HK 7: Theorie

Zeit: Montag 14:00–16:00 Raum: 2F

Gruppenbericht HK 7.1 Mo 14:00 2F

Status of *ab-initio* calculations of many-body Green functions of atoms and nuclei — •Carlo Barbieri[1], Dimitri Van Neck[2], and Willem H. Dickhoff[3] — [1]GSI, Planckstr. 1, 64291 Darmstadt, Germany — [2]Laboratory of Theoretical Physics, Ghent University, Proeftuinstraat 86, B-9000 Gent, Belgium — [3]Department of Physics, Washington University, St. Louis, MO 63130, USA

We report on recent advances in calculations of atoms and nuclei, using the Faddeev expansion of the many-fermion self-energy. This method offers a microscopic approach to couplings between single particles and collective excitations of the system.

For nuclei, emphasis will be given to the accuracy achieved–sofar–in extracting binding energies, and in further extensions of the formalism.

For atoms, the Faddeev-RPA (FRPA) approach has been found to match the best (ab-initio) calculations of ionization energies and strengths (corresponding to separation energies and spectroscopic factors in nuclear physics). The use of RPA (random phase approximation) phonons opens interesting perspectives for bridging the description of small atoms or molecules to that of extended electron systems.

It will be reminded that the FRPA method has relevance for the study of transfer reactions and nuclear response, as well as close connection to dispersive optical models (DOM) and quasiparticle extensions of DFT theory (QP-DFT).

HK 7.2 Mo 14:30 2F

Halo nuclei and universal properties of Efimov states — •David Canham and Hans-Werner Hammer — Helmholtz-Institut für Strahlen- und Kernphysik (Theorie), Universität Bonn

An s-wave separable potential model is used to explore the universal properties of Efimov states in a three-body system composed of two neutrons and a core. This effective potential is well suited to describe the short-range interactions of halo nuclei. One can construct a boundary curve parameterized by the ratio of the two-body subsystem energies, or corresponding scattering lengths, to the three-body bound state, within which Efimov excited states can exist. Universal properties of the Efimov effect, such as the universal scaling parameter, are found to match with similar studies done with effective field theory. The possibility of known halo nuclei displaying these universal properties is also explored.

HK 7.3 Mo 14:45 2F

Nuclear structure calculations of Be isotopes using FMD — •Ramin Torabi[1,2], Hans Feldmeier[1,2], and Thomas Neff[1] — [1]GSI, Darmstadt — [2]TU Darmstadt

The structure of light nuclei is studied using the Fermionic Molecular Dynamics (FMD) approach. The same interaction derived from the Argonne V18 interaction with the Unitary Correlator Operator Method (UCOM) is used for all nuclei.

The many-particle Hilbert space is spanned by parity and angular momentum projected Slater determinants which are created using the Generator Coordinate Method. As generator coordinate several constraints like number of oscillator quanta, radius, quadrupole, octupole or single particle $\vec{j}^2$ are used. The expectation value of the Hamiltonian is minimized for a Slater determinant, which is projected either not at all, on total parity, on proton and neutron parity separately or on angular momentum and parity.

Since the FMD states are very flexible it is possible to describe shell and cluster model like states as well as halo states using a rather modest amount of basis states. Spectra, radii, shell model occupation numbers as well as density distributions for the Be isotopes are presented and compared to experimental data.

HK 7.4 Mo 15:00 2F

Dibaryon concept for basic two- and three-nucleon forces at intermediate and short ranges: theory vs. experiment — •Vladimir Kukulin[1], Vladimir Pomerantsev[1], Igor Obukhovsky[1], Peter Grabmayr[2], and Amand Faessler[1] — [1]Institut für Theoretische Physik, Universität Tübingen — [2]PhysikaIische Institut, Universität Tübingen

Quite evident and numerous discrepancies between modern high-quality experimental data and careful predictions of conventional nuclear force models have been found in recent years for many observables in two and few-nucleon systems in such processes like $pp \to pp\gamma$, $d(\gamma,\vec{n})p$, ${}^3\mathrm{He}(e,e'pp)$, $p+d \to {}^3\mathrm{He}+\pi^0\pi^0$ etc. Moreover, some of the basic concepts of the conventional force models, being treated more consistently, occured to be invalid. These discrepancies and the basic QCD arguments motivated our group to develop an alternative concept for nuclear force and $3N$-interactions at intermediate and short distances, based on generation of an intermediate six-quark dressed dibaryon. The main agent stabilizing the above dibaryon is the strong scalar field surrounding the six-quark bag which forms a multiquark core of the dressed dibaryon. This new force concept has been demonstrated to result in strong intermediate-range attraction in NN channel and make it possible to describe NN phase shifts (in large energy range) and deuteron properties even a bit better than with most accurate modern NN potential models. The new model leads to numerous important implications for many aspects of nuclear structure and hadronic reactions which are planned to be discussed in present talk.

HK 7.5 Mo 15:15 2F

Nuclear Structure Calculations with Modern Effective Interactions — •Heiko Hergert, Robert Roth, Panagiota Papakonstantinou, Sabine Reinhardt, and Anneke Zapp — Institut für Kernphysik, TU Darmstadt

We discuss nuclear structure calculations based on effective interactions derived from current realistic NN potentials by means of the Unitarity Correlation Operator Method and the Similarity Renormalization Group [1,2]. Both methods employ unitary transformations to treat the short-range physics of the parent NN interaction — in the UCOM, the transformation is based on a physically motivated explicit treatment of short-range central and tensor correlations, in the SRG method it is obtained by solving a flow equation in momentum space.

The resulting interactions have an improved convergence behaviour, allowing their use in a wide range of many-body methods, including the No-Core Shell Model (NCSM), Hartree-Fock(-Bogoliubov) (HF/HFB), Many-Body Perturbation Theory, RPA & quasi-particle RPA.

Quasi-exact NCSM binding energies and spectra for p-shell nuclei are in reasonable agreement with experiment already with a two-body interaction. A systematic underprediction of charge radii and level densities for larger nuclei in HF-based methods can be addressed by including $3N$ forces, either exactly or approximately by means of a density-dependent two-body interaction.

Work supported by the DFG (SFB 634).

[1] R. Roth et al., Phys. Rev. **C73** (2006) 044312
[2] H. Hergert, R. Roth, Phys. Rev. **C75** (2007) 051001(R)

HK 7.6 Mo 15:30 2F

Relativistic Quasiparticle Random Phase Approximation in Exotice Nuclei — •Daniel Pena[1], John Daoutidis[1], George A. Lalazissis[2], and Peter Ring[1] — [1]Physikdepartment TU München, James Franck Str. 1, 85748 Garching — [2]Aristotle University of Thessaloniki, Thessaloniki, Greece

Covariant density functional theory is used to study the influence of electromagnetic radiation on nuclei far from stability. The relativistic Hartree-Bogoliubov equations and the resulting equations for the quasiparticle random phase approximation are solved for spherical as well as for axially symmetric systems in a fully self-consistent way. Three different kinds of high precision energy functionals are investigated and special care is taken for the decoupling of the Goldstone modes. This allows the microscopic investigation of the giant dipole mode and giant monopole modes in spherical and deformed nuclei. We also investigate low-lying modes such as the pygmy modes in deformed neutron rich Ne- and Mo-isotopes as well as scissor like resonances in deformed nuclei. Excellent agreement with recent experiments is found and new types of modes are predicted for deformed systems with large neutron excess.

HK 7.7 Mo 15:45 2F

Giant Resonances using Realistic Interactions and Second RPA — •Panagiota Papakonstantinou, Robert Roth, Heiko Hergert, and Anneke Zapp — Institut für Kernphysik, T.U. Darmstadt

The Unitary Correlation Operator Method (UCOM) considers exlicitly the short-range correlations induced in nuclei by the nucleon-nucleon

(NN) interaction and provides a way to derive a universal, phase-shift equivalent effective NN potential starting from a realistic one. The correlated potential can then be used within standard many-body methods and tractable Hilbert spaces. Recent applications have shown that first-order RPA with a two-body UCOM potential can not, in general, reproduce quantitatively the properties of Giant Resonances (GRs), due to missing higher-order configurations and long-range correlations as well as neglected three-body terms in the Hamiltonian.

In this work we employ a UCOM interaction in Second RPA (SRPA) calculations of GRs. We find that the inclusion of second-order configurations – which effectively dress the underlying single-particle states with self-energy insertions – produces sizable corrections. These appear essential for a realistic description of GRs when using the UCOM. We argue that effects of higher than second order should be negligible. Therefore, UCOM-SRPA emerges as a promising tool for consistent calculations of GRs in closed-shell nuclei. This is an interesting development, since SRPA can accommodate more physics than RPA (e.g., fragmentation). Remaining discrepancies due to missing three-body terms and self-consistency issues of the model are discussed.