HK 23: Struktur und Dynamik von Kernen V

Time: Tuesday 16:30–19:00 — Location: O-1

Group Report HK 23.1 Tue 16:30 O-1

Nuclear energy density functional from realistic two- and three-body chiral interactions — •JEREMY W. HOLT, N. KAISER, and W. WEISE — Technische Universität München, Garching, Germany

We construct from chiral two- and three-body interactions a nuclear energy density functional following the density matrix expansion of Negele and Vautherin. We consider isoscalar densities only and employ the improved scheme of Gebremariam *et al.* for phase space averaging the one-body density matrix. In particular, such a prescription has been shown to lead to a significantly better description of the spin-dependent part of the one-body density matrix. The chiral N3LOW potential with a sharp momentum-space cutoff of $\Lambda = 2.1$ fm^{-1} is used throughout together with the leading-order chiral three-nucleon interaction with low-energy constants c_D and c_E fit (together with $V_{\text{low}-\text{k}}(\Lambda = 2.1$ fm$^{-1})$) to the binding energies of $A = 3, 4$ nuclei. The explicit separation of the chiral two- and three-body potentials into contact and pion-exchange terms is shown to facilitate the computation of the energy density functional. We compare the resulting density-dependent strength functions occurring in the energy density functional to those from phenomenological Skyrme interactions.

Work supported in part by BMBF, GSI and by the DFG cluster of excellence: Origin and Structure of the Universe.

HK 23.2 Tue 17:00 O-1

Thermodynamics of the chiral condensate — •SALVATORE FIORILLA, WOLFRAM WEISE, and NORBERT KAISER — Physik-Department, TU München, D-85747 Garching

In-medium chiral perturbation theory at finite temperature is used to calculate the quark condensate as a function of the baryon density and of the temperature. Contributions beyond the linear density approximation are given in terms of the derivative of the interaction part of the free energy density with respect to the pion mass. The pion mass dependence results from chiral one- and two-pion exchange processes in the medium, with inclusion of Δ-isobar excitations and Pauli-blocking effects on nucleons in intermediate states. The calculation is performed to three-loop order and includes chiral three-body forces. It turns out that correlation effects stabilize the chiral condensate in nuclear matter. As a consequence, there is no tendency toward a chiral first order phase transition at baryon densities below twice the density of normal nuclear matter and at temperatures $T \lesssim 100$ MeV.

Work supported in part by BMBF, GSI and the DFG Cluster of Excellence "Origin and Structure of the Universe".

HK 23.3 Tue 17:15 O-1

Stability of the three-fermion bound state on the light front — •STEFANO MATTIELLO and STEFAN STRAUSS — Institut für Theoretische Physik, Universität Giessen, Ger many

We derive and solve a set of coupled equations of a relativistic three fermion system subject to an effective scalar zero-rage interaction in the $^1S_0$ channel on the light front. In the computation of the three-and two-fermion bound states as functions of the coupling constant λ we have introduced an invariant cut-off Λ. The invariant cut-off allows us to investigate the stability of the three-fermion bound state, i.e. the dependence on the coupling strength also for cases where the two-fermion system is unbound. Analogous to the three-boson system we find the relativistic Thomas collapse. Furthermore, we explicitly investigate the ground state mass of the three-fermion system and compare to previous simplifying calculations.

This work was supported by DFG.

HK 23.4 Tue 17:30 O-1

Chiral two- plus three-body interactions in the Importance Truncated NCSM — •ANGELO CALCI, JOACHIM LANGHAMMER, SVEN BINDER, and ROBERT ROTH — Institut für Kernphysik - Theoriezentrum, Technische Universität Darmstadt

So far, the chiral effective field theory provides the most consistent way to obtain an Hamiltonian with two- (NN) and three-body (3N) interactions from QCD. For the inclusion of these interactions in many-body calculations using an oscillator basis, e.g. the No-Core Shell Model (NSCM), one has to compute three-body matrix elements efficiently. The handling of three-body m-scheme matrix elements is a major bot-

tleneck and limits the model-space size for many-body calculations. We present an improved scheme that allows to perform NCSM calculations for p-shell nuclei in model spaces up to $N_{\text{max}} = 12$. We use the Importance Truncated NCSM with SRG-transformed chiral NN+3N interactions to discuss ground states and spectra throughout the p-shell, e.g. for ^{4}He, ^{6}Li, ^{10}B, ^{12}C, and ^{16}O. This provides a rigorous benchmark for chiral Hamiltonians and the SRG transformation.

Supported by DFG (SFB 634), HIC for FAIR, and BMBF (NuSTAR.de).

HK 23.5 Tue 17:45 O-1

The magnetic moment of the deuteron in chiral effective theory — •STEFAN KÖLLING[1,2,4], EVGENY EPELBAUM[3], and DANIEL R. PHILLIPS[4] — [1]Forschungszentrum Jülich, Institut für Kernphysik (IKP-3), D-52425 Jülich, Deutschland — [2]Helmholtz-Institut für Strahlen- und Kernphysik (Theorie), Universität Bonn, D-53115 Bonn, Deutschland — [3]Institut für Theoretische Physik II, Ruhr-Universität Bochum, D-44780 Bochum, Deutschland — [4]Institute of Nuclear and Particle Physics and Department of Physics and Astronomy, Ohio University, Athens, OH 45701, USA

Chiral effective theory offers a systematic and model independent way to calculate observables in nuclear physics. In this talk we focus on the magnetic moment form factor of the deuteron at low momentum transfers. The results are obtained with the current operator that involves two- and one-pion exchange contributions as well as contributions from contact terms and that is consistent with the chiral potential we use. We discuss the determination of the contact terms from a fit to the deuteron magnetic moment data as well as future applications of the current operator to 3He and 4He.

HK 23.6 Tue 18:00 O-1

Ab Initio Störungstheorie für Anregungsspektren — •CHRISTINA STUMPF, ROLAND WIRTH, JOACHIM LANGHAMMER und ROBERT ROTH — Institut für Kernphysik - Theoriezentrum, TU Darmstadt

Störungstheorie ist eine effiziente Methode zur approximativen Behandlung des nuklearen Vielteilchenproblems. Es wurde gezeigt, dass mithilfe Störungstheorie hoher Ordnung und anschließender Padé-Resummation präzise Vorhersagen für Grundzustandsenergien doppeltmagischer Kerne möglich sind. Für angeregte Zustände und Grundzustände nicht-doppeltmagischer Kerne ist eine Erweiterung auf die entartete Störungstheorie nötig. Wir zeigen eine rekursive Form der Energie- und Zustandskorrekturen der entarteten Störungstheorie beliebiger Ordnung. Wir diskutieren endliche Partialsummen der Störungsreihe bis zur 30. Ordnung und demonstrieren, dass im Allgemeinen keine Konvergenz der Störungsreihen gewährleistet ist. Durch Padé-Resummation der Störungsreihen ist es jedoch möglich, konvergierende Ergebnisse zu erhalten. Wir bestimmen die Grundzustandsenergie und die Energie niedrig liegender angeregter Zustände an den Beispielen ^{6}Li und ^{7}Li und belegen die Genauigkeit der Ergebnisse durch Vergleich mit einer exakten No-Core Schalenmodell Rechnung. Außerdem zeigen wir, wie sich mithilfe der Padé-Resummation weitere Observablen, beispielsweise Radien, berechnen lassen.

Unterstützt von der DFG (SFB 634), von HIC for FAIR und vom BMBF (NuSTAR.de).

HK 23.7 Tue 18:15 O-1

The total photo-absorption cross section of ^{6,7}Li below π-threshold — •MADDALENA BOSELLI[1], PETER GRABMAYR[2], and DUNCAN MIDDLETON[3] — [1]Università degli Studi di Trento, I-38100 Povo (Trento), Italy — [2]Kepler Center for Astro and Particle Physics, Universität Tübingen, Auf der Morgenstelle 14, 72076, Tübingen — [3]Institut für Kernphysik, Universität Mainz, J.J. Becher Weg 45, 55128, Mainz

The study of few body systems via electromagnetic probes provides a good test for theoretical calculations of nuclear structure. The Li nucleus is of particular interest as calculations exist for both the ^{6}Li and ^{7}Li isotopes with which experimental measurements can be compared. Here we report on a measurement of the total photo-absorption cross section for the ^{6,7}Li isotopes below π-threshold.

The measurement was carried out at the MAX-Lab photon tagging facility in Lund, Sweden. An incident electron energy of 168 MeV

was used to produce Brehmsstralung photons in the range range $15 \leq E_\gamma \leq 120$ MeV. Two 2 m long target bars of ^{6}Li and ^{7}Li were used to attenuate the incident photon beam. A BaF$_2$ detector, placed behind a veto detector, was used in the beam line for detection of photons which traversed the target material.

The ongoing analysis from the measurement will be reported and cross sections presented. The data are compared to microscopic calculations of the cross section from the Trento group.

HK 23.8   Tue 18:30   O-1

Hochpräzise Messung des Kernladungsradius von Beryllium 12 mittels frequenzkammgestützter kollinearer Laserspektroskopie — •A. Krieger[1], Ch. Geppert[1], R. Sanchez[2], M. Bissell[3], K. Blaum[4], N. Frömmgen[1], M. Hammen[1], M. Kowalska[5], J. Krämer[1], K. Kreim[1], R. Neugart[1], D. Yordanov[4] und W. Nörtershäuser[1,2] — [1]Institut für Kernchemie, Universität Mainz — [2]GSI Darmstadt — [3]Instituut voor Kern-en Stralingsfysica, Universiteit Leuven — [4]MPI für Kernphysik, Heidelberg — [5]CERN, ISOLDE Physics Department, Genf

Die Kernladungsradien der leichtesten Elemente sind wichtige Prüfsteine für Kernstrukturmodelle in diesem Bereich der Nuklidkarte, in dem eine starke Clusterisierung der Atomkerne auftritt und die hier anzutreffenden Halo-Kerne gegenwärtig Gegenstand intensiver Forschungstätigkeit sind. Einen kernmodellunabhängigen Zugang zur Messung der Kernladungsradien bietet die Laserspektroskopie mittels derer die Ladungsradien der Helium-, Lithium- und Berylliumisotope gemessen wurden. Im Jahr 2008 konnte die Isotopieverschiebung der Isotope Be-7, 9, 10 und dem Halo-Isotop Be-11 erfolgreich mittels frequenzkammgestützter kollinearer Laserspektroskopie gemessen werden. Der Nachweis mittels Photonen-Ionen Koinzidenz ermöglichte nun die Messung des Isotopes Be-12 trotz niedriger Produktionsrate. Der Ladungsradius von Be-12 ist von besonderem Interesse, da neue Streuexperimente Aussagen über dessen Struktur liefern, die im Widerspruch zu früheren Messungen stehen. Eine erste Auswertung der 2010 an ISOLDE/CERN gewonnen Daten der kollinearen Laserspektroskopie wird vorgestellt.

HK 23.9   Tue 18:45   O-1

Neutral pion photoproduction on the trinucleon in ChPT — •Mark Lenkewitz[1], Evgeny Epelbaum[2], and Hans-Werner Hammer[1] — [1]Helmholtz-Institut für Strahlen- und Kernphysik und Bethe-Center for Theoretical Physics, Universität Bonn — [2]Institut für Theoretische Physik II, Ruhr-Universität Bochum

Threshold pion photoproduction on the trinucleon is investigated in the framework of baryon ChPT at leading one-loop order in the chiral expansion. To this order in small momenta, the production operator is a sum of one- and two-nucleon terms. We calculate the expectation value of the production operator using chiral wave functions in a manifestly three-dimensional approach without partial wave expansion. The resulting integrals are evaluated using Monte Carlo integration. We obtain results for the threshold production multipoles on 3He and 3H and comment on the sensitivity to the fundamental neutron amplitude.