No-core Shell Model Approach to Hypernuclear Structure

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One of the major goals of hypernuclear physics is to calculate the properties of hypernuclei starting from the microscopic interactions of nucleons and hyperons. Chiral perturbation theory [1], or even lattice QCD simulations [2], seems to be a promising bridge which allows us to link QCD in the strangeness sector with low-energy hypernuclear physics. To connect the characteristics of hypernuclei to the underlying baryon–baryon interactions reliable *ab initio* many-body hypernuclear calculations are required.

We developed an *ab initio* method for nuclear systems with strangeness, based on the no-core shell model (NCSM) methodology [3], with explicit Λ and Σ hyperon degrees of freedom including $\Lambda - \Sigma$ conversion. Two equivalent versions of the hypernuclear NCSM were developed [4]. The first formulation utilizes a many-body harmonic oscillator (HO) basis defined in relative Jacobi coordinates. In this formulation the center of mass degree of freedom can be removed explicitly, allowing calculations in model spaces with very large number of HO excitation quanta. On the other hand, the HO basis constructed in relative coordinates has to be fully antisymmetrized with respect to the exchanges of all nucleons. With increasing number of particles the antisymmetrization procedure becomes more and more involved. For larger number of particles a formulation of the NCSM in an antisymmetrized basis of Slater determinants of single-nucleon HO wave functions becomes more efficient.

In our calculations we employed state-of-the-art realistic two- and three-body interactions derived from chiral perturbation theory. For the nucleonic sector we used chiral nucleon–nucleon potential at order N^3LO [5], together with chiral three-nucleon potential at order N^2LO [6]. For hyperon–nucleon interaction we used chiral LO interactions [7], as well as phenomenological Juelich'04 [8] potential, as a representative of boson-exchange potentials.

The powerful hypernuclear NCSM methodology allowed us to perform for the first time systematic *ab initio* study of light s- as well as p-shell single-Λ hypernuclei up to ${}^{13}_{\Lambda}C$. In this talk I will briefly introduce the hypernuclear NCSM and report on our recent results.

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