HK 46: Structure and Dynamics of Nuclei IX

Time: Thursday 14:00–16:00 Location: J-HS H

Group Report HK 46.1 Thu 14:00 J-HS H

Accurate Nuclear Structure Studies with Consistent Chiral Two- plus Three-Nucleon Interactions — •Thomas Hüther, Stefan Alexa, Marco Knöll, Laura Mertes, Tobias Mongelli, Julius Müller, Tobias Wolfgruber, and Robert Roth — Institut für Kernphysik, Darmstadt, Deutschland

We have developed a family of chiral two- plus three-nucleon interactions for an accurate ab initio description of ground-state energies and charge radii up to the medium mass regime. This family uses consistent chiral order, regulator, and cutoff values for two- and three-nucleon interactions up to N^3LO and allows for a vigorous quantification of theory uncertainties based on the chiral order-by-order convergence and the cutoff dependence.

Recent advances in ab initio many-body methods, in particular, the no-core shell model and the in-medium similarity renormalization group, provide us with the opportunity to probe ground-states and excitation spectra in light as well as in medium mass nuclei. We focus on presenting oxygen and carbon spectroscopy results for the chiral interaction family.

Supported by DFG (SFB 1245).

HK 46.2 Thu 14:30 J-HS H

Elastic NN-Scattering with Coupled NΔ-Channels in Chiral Effective Field Theory — •Susanne Strohmeier and Norbert Kaiser — Technische Universität München

We study the elastic nucleon-nucleon scattering ($T_{\mathrm{lab}} \leq 300$MeV) by employing the dynamics of the coupled nucleon-delta channels. The potentials arising from one- and two-pion exchange, with iterative contributions properly subtracted, are derived from chiral effective field theory at next-to-leading order. For the chiral two-pion exchange we calculate directly the spectral functions (imaginary parts) and implement a local regulator. The short-range contact interaction in the coupled (NN, NΔ, ΔN, ΔΔ)-channels is constructed up to next-to-leading order (i.e. quadratic in momenta) and the low energy constants with significant influence are determined in fits to empirical NN-scattering phase shifts. We compare the phase shifts of this coupled channel approach with the next-to-next-to-leading order results of the uncoupled situation.

Work supported in part by DFG and NSFC (CRC110).

HK 46.3 Thu 14:45 J-HS H

Density-dependent NN-interaction from subleading chiral three-nucleon forces — •Norbert Kaiser — Physik Department, Technische Universität München

From the sub- and subsubleading contributions to the chiral 3N-force a density-dependent two-nucleon interaction V_{med} in isospin-symmetric nuclear matter is derived. V_{med} is calculated from the on-shell scattering process $N_1(\vec{p}) + N_2(-\vec{p}) \to N_1(\vec{p}\,') + N_2(-\vec{p}\,')$ in the nuclear matter rest frame. The momentum and k_f-dependent potentials associated with the isospin operators $1, \vec{\tau}_1 \cdot \vec{\tau}_2$ and five spin-structures $1\,, \vec{\sigma}_1 \cdot \vec{\sigma}_2\,, \vec{\sigma}_1 \cdot \vec{q}\,\vec{\sigma}_2 \cdot \vec{q}\,, i(\vec{\sigma}_1 + \vec{\sigma}_2) \cdot (\vec{q} \times \vec{p}), \vec{\sigma}_1 \cdot \vec{p}\,\vec{\sigma}_2 \cdot \vec{p} + \vec{\sigma}_1 \cdot \vec{p}\,'\vec{\sigma}_2 \cdot \vec{p}\,'$ are expressed in terms of functions, which are either given in closed analytical form or require at most one (or two) numerical integration. For the (most challenging) 3N-ring diagrams proportional to $c_{1,2,3,4}$, one gets at two-loop order regularized double-integrals $\int_0^\lambda dr\, r \int_0^{\pi/2} d\psi$ from which the λ^2-divergence has been subtracted and the logarithmic piece $\sim \ln(m_\pi/\lambda)$ is isolated. After partial wave decomposition these results are most helpful to implement the sub- and subsubleading chiral three-nucleon forces into nuclear many-body calculations.

Work supported in part by DFG and NSFC (CRC110).

HK 46.4 Thu 15:00 J-HS H

Exploring density-matrix expansions for local chiral interactions — •Lars Zurek[1,2], Eduardo A. Coello Pérez[3], Scott K. Bogner[4], Richard J. Furnstahl[5], and Achim Schwenk[1,2,6] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Lawrence Livermore National Laboratory, Livermore, CA, USA — [4]Facility for Rare Isotope Beams and Department of Physics and Astronomy, Michigan State University, East Lansing, MI, USA — [5]Department of Physics, The Ohio State University, Columbus, OH, USA — [6]Max-Planck-Institut für Kernphysik, Heidelberg

We employ the density-matrix expansion originally introduced by Negele and Vautherin in order to rewrite one-body density matrices in terms of local densities and their derivatives. The resulting approximations for the density matrices are applied to calculate energy-density functionals at the Hartree-Fock level based on local interactions derived from chiral effective field theory. The accuracy of this approach is investigated and analyzed for various approximations and choices in the scalar density-matrix expansion.

* Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Projektnummer 279384907 - SFB 1245 and the BMBF under Contract No. 05P18RDFN1.

HK 46.5 Thu 15:15 J-HS H

Precision calculation of deuteron form factors in chiral effective field theory — Arseniy A. Filin[1], •Daniel Möller[1], Vadim Baru[2,3,4], Evgeny Epelbaum[1], Hermann Krebs[1], and Patrick Reinert[1] — [1]Ruhr-Universität Bochum, Fakultät für Physik und Astronomie, Institut für Theoretische Physik II, D-44780 Bochum, Germany — [2]Helmholtz-Institut für Strahlen- und Kernphysik and Bethe Center for Theoretical Physics, Universität Bonn, D-53115 Bonn, Germany — [3]Institute for Theoretical and Experimental Physics, B. Cheremushkinskaya 25, 117218 Moscow, Russia — [4]P.N. Lebedev Physical Institute of the Russian Academy of Sciences, 119991, Leninskiy Prospect 53, Moscow, Russia

We employ the precise two-nucleon potentials worked out to fifth order in chiral effective field theory to perform high-accuracy calculations of the deuteron form factors. The corresponding electromagnetic charge and current operators are derived and regularized consistently with the potentials. The single-nucleon contributions to these operators are expressed in terms of the proton and neutron form factors, for which up-to-date empirical parametrizations are employed. The short-range two-nucleon operators contain undetermined parameters which are fixed from the deuteron static moments and/or the world data of deuteron form factors, allowing for different kinds of predictions. A comprehensive error analysis is carried out, including a Bayesian analysis of the uncertainty stemming from the truncation of the chiral expansion.

HK 46.6 Thu 15:30 J-HS H

Precise measurement of the neutron-neutron scattering length — •Marco Knösel[1] and Thomas Aumann[1,2] for the NeuLAND-SAMURAI-Collaboration — [1]Technische Universität Darmstadt — [2]GSI Helmholtz-Zentrum für Schwerionenforschung

In this contribution, a new experimental approach to determine the neutron-neutron scattering length is presented. In order to create free neutron pairs, the knockout reactions $^6\mathrm{He}(p,p\alpha)^2n$ and $t(p,2p)^2n$ as well as the charge-exchange reaction $d(^7\mathrm{Li},^7\mathrm{Be})^2n$ are proposed to be measured in inverse kinematics at the RIBF in RIKEN. In a kinematically complete measurement, the momenta and positions of the neutrons are determined using the new high-resolution neutron detector HIME, after they freely scattered off each other. From this information, the spectrum of relative energy of the two-neutron system can be obtained and by comparison to halo EFT calculations the neutron-neutron scattering length can be determined.

This work is supported by the DFG through grant no. SFB 1245, the BMBF under contract number 05P15RDFN1 and the GSI-TU Darmstadt cooperation agreement.

HK 46.7 Thu 15:45 J-HS H

Exploring alternative SRG generators in one dimension — •Matthias Heinz[1], Kai Hebeler[1,2], and Achim Schwenk[1,2,3] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Max-Planck-Institut für Kernphysik, Heidelberg

The Similarity Renormalization Group (SRG) is used in nuclear theory to decouple high- and low-momentum components of nuclear interactions to improve convergence and thus reduce the computational requirements of many-body calculations. The SRG evolution is characterized by the generator, which determines toward what form the Hamiltonian is transformed. Currently, the standard choice for the generator is the kinetic energy, which evolves the Hamiltonian towards a diagonal form. However, it has been shown that significant contributions from four- and higher-body forces can be induced during the evolution, which limits the application of evolved potentials to many-body problems. Alternative generators may generate weaker many-body forces while offering the same improvements of the many-body convergence. In this talk, I will present some different generators tested in 1-D systems, analyzing their effect on many-body convergence and induced many-body forces.

This work is supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Projektnummer 279384907 – SFB 1245.