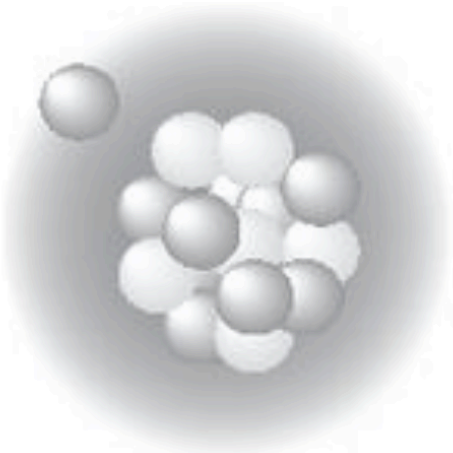
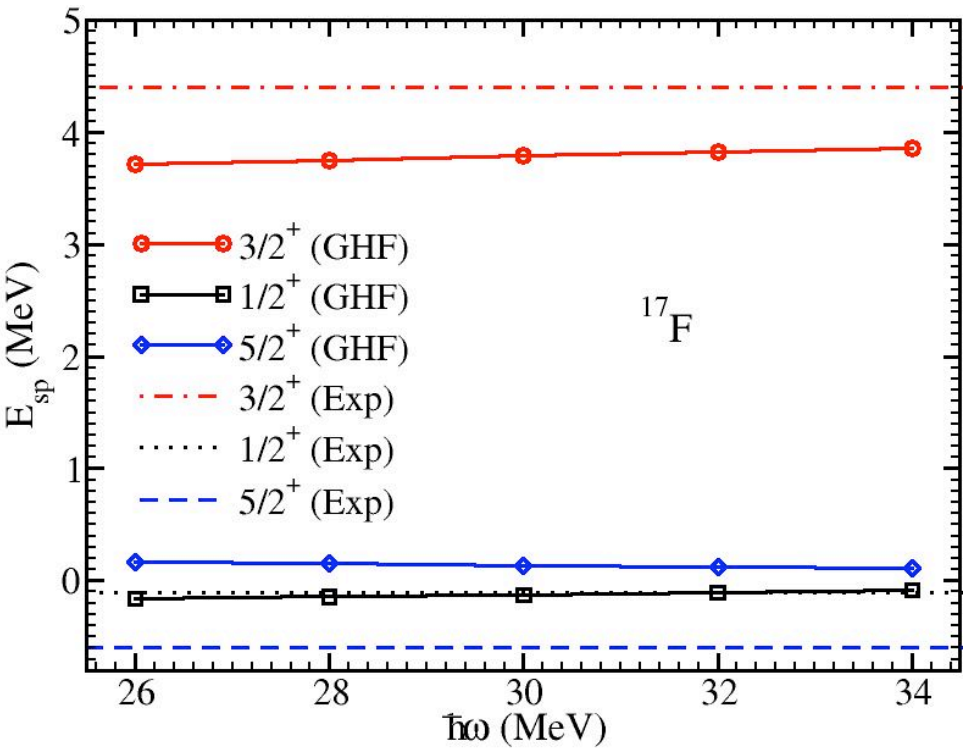
Proton halo in fluorine-17 as a fragile 17-body quantum state





The halo state in the atomic nucleus fluorine-17 is characterized by an excited proton that is orbiting in an appreciable distance around oxygen-16. This spatially extended nuclear state – playing a significant role in the radiative capture reaction 16O(p,gamma)17F of astrophysical interest – has so far eluded a parameter-free direct computation. In this paper, we present a first-principles coupled-cluster description of the proton halo in fluorine-17. This is a daunting challenge for nuclear theory due to the presence of seventeen strongly interacting particles and a weak binding of the state that demands applications of novel techniques for open quantum systems. Our calculations contain no adjustable parameters and are based on the strong nuclear interaction rooted in fundamental properties of the interactions between quarks and gluons. We reproduce the tiny separation energy of the halo (about 105 keV compared to 12127 keV for the ground state in oxygen-16) and demonstrate that an appreciable contribution to its binding energy comes from the coupling to the particle continuum, a generic property of open systems.

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