HK 42: Structure and Dynamics of Nuclei IX

Zeit: Mittwoch 16:30–18:30 Raum: S1/01 A03

HK 42.1 Mi 16:30 S1/01 A03

Ab Initio Spectroscopy of Open-Shell Medium-Mass Nuclei: Merging Configuration Interaction and In-Medium Similarity Renormalization Group — •Eskendr Gebrerufael[1], Robert Roth[1], Klaus Vobig[1], and Heiko Hergert[2] — [1]IKP, TU Darmstadt, Germany — [2]NSCL, Michigan State University, USA

In the past years there has been rapid progress in the ab initio description of medium-mass closed-shell nuclei. One of the most flexible and efficient approaches is the In-Medium Similarity Renormalization Group (IM-SRG). The initial formulation of the IM-SRG is limited to ground states of closed-shell nuclei, but first extensions to open-shell systems and spectra have been proposed through multi-reference or valence-space formulations.

Building and extending these ideas, we present a novel ab initio approach for the structure and spectroscopy of all open-shell nuclei in the medium-mass regime. An initial Configuration-Interaction (CI) calculation in a limited model space is used to define a reference state for the multi-reference IM-SRG evolution of the Hamiltonian for the target nucleus. The resulting IM-SRG evolved Hamiltonian is employed in a second no-core CI calculation to extract ground and excited states as well as spectroscopic observables. We present first applications to the spectroscopy of carbon, oxygen and neon isotopes and compare to ab initio no-core shell model calculations.

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HK 42.2 Mi 16:45 S1/01 A03

Block Generators for the Similarity Renormalization Group — •Thomas Hüther and Robert Roth — TU Darmstadt

The Similarity Renormalization Group (SRG) is a powerful tool to improve convergence behavior of many-body calculations using NN and 3N interactions from chiral effective field theory. The SRG method decouples high and low-energy physics, through a continuous unitary transformation implemented via a flow equation approach.

The flow is determined by a generator of choice. This generator governs the decoupling pattern and, thus, the improvement of convergence, but it also induces many-body interactions. Through the design of the generator we can optimize the balance between convergence and induced forces.

We explore a new class of block generators that restrict the decoupling to the high-energy sector and leave the diagonalization in the low-energy sector to the many-body method. In this way one expects a suppression of induced forces. We analyze the induced many-body forces and the convergence behavior in light and medium-mass nuclei in No-Core Shell Model and In-Medium SRG calculations.

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HK 42.3 Mi 17:00 S1/01 A03

Importance-Truncated Shell Model for Multi-Shell Valence Spaces — •Christina Stumpf, Klaus Vobig, and Robert Roth — Institut für Kernphysik, TU Darmstadt

The valence-space shell model is one of the work horses in nuclear structure theory. In traditional applications, shell-model calculations are carried out using effective interactions constructed in a phenomenological framework for rather small valence spaces, typically spanned by one major shell. We improve on this traditional approach addressing two main aspects. First, we use new effective interactions derived in an ab initio approach and, thus, establish a connection to the underlying nuclear interaction providing access to single- and multi-shell valence spaces. Second, we extend the shell model to larger valence spaces by applying an importance-truncation scheme based on a perturbative importance measure. In this way, we reduce the model space to the relevant basis states for the description of a few target eigenstates and solve the eigenvalue problem in this physics-driven truncated model space. In particular multi-shell valence spaces are not tractable otherwise. We combine the importance-truncated shell model with refined extrapolation schemes to approximately recover the exact result. We present first results obtained in the importance-truncated shell model with the newly derived ab initio effective interactions for multi-shell valence spaces, e.g., the *sdpf* shell.

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HK 42.4 Mi 17:15 S1/01 A03

Non-perturbative renormalization of the two-dipole system — •Maximilian Jansen and Hans-Werner Hammer — Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany

The dipole-dipole interaction is an example for an anisotropic and singular potential. Its similarity to the one pion exchange potential in the chiral limit establishes an interesting tie between nuclear and atomic physics. Of particular interest is its tunability, employing electric or magnetic fields in table-top experiments. We investigate a system of two oriented, bosonic dipoles by solving the Lippmann-Schwinger equation numerically. We treat ultraviolet divergences utilizing a cutoff regularization prescription. Cutoff dependence has to be removed subsequently in the procedure of renormalization. We show that in order to do so, anisotropic operators are required besides an isotropic, short-range *s*-wave interaction. We propose operators for which cutoff independence is obtained in the limit of an infinite ultraviolet cutoff and present our results for the binding energy. Possible consequences for the renormalization of nuclear forces are commented on.

HK 42.5 Mi 17:30 S1/01 A03

Renormalization Group Approach to Density Functional Theory — •Sandra Kemler, Jens Braun, and Martin Pospiech — Institut für Kernphysik, TU Darmstadt

We study specific types of 1+1-dimensional field theories which allow us to study the ground-state properties of self-bound systems of spinless fermions which can also be viewed as toy models of nuclei. To this end, we apply our recently developed renormalization group (RG) approach to Density Functional Theory (DFT) to these systems. Our approach indeed relates to conventional DFT in a simple manner and can in principle be used to study ground-state properties of non-relativistic many-body systems from microscopic interactions. Although the basic RG equation underlying our approach is exact, its solution requires approximations. To construct the latter, we employ the exact solution for the two-body system. In this talk, we present our results for ground-state properties, such as ground-state energies, densities, and pair-correlation functions, from this RG approach to DFT for self-bound systems with many fermions interacting via a short-range repulsive and long-range attractive interaction.

HK 42.6 Mi 17:45 S1/01 A03

Effective Field Theory for the Λnn System — •Fabian Hildenbrand and Hans-Werner Hammer — Institut für Kernphysik, TU Darmstadt, 64289 Darmstadt, Germany

Because of the recent results from the HypHI collaboration at GSI, the question of whether the Λnn system is bound or not has received considerable interest recently. We construct an effective field theory for the Λnn system without explicit pions. An asymptotic analysis of the resulting scattering equations reveals that a Λnn three-body force is required for consistent renormalization. In this talk, we present first results of our analysis with a special focus on the sensitivity on the neutron-neutron-scattering length.

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HK 42.7 Mi 18:00 S1/01 A03

Induced Hyperon-Nucleon-Nucleon Interactions and the Hyperon Puzzle — •Roland Wirth and Robert Roth — Institut für Kernphysik, TU Darmstadt, Germany

There is a strong experimental and theoretical interest in determining the structure of hypernuclei and the effect of strangeness in strongly interacting many-body systems. Recently, we presented the first calculations of hypernuclei in the *p* shell from first principles. However, these calculations showed either slow convergence with respect to model-space size or, when the hyperon-nucleon potential is transformed via the Similarity Renormalization Group, strong induced three-body terms.

By including these induced hyperon-nucleon-nucleon (YNN) terms explicitly, we get precise binding and excitation energies. We present first results for *p*-shell hypernuclei and discuss the origin of the YNN terms, which are mainly driven by the evolution of the Λ–Σ conversion terms. We find that they are tightly connected to the hyperon puzzle, a long-standing issue where the appearance of hyperons in models of neutron star matter lowers the predicted maximum neutron star mass below the bound set by the heaviest observed objects.

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HK 42.8 Mi 18:15 S1/01 A03

Electric properties of one-neutron halo nuclei in Halo EFT
— •Jonas Braun and Hans-Werner Hammer — Institut für Kernphysik, TU Darmstadt, 64289 Darmstadt, Germany

We exploit the separation of scales in weakly-bound nuclei to compute E2 transitions and electric radii in a Halo EFT framework. The relevant degrees of freedom are the core and the halo neutron. The EFT expansion is carried out in powers of R_{core}/R_{halo}, where R_{core} and R_{halo} denote the core and halo radius, respectively. We include the strong s-wave and d-wave interactions by introducing dimer fields. The dimer propagators are regulated by employing the power-law divergence subtraction scheme and matched to the effective-range expansion in the respective channel. Electromagnetic interactions are included via minimal substitution in the Lagrangian. We demonstrate that, depending on the observable and respective partial wave, additional local gauge-invariant operators contribute in LO, NLO and higher orders. We present the modifications needed for the extension of our work to higher partial-wave bound states and discuss the consequences for universality in such systems.

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