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Evolution of the structure of neutron rich calcium isotopes with microscopic two- and three-body forces

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Three-body (3N) forces have been shown to be essential to the description of light nuclei. For instance, exact ab-initio methods such as no-core shell model (NCSM) or Green Function Monte Carlo (GFMC) need to include 3N forces in order to reproduce the spectra of light nuclei. Recent NCSM calculations showed that 3N forces are also needed to explain the beta-decay lifetime of 14C.

However, most of the studies that include microscopic 3N forces are restricted to very light systems. Recently, chiral effective field theory (EFT) nucleon -nucleon (NN) and 3N interactions have been applied in shell model calculations of medium-mass nuclei. They have succeeded to explain, from a microscopic point of view, features such as the oxygen dripline at O24, or the very existence of the magic number N=28. To the moment, these could only be explained through phenomenology.

I will present new results obtained within this framework, regarding the ground and excited states of neutron rich calcium isotopes. In particular, I will focus on the importance of including 3N forces in the calculation of binding energies and excitation spectra.

Our theoretical results nicely compare to experiments for the isotopes for whom experimental information is available, both for masses and spectra. In particular, we agree with the new trend of the two-nucleon separation energies between Ca50 and Ca52 (the mass of Ca52 was recently re-measured). The theoretical spectra reasonably agree with experiment, in many cases with the same level of agreement as calculations based on phenomenological interactions.

This is very encouraging because there are no phenomenological or fitted parameters in our approach. When going to exotic systems, we expect our calculations, based directly on the microscopic chiral EFT, to give more reliable predictions than standard phenomenological approaches.

Based on our results, I will also explore the existence (or not) of non-standard magic numbers N=32,34 or 40.

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