HK 11: Few-body physics

Time: Monday 14:00–16:00 Location: H-ZO 100

Invited Group Report HK 11.1 Mo 14:00 H-ZO 100

Theory of three- and four-body scattering — •Arnoldas Deltuva — Centro de Fisica Nuclear, University of Lisbon, Portugal

Few-body nuclear reactions are described in the framework of Alt, Grassberger, and Sandhas equations that are Faddeev-like integral equations. The Coulomb interaction between charged particles is included using the method of screening and renormalization. Momentum-space partial-wave basis is used for solving those equations. Results are obtained for proton-deuteron elastic scattering and breakup, electromagnetic disintegration of 3He, low-energy four-nucleon elastic and transfer reactions, and for direct nuclear reactions dominated by three-body degrees of freedom, e.g., d+4He, d+12C, and p+11Be.

HK 11.2 Mo 14:30 H-ZO 100

Deuteron-Proton Breakup as a Probe of Three-Nucleon System Dynamics — •Stanislaw Kistryn[1], Elzbieta Stephan[2], and Nasser Kalantar-Nayestanaki[3] — [1]Jagiellonian University, PL-30059 Krakow, Poland — [2]University of Silesia, PL-4007 Katowice, Poland — [3]Kernfysisch Versneller Instituut, NL-9747 Groningen,

Modern nucleon-nucleon (NN) interaction models can be probed quantitatively in the three-nucleon (3N) environment by means of rigorous technique of solving the Faddeev equations and comparing the calculated observables with the measured ones. It has been found that a proper description of the experimental data cannot be achieved with the use of NN forces alone. This indicates a necessity of including additional dynamics: subtle effects of suppressed degrees of freedom, introduced by means of genuine 3N forces. Also other contributions (Coulomb force, relativistic effects) have to be taken into account.

A large set of high precision, exclusive cross-section data for the ^{1}H($\vec{\text{d}}$,pp)n breakup reaction at 130 MeV deuteron energy, contribute significantly to constrain the physical assumptions underlying the theoretical interaction models. Comparison of nearly 1800 cross-section data points with the predictions using nuclear interactions generated in various ways (semi-phenomenological meson exchanges, coupled barion channels approach, chiral perturbation theory), allowed to establish for the first time a clear evidence of importance of the 3N forces in the breakup process. Moreover, the results confirmed predictions of sizable Coulomb force influences in this reaction. Studies on the importance of the relativistic effects are under way.

HK 11.3 Mo 14:45 H-ZO 100

Analyzing Powers of the Deuteron-Proton Breakup in a Wide Phase Space Region — •Elzbieta Stephan[1], Stanislaw Kistryn[2], and Nasser Kalantar-Nayestanaki[3] — [1]University of Silesia, PL-4007 Katowice — [2]Jagiellonian University, PL-30059 Krakow — [3]Kernfysisch Versneller Instituut, NL-9747 Groningen

Deuteron-proton breakup can serve as a very rich testing ground for modern calculations based on model nucleon-nucleon interactions and including also subtle effects of the so-called three-nucleon force (3NF). In the case of experiment exploring a significant part of the phase space, data obtained for continuum of final states constitute a large base for comparisons with theoretical predictions. Moreover, studies with transversally polarized deuterons give access to two vector and three tensor analyzing powers, some of which vanish in the case of the elastic scattering process.

A dedicated experiment has been performed at KVI Groningen, with the use of 130 MeV polarized deuteron beam and high acceptance position-sensitive detection system. About 800 data points have been analyzed for each spin observable: vector A_x, A_y and tensor A_{xx}, A_{xy}, A_{yy} analyzing powers of the ^{1}H($\vec{\text{d}}$,pp)n breakup reaction. Theoretical predictions generally describe analyzing power data quite well and the quality of description provided by various approaches is rather similar. There are, however, configurations where the agreement between the data and theory is not so satisfactory. These discrepancies are not always cured by inclusion of 3NF, what indicates incompleteness of the treatment of the spin part of three nucleon system dynamics.

HK 11.4 Mo 15:00 H-ZO 100

The MAX-lab tagged photon facility — •Lennart Isaksson — MAX-lab, Lund University, Sweden

The tagged photon facility at MAX-lab in Lund, Sweden has recently been upgraded to higher energy. The present facility consists of a ∼200 MeV linac followed by a pulse stretcher ring. The extracted electron beam (∼50% duty factor) is used to generate a bremsstrahlung beam and photons are tagged by a choice of two different tagging spectrometers, optimized for different energy regions. The tagged photon range may presently be chosen between 15 MeV and 185 MeV. The energy resolution is typically ∼0.5 MeV and the tagged intensity is $\sim 10^6$ MeV^{-1} s^{-1}. The available energy may increase somewhat in the near future.

The initial experimental programme includes Compton scattering on deuterium using very large NaI detectors, (γ,π^+) measurements using both solid-state and scintillator set-ups, and tests of electromagnetic calorimeter elements for the PANDA detector. Initial tests have been performed on total absorption cross-section measurements on ^{4}He, using an active target, and on ^{6,7}Li. A linearly polarized photon beam from coherent bremsstrahlung is being commissioned.

The MAX-lab tagged photon facility will be presented and an overview of the present experimental programme given.

HK 11.5 Mo 15:15 H-ZO 100

Ab-initio longitudinal response function of 4He — •Sonia Bacca[1], Nir Barnea[2], Winfried Leidemann[3], and Giuseppina Orlandini[3] — [1]TRIUMF, Vancouver, B.C., Canada — [2]Racah Institute of Physics, Hebrew University, Jerusalem, Israel — [3]Dipartimento di Fisica, Universita' di Trento and INFN, Italy

We report on our recent ab-initio calculation of the inclusive longitudinal electron scattering off 4He with two- and three-nucleon forces [1]. The full four-body continuum dynamics is considered exactly via the Lorentz integral transform method. We show results for various kinematics up to q=500 MeV/c and compare it with available experimental data. The great importance of the final state interaction is demonstrated. The plane wave impulse approximation particularly fails in the quasi-elastic peak at low energies. The effect of the three-nucleon force results in the reduction of the quasi-elastic peak by 10% for momentum transfers q between 300 and 500 MeV/c. A good agreement with experimental data is found in the peak region. Only at q=500 MeV/c some discrepancies between theory and experiment are present in the low- and high-energy range. Interestingly, the effect of the three-nucleon force increases significantly at lower q, up to about 40% at q=100 MeV/c. Our findings suggest that the longitudinal response function is an electromagnetic observable, where one can learn about the not yet well established three-nucleon force. Unfortunately, at low momentum transfer experimental data are still missing.

[1] S. Bacca, N. Barnea, W. Leidemann, G. Orlandini, arXiv:0811.4624.

HK 11.6 Mo 15:30 H-ZO 100

Recent results for trinucleon transverse response functions using the LIT method — •Edward L. Tomusiak[1], Victor D. Efros[2], Winfried Leidemann[3,4], and Giuseppina Orlandini[3,4] — [1]Dept. of Physics and Astronomy, University of Victoria, Victoria, BC V8P 1A1, Canada — [2]Russian Research Centre "Kurchatov Institute", 123182 Moscow, Russia — [3]Dipartimento di Fisica, Universita' di Trento, Via Sommarive 14, 38100 Trento, Italy — [4]Istituto Nazionale di Fisica Nucleare, Gruppo Collegato di Trento

The ^{3}He and ^{3}H electron scattering transverse response functions $R_T(q,\omega)$ are calculated using the AV18 nucleon-nucleon potential and the UrbanaIX three-body force. The transition to continuum states is treated ab initio via the Lorentz Integral Transform (LIT) method [1]. The electromagnetic interactions include exchange currents. Their construction is unambiguous for boson exchange potentials, but require a prescription for "phenomenological" forces. Since the calculation is carried out in coordinate space the Arenhövel-Schwamb technique [2] is used for constructing consistent π- and ρ-like exchange currents for the AV18 potential. Theoretical results are compared to existing experimental data [3] in the threshold region at q=0.0882, 1.64 and 2.47 fm^{-1}, both for ^{3}He and ^{3}H.

[1] V.D. Efros, W. Leidemann, and G. Orlandini, Phys. Lett. B 338, 130 (1994).

[2] H. Arenhövel and M. Schwamb, Eur. Phys. J. A, 12, 207 (2001).

[3] G. A. Retzlaff et al. Phys. Rev. C49, 1263 (1994).

HK 11.7 Mo 15:45 H-ZO 100

pions in nuclei — •LEILA JOULAEIZADEH[1], JOSE BACELAR[1], IGOR GAŠPARIĆ[2], and HERBERT LÖHNER[1] — [1]KVI, University of Groningen, Groningen, The Netherlands — [2]Ruder Bošković Institute, Zagreb, Croatia

The role of pions in nuclei has been studied in pionic fusion, a highly coherent process in which two nuclei fuse to a united nucleus. The available center-of-mass energy is emitted in the pion channel. This production mechanism is sensitive to the pion-nucleon interaction and the structure of the fused nuclei, in particular to their cluster components. The experiment exploits the two-photon decay of neutral pions and provides the exclusive cross sections for the $^4He(^3He,\pi^0)^7Be$ and $^6Li(^4He,\pi^0)^{10}B$ reactions at energies just above the coherent production threshold. The pion angular distributions and their dependence on the fused system mass reflect the importance of the cluster substructure of nuclei and the pion interaction in nuclei.

[1] L. Joulaeizadeh et al., Pionic Fusion Experiments at Subthreshold Energies, AIP proceedings, Carpathian Summer School of Physics 2007, 475 (2008), ISBN 978-0-7354-0490-8.