HK 20: Structure and Dynamics of Nuclei III

Time: Tuesday 17:00–18:45 Location: SCH/A118

Group Report HK 20.1 Tue 17:00 SCH/A118

Recent R3B experiments with radioactive nuclear beams —
•Valerii Panin for the R3B-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, Darmstadt 64291, Germany

R3B is a versatile experimental setup designed to tackle some of the most forefront problems in modern nuclear physics. The setup is developed within the FAIR project in Darmstadt and it has been extensively used for various experiments over the past few years. The studies conducted thus far include short-range correlations in unstable nuclei, density-dependence of the symmetry energy, helium burning in stars, fission of heavy radioactive nuclei and isospin evolution of single-particle shells. Owing to the radioactive-ion beams provided by the GSI accelerator facility, the involved nuclear reactions can be studied in relativistic energy regime and in some cases also around extremes of nuclear stability. An overview on the R3B experiment, its recent research program and detector upgrades, as well as ongoing developments will be presented.

Group Report HK 20.2 Tue 17:30 SCH/A118

Ab initio structure of neutron-rich calcium isotopes —
•Matthias Heinz[1,2,3], Kai Hebeler[1,2,3], Jan Hoppe[1,2], Takayuki Miyagi[1,2], Achim Schwenk[1,2,3], S. Ragnar Stroberg[4], and Alexander Tichai[1,2,3] — [1]Technische Universität Darmstadt, Department of Physics — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]Department of Physics and Astronomy, University of Notre Dame

The in-medium similarity renormalization group (IMSRG) has emerged as a flexible and powerful method for the ab initio description of atomic nuclei. Its current standard truncation including up to normal-ordered two-body operators, the IMSRG(2), has been very successful in the description of systems up to mass numbers 100 and beyond. For certain observables, however, the IMSRG(2) truncation is not sufficient and the inclusion of three-body operators, the IMSRG(3), is required.

We apply the IMSRG(3) to neutron-rich calcium isotopes, delivering a more precise many-body treatment of these systems. We find an improved description of the shell-closure at ^{48}Ca. We also discuss sources of observed discrepancies between experiment and theory in the charge radii of these systems.

* Funded by the ERC Grant Agreement No. 101020842.

HK 20.3 Tue 18:00 SCH/A118

Halo-EFT desription of one-neutron halo nuclei with perturbative inclusion of core excitations —
•Live-Palm Kubushishi and Pierre Capel — Institute of Nuclear Physics, Johannes Gutenberg-Universität Mainz - Johann-Joachim-Becher Weg 45 D-55099 Mainz, Deutschland.

Halo nuclei are fascinating short-lived nuclear objects found near the dripline. In standard reaction models, halo nuclei are usually described as an inert core with one or two weakly bound neutrons. However, some breakup data suggest that the excitation of the core to its excited states to have a significant influence in the dynamics of the reaction [1]. In order to shed more light on this phenomenon, we study the typical one-neutron halo nucleus Be11 and we propose a simple structure model of it based on the rigid rotor model. We assume the core to be weakly deformed, which we treat at the first order of perturbations to couple it to its 2+ first excited state. In this way, we explicitly account for core excitations as a new degree of freedom while still describing the interaction between the core and the neutron in halo-EFT [2]. Our calculations were performed using the calculable R-Matrix method on a Lagrange mesh. We have been able to reproduce with a good agreement, the coupled-channels results [3], improve the halo-EFT model [2] and bring another physical insight on the structure of the bound states of Be11.

[1] R. de Diego et al., Phys. Rev. C 95, 044611 (2017).
[2] P. Capel et al., Phys. Rev. C 98, 034610 (2018).
[3] F.M. Nunes et al., Nucl. Phys. A 596, 171 (1996).

HK 20.4 Tue 18:15 SCH/A118

Total Reaction Cross-Section Measurements in the S444 Commissioning Experiment for R3B —
•Lukas Ponnath[1], Roman Gernhäuser[1], Tobias Jenegger[1], Philipp Klenze[1], and Thomas Aumann[2] for the R3B-Collaboration — [1]Technische Universität München — [2]Technische Universität Darmstadt

The R3B (Reactions with Relativistic Radioactive ion Beams) experiment at the research facility FAIR, currently under construction in Darmstadt, enables kinematically complete reaction studies for the most exotic nuclei.

The S444 commissioning experiment for R3B, performed in the FAIR Phase-0 campaign in 2019, was the first operation of many new R3B detectors in a common setup. With a stable 12C beam and a set of different beam energies ranging from 400AMeV to 1AGeV we challengend this large installation around the GLAD magnet using the 12C(p,2p)11B benchmark reaction.

During this successful commissioning we could measure the energy-dependence of total reaction cross-sections of a 12C beam on a 12C target, which is poorly known for energies above 400AMeV. This is an important input for current calculations based on the eikonal reaction theory in order to validate in-medium extensions of a parameter-free Glauber model.

I will present the current status and preliminary results of the analysis and discuss the technique and evaluated error budget for the different steps. (supported by BMBF 05P19WOFN1 & 05P21WOFN1)

HK 20.5 Tue 18:30 SCH/A118

Improving Skryme energy density functionals with chiral effective field theory —
•Lars Zurek[1,2], Scott K. Bogner[3], Richard J. Furnstahl[4], Rodrigo Navarro Pérez[5], Nicolas Schunck[6], and Achim Schwenk[1,2,7] — [1]Technische Universität Darmstadt, Department of Physics — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Facility for Rare Isotope Beams and Department of Physics and Astronomy, Michigan State University — [4]Department of Physics, The Ohio State University — [5]Department of Physics, San Diego State University — [6]Nuclear and Data Theory group, Nuclear and Chemical Science Division, Lawrence Livermore National Laboratory — [7]Max-Planck-Institut für Kernphysik, Heidelberg

Nuclear energy density functionals (EDFs) successfully reproduce experimental binding energies but due to their phenomenological nature it is at present unclear how to improve the currently established forms. We construct hybrid EDFs by starting from a standard Skyrme functional, here considered to represent short-range physics, and adding explicitly pion exchanges derived from chiral effective field theory. Pions are included at the Hartree-Fock level without introducing further fit parameters to the functional. When going beyond next-to-leading order in the chiral expansion the functionals are significantly improved compared to a reference Skyrme EDF constructed with the same protocol. We compare the different functionals and analyze their performance.

* Funded by BMBF Contract No. 05P21RDFNB.