HK 60: Structure and Dynamics of Nuclei XI

Time: Friday 11:00–13:00 Location: J-HS H

Group Report HK 60.1 Fri 11:00 J-HS H

Accepting the breaking of axial symmetry for all heavy nuclei improves the consistency of nuclear modelling — •Eckart Grosse[1], Arnd R. Junghans[2], Ralph Massarczyk[3], and Jon N. Wilson[4] — [1]IKTP, TU Dresden — [2]IRP, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden — [3]LANL, New Mexico 87545, USA — [4]IPN and CNRS/IN2P3, F-91406 Orsay, France

Although atomic hyperfine structure as well as most nuclear spectroscopy data do not deliver accurate information on nuclear axiality the ad-hoc assumption of symmetry about one axis found widespread use in nuclear models. In the theoretical interpretation of nuclear properties as well as in the analysis of experimental data triaxiality was considered - if at all - only for some, often exotic, nuclides. Detailed studies of the mass and charge dependence of the electric dipole strength in the range of and also outside of giant dipole resonances clearly indicate the need for accepting broken axial symmetry already for nuclei in the valley of stability. Allowing triaxiality for quasi all heavy nuclei helps to get rid of the need to introduce an arbitrary level density parameter $\tilde{a}$ to fit the accurate values observed in n-capture experiments. Using the value for $\tilde{a}$ as taken from nuclear matter studies allows to even extend such predictions to all spins when the yrast energies are no longer approximated as for an axial rigid rotor. Allowing a breaking of axial symmetry together with spin-independent moments of inertia (MI) a surprisingly simple parametrization is found without using VMI fitting and allowing symmetry breaking instead and hence predictions for compound nuclear reactions are improved.

Group Report HK 60.2 Fri 11:30 J-HS H

Towards a nuclear clock with ^{229}Th — •Benedict Seiferle[1], Daniel Moritz[1], Lars von der Wense[2], and Peter Thirolf[1] — [1]LMU Munich — [2]JILA, Boulder, USA

With an excitation energy of 8.28±0.17 eV [1], the first isomeric state in ^{229}Th (called ^{229m}Th) is the only (currently known) nuclear state that can be excited with today's laser technology. Its properties make ^{229m}Th an ideal candidate for a nuclear optical clock, which is expected to compete with optical atomic clocks. Experiments that led to the first direct energy determination of ^{229m}Th, as well as future experiments aiming towards a nuclear optical clock will be presented.

[1] B. Seiferle et al., Nature 573, 243 (2019).

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HK 60.3 Fri 12:00 J-HS H

Dynamically assisted nuclear fusion — •Friedemann Queisser[1,2,3] and Ralf Schützhold[1,2,3] — [1]Fakultät für Physik, Universität Duisburg-Essen, Lotharstraße 1, Duisburg 47057, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [3]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

We consider deuterium-tritium fusion as a generic example for general fusion reactions. For initial kinetic energies in the keV regime, the reaction rate is exponentially suppressed due to the Coulomb barrier between the nuclei, which is overcome by tunneling. Here, we study whether the tunneling probability could be enhanced by an additional electromagnetic field, such as an x-ray free electron laser (XFEL). We find that the XFEL frequencies and field strengths required for this dynamical assistance mechanism should come within reach of present-day or near-future technology.

Reference:

F. Queisser and R. Schützhold, Phys. Rev. C **100**, 041601(R) (2019)

HK 60.4 Fri 12:15 J-HS H

Experimental measurements of total inelastic cross sections of light anti-nuclei up to anti-Helium 3 in ALICE — •Stephan Koenigstorfer, Ivan Vorobyev, and Laura Fabbietti for the ALICE-Collaboration — Technische Universität München, Physik Department E62

Recent work by the ALICE Collaboration presented the first experimental measurement of the total inelastic cross section for anti-deuterons at low momenta between 0.5GeV/c and 4GeV/c, as well as new measurements of the total inelastic cross section for anti-protons at momenta between 0.3GeV/c and 4GeV/c, in p-Pb collisions. These measurements offer unprecedented constraints on the propagation of light anti-nuclei through matter. In particular, light anti-nuclei from dark matter decays can be separated from secondary anti-nuclei produced in high energy cosmic ray collisions only if their propagation through the interstellar medium can be accurately simulated.

In this contribution we present the studies of the total inelastic cross section of light anti-nuclei in ALICE. They are extended to high multiplicity triggered p-p collisions at $\sqrt{s} = 13TeV$, and from $\bar{p}$ and $\bar{d}$ to anti-Helium 3. The cross sections are extracted by measuring the difference in propagation between particles and anti-particles, and comparing it to Monte Carlo simulations.

HK 60.5 Fri 12:30 J-HS H

Neural network-based analysis of the nucleus-antiproton annihilation for the PUMA project — •Yuki Kubota[1], Yohei Ono[2], and Alexandre Obertelli[1] for the PUMA-Collaboration — [1]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [2]The Open University of Japan, Japan

One of the most fascinating quantum phenomena in Nature is the occurrence of neutron skins and halos in atomic nuclei. The PUMA (antiProton Unstable Matter Annihilation) project aims at determining the neutron over proton densities at the surface of the short-lived nuclei by means of the nucleus-antiproton annihilation. The annihilation is followed by pion emission. The reconstruction of the total charge of the emitted pions allows for the determination of the annihilated particles: 0 in the case of proton and -1 in the case of neutron. However, the primordial pions may re-interact with the residual nucleus before being detected so that the total charge information is distorted. Thus the event-by-event basis identification is not possible.

We are developing the statistical analysis by using the neural network to determine the neutron-to-proton annihilation ratio from the multiplicity and total charge of charged pions. The typical uncertainty of less than 5% can be achieved with the 10^3 annihilation events, which was drastically improved by two orders of magnitude better than the previous study [1]. An overview of the analysis as well as a method to reduce the systematic uncertainty coming from the model dependence are presented.

[1] M. Wada and Y. Yamazaki, AIP Conf. Proc. 793, 233 (2005).

HK 60.6 Fri 12:45 J-HS H

Single-particle potentials of hyperons in nuclear and neutron matter: Role of 3-baryon forces — •Dominik Gerstung, Norbert Kaiser, and Wolfram Weise — Physik Department T39, TU München

The Brueckner G-matrix formalism is employed to calculate the single-particle potentials of nucleons and hyperons in isospin-symmetric nuclear matter and pure neutron matter. The underlying two-body interactions consist of NLO chiral two-baryon potentials and effective density-dependent baryon-baryon interactions derived from the leading order chiral three-baryon forces. We compute the chemical potentials of neutrons and $\Lambda(1116)$-hyperons in order to investigate the critical density for the onset of Λ-formation in neutron-star matter.

The contact and one-pion exchange components of the ΛNN 3-body force depend on two yet undetermined short-distance parameters H_1 and H_2, whose ranges are explored by imposing empirical constraints from Λ-hypernuclei and nuclear matter.

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