HK 76: Struktur und Dynamik von Kernen

Zeit: Donnerstag 16:45–19:00 Raum: HSZ-301

Gruppenbericht HK 76.1 Do 16:45 HSZ-301

Short-range correlations studied with unitarily transformed interactions and operators — •Thomas Neff, Hans Feldmeier, and Dennis Weber — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Short-range correlations in light nuclei are investigated using the Argonne V18 and the chiral N3LO interactions. Unitary transformations in the similarity renormalization group (SRG) approach are used to obtain effective interactions which allow to obtain converged wave functions within the no-core shell model. For a consistent description the SRG transformation has to be applied also to observables. This is especially important for observables that are sensitive to short-range or high-momentum physics. A prime example are two-body densities that reflect the short-range correlations inside the nucleus.

We find for each interaction a universal behaviour of the two-body density at small nucleon distances and for high relative momenta. The momentum distributions above the Fermi momentum are dominated by tensor forces. At intermediate momenta the two-body densities are sensitive to three-body correlations that vary with the SRG flow parameter. This dependence is minimized for nucleon pairs with vanishing center-of-mass momentum.

[1] H. Feldmeier, W. Horiuchi, T. Neff, and Y. Suzuki, Phys. Rev. C 84, 054003 (2011)
[2] T. Neff, H. Feldmeier, D. Weber, *in preparation*

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Chiral Interactions with Similarity Renormalization Group at the Three-Body Level and Beyond — •Angelo Calci, Joachim Langhammer, Sven Binder, and Robert Roth — Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany

Chiral effective field theory provides a systematic scheme to obtain two- (NN), three-body (3N) and higher-body interactions based on the fundamental symmetries of QCD. In the past years several chiral interactions were developed using different regulator functions, cutoffs and chiral expansion orders. Due to the recent extension of the Similarity Renormalization Group (SRG) beyond the two-body level, we are able to probe these interactions in ab initio nuclear structure calculations for nuclei in the p- and lower sd-shell. By applying the importance-truncated no-core shell model (IT-NSCM) to specific nuclei in the p-shell, we provide an uncertainty quantification for various NN+3N interaction e.g. by varying the cutoffs of the chiral order. In this context we demonstrate the importance of the three- and four-body contributions induced during the SRG transformation and give a perspective for the handling of SRG transformed chiral interactions including four-body contributions.

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HK 76.3 Do 17:30 HSZ-301

Operator representation for effective realistic interactions — •Dennis Weber, Hans Feldmeier, and Thomas Neff — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

We present a method to derive an operator representation from the partial wave matrix elements of effective realistic nucleon-nucleon potentials. This method allows to employ modern effective interactions, which are mostly given in matrix element representation, also in nuclear many-body methods requiring explicitly the operator representation, for example "Fermionic Molecular Dynamics" (FMD). We present results for the operator representation of effective interactions obtained from the Argonne V18 potential with the "Unitary Correlation Operator Method" (UCOM) and the "Similarity Renormalization Group" (SRG). Moreover, the operator representation allows a better insight in the nonlocal structure of the potential: While the UCOM transformed potential only shows a quadratic momentum dependence, the momentum dependence of SRG transformed potentials is beyond such a simple polynomial form.

HK 76.4 Do 17:45 HSZ-301

Asymmetric nuclear matter based on chiral effective field theory interactions — •Christian Drischler[1,2], Vittorio Somà[1,2], and Achim Schwenk[2,1] — [1]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

We investigate the properties of asymmetric nuclear matter with small proton fractions (high asymmetries). Our calculations are based on two- and three-nucleon forces from chiral effective field theory. We compare our microscopic results, including theoretical uncertainties, to a quasi-parabolic approximation developed to interpolate between pure neutron and symmetric nuclear matter. Our investigations are important for neutron-rich matter in astrophysics and as constraints for energy density functionals.

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HK 76.5 Do 18:00 HSZ-301

Spectroscopy of Open-Shell Nuclei with Normal-Ordered 3N Interactions — •Eskendr Gebrerufael, Robert Roth, Joachim Langhammer, and Angelo Calci — Institut für Kernphysik, Technische Universität Darmstadt

The inclusion of three-nucleon (3N) interactions, that are important to understand the structure of nuclei, is still a challenging task in *ab-initio* nuclear-structure calculations, because of the tremendous computational cost.

We have shown that normal ordering with respect to a single-reference state provides a helpful tool to derive an approximate lower-particle-rank form of any 3N interaction. This approximation, however, is limited to closed-shell nuclei. We now extend the normal-ordering approximation to open-shell systems using a multi-determinantal reference state, i.e. a linear combination of single Slater determinants.

For the first time, we present spectra for p-shell nuclei, e.g. ^{6}Li and ^{10}B, calculated in importance-truncated no-core shell model using chiral 3N interactions in normal-order approximation with respect to a multi-determinantal reference state. We compare them to calculations using full 3N interactions, and go beyond model-space sizes that can be handled with full 3N interactions.

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HK 76.6 Do 18:15 HSZ-301

Random-phase approximation with chiral two- plus three-body interactions — •Richard Trippel and Robert Roth — Institut für Kernphysik, Technische Universität Darmstadt

The random-phase approximation (RPA) is a standard tool for the description of collective excitations in nuclei. We derive the equations for the RPA for full three-body (3B) interactions within the framework of the quasi-boson approximation. The RPA is then applied to a number of doubly magic nuclei (^{16}O, ^{40}Ca, ^{48}Ca, ^{56}Ni and ^{90}Zr).

For the calculations we use two- plus three-body interactions derived from chiral effective field theory with different momentum cutoffs, which are the same as in few-body calculations. These bare interactions are then transformed by means of the similarity renormalization group (SRG) to improve convergence. We perform the calculations for pure two-body (2B) potentials as well as SRG-induced and initial 3B forces. We investigate the convergence properties of the Hartree-Fock and RPA results with respect to the basis size. From the solution of the RPA problem we compute the isoscalar monopole, the isovector and isoscalar dipole as well as the isocalar quadrupole transition strengths. We compare the different potentials with each other and with experimental values and examine the impact of 3B interactions.

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HK 76.7 Do 18:30 HSZ-301

Importance-Truncated Large-Scale Shell Model — •Christina Stumpf and Robert Roth — Institut für Kernphysik, Technische Universität Darmstadt

The (valence-space) shell model is a successful tool for the spectroscopic description of medium-mass and heavy nuclei. Shell-model calculations require the computation and diagonalization of huge Hamilton matrices for large-scale model spaces. We apply an importance-truncation scheme with an importance measure derived from pertur-

bation theory to the shell model in order to reduce the model spaces to those basis states that are relevant for the description of a few target eigenstates. In this way, we extend the applicability to valence spaces and nuclei beyond the reach of the conventional shell model.

We benchmark ground-state and excitation energies as well as transition strengths of ^{56}Ni obtained in the importance-truncated pf-shell model space and compare them to results obtained in standard shell-model calculations. Furthermore, we present results for ^{64}Ge in a full $pfg_{9/2}$ valence space, which is not accessible in the conventional shell model.

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HK 76.8 Do 18:45 HSZ-301

Non-yrast split parity-doublet spectra in odd-mass nuclei —

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We extend the coherent quadrupole and octupole model to describe non-yrast split parity-doublet bands in odd-A nuclei. It is shown that the model describes both the yrast and non-yrast quasi-parity doublet spectra and the related B(E1) and B(E2) transition rates in various odd-A nuclei from the rare-earth to the actinide region. As in case of even-even nuclei we make use of an analytically derived formula for the energies. The model parameters are adjusted in order to obtain the best description of the experiment. The observed Coriolis decoupling effects are taken into account phenomenologically. Results are compared to recent spectroscopic data.

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