# HK 36: Nuclear Structure and Dynamics I

Time: Tuesday 16:30–19:00 Location: H-ZO 40

HK 36.1 Tu 16:30 H-ZO 40

**Short lived radioactive isotopes at TRI$\mu$P facility** — •P.D. Shidling, G.S. Giri, K. Jungmann, W.L. Kruithof, M. Sohani, D.J. van der Hoek, O.O. Versolato, L. Willmann, and H.W. Wilschut — KVI, University of Groningen, The Netherlands

At TRI$\mu$P facility radioactive ion beam are produced and trapped for the study of fundamental symmetries and interaction in physics. The TRI$\mu$P magnetic separator is used for in-flight production and separation of different radioactive isotopes. Different radioactive ion beam have been produced, via charge exchange, stripping, projectile fragmentation and fusion evaporation reactions in inverse kinematics. The radioactive beam can be used directly or can be converted to a low energy beam using a thermal ionizer. In this talk we focus on $^{21}$Na, $^{213}$Ra which are trapped as atoms or ions. With the trapping of $^{21}$Na we have completed the TRI$\mu$P facility. Details on some selected aspect will be discussed.

HK 36.2 Tu 16:45 H-ZO 40

**Nuclei production in the spallation reaction $^{136}$Xe (200 MeV/A)+$^{1}$H** — •Carlos Paradela for the s184-FRS-Collaboration — Universidad de Santiago de Compostela,, Spain

For several years, an extensive research program in spallation reactions have carried out at GSI (Darmstadt, Germany) taking advantage of the relativistic heavy-ion beams and the high-resolution magnetic spectrometer (FRS)[1]. The measured cross sections are highly relevant for the validation of the existing nuclear codes in their low energy range. These codes are employed in the studies for radioactive beam facilities (RIBs) or accelerator-driven systems (ADS) dedicated to the radioactive waste incineration.

The study of $^{136}$Xe on Hydrogen at 1000, 500 and 200 MeV/A is conceived as an extension of the previous experimental data in order to provide decisive information on the energy dependence of the spallation process, achieving the lowest primary beam energy ever studied at FRS for a projectile that present a behaviour close to the heaviest elements.

In this work, the reaction $^{136}$Xe + p at 200 MeV/A has been studied by separating and identifying the produced fragments and determining their kinematical properties. The results obtained for the production cross section were compared to different codes describing the spallation process such as ISABEL, INCL4 or ABLA. The integral cross section obtained is compatible with the value given by the optic-model computation from Karol [2].

[1] Charms web site http://www-w2k.gsi.de/charms/data.htm
[2] P.J. Karol, Phys. Rev. C 11, 1203 (1975)

HK 36.3 Tu 17:00 H-ZO 40

**Even-odd effect in the yields from high-energy reactions** — •M.Valentina Ricciardi[1], Karl-Heinz Schmidt[2], Aleksandra Kelic[1], Fanny Rejmund[2], and Christelle Schmitt[3] — [1]GSI, Darmstadt, Germany — [2]GANIL, Caen, France — [3]IPN, Lyon, France

In 2003, the analysis of experimental production cross-sections of the light products of the reaction $^{238}$U+Ti at 1 A GeV, measured at the FRS, GSI, revealed a very strong even-odd staggering, which in some cases amounted to 50 percent, a magnitude comparable to even-odd effects found in low-energy fission. The origin of this effect was explained on the basis of the statistical model of nuclear reaction, by carefully considering the appropriate nuclear-structure effects in binding energies and level densities.

In the meantime, a large amount of new experiments on nuclear reactions at high energy were performed at the FRS. The cross sections of the produced nuclei, fully identified in mass and atomic number, and kinematically separated to disentangle the different contributing reaction-mechanisms, also showed to be modulated by a complex and very strong even-odd structure. The new systematic analysis of the even-odd effect over a large range of nuclear reactions and nuclear systems, on one hand confirmed the expected behaviors for the light residual nuclei produced in high-energy reactions, on the other, revealed new and unexpected tendencies of the even-odd phenomenon in regions of the production yields up to now unexplored. The new features are discussed and possible explanations offered.

HK 36.4 Tu 17:15 H-ZO 40

**Isomeric ratios for nuclei with Z=62-67 and A=142-152 produced in the relativistic fragmentation of 208Pb** — •Szymon Myalski[1], Adam Maj[1], and Zsolt Podolyak[2] for the RISING-IR-Collaboration — [1]IFJ PAN, Kraków,Poland — [2]Dept. of Physics, Univ. of Surrey, Guildford, UK

We have investigated isomeric states in a number of nuclei with Z=62-67 and A=142-152, produced by the fragmentation of the relativistic(1 GeV/u)$^{208}$Pb beam from the SIS-18 synchrotron of the GSI facility on a $^{9}$Be target, and selected by the FRagment Separator(FRS). The selected nuclei of interest were implanted into the stopper, a block of plastic 7mm thick. The gamma-rays from the decay of isomeric states in the implanted nuclei were measured by the high purity germanium array, RISING. In total 22 nuclides were detected, isomeric states were observed in 9 of them:19$^-$in $^{152}$Ho, 31/2$^+$in $^{153}$Ho, 27$^+$in $^{148}$Tb, 10$^+$in $^{144}$Gd, 49/2$^+$in $^{147}$Gd, 11/2$^-$in $^{143}$Eu, 8$^-$in $^{144}$Eu, 11/2$^-$ in $^{145}$Eu, 10$^+$in $^{142}$Sm and 7$^-$in $^{142}$Sm. Of special interest is the 27$^+$ state in $^{148}$Tb, the highest spin populated through the fragmentation reaction until present day. The aim of this work was the extraction of isomeric ratios(R) for these isomeric states. The R is the number of ions populated in a given isomeric state compared to the total number of ions populated for the selected nuclide. The R can provide information about the production reaction and nuclear structure. It was evaluated based on flight time, half-life, in-flight losses and by considering the finite measurement time. Results were compared with theoretical predictions, calculated using an abrasion-ablation approach.

HK 36.5 Tu 17:30 H-ZO 40

**Production of medium-mass neutron-rich nuclei from fragmentation of $^{132}$Sn nuclei** — •David Pérez-Loureiro — Universidade de Santiago de Compostela, Spain

The extension of the nuclear chart towards the neutron-rich side is of utmost importance for nuclear structure and nuclear astrophysics. However, these investigations are limited because of the dificulties in producing neutron-rich nuclei. In the case of masses around $A \sim 130$ a two step reaction scheme was proposed to partially overcome this limitation [1]. Therefore, this experimental technique might be a tool for producing beams of extremely neutron-rich isotopes of refractory elements and short lived nuclei in future ISOL facilities [2].

The production cross sections of residual nuclei, were investigated in an experiment performed at the Fragment Separator (GSI). A 950 MeV/u, and $10^9$ particles per spill, $^{238}$U beam impinged onto a 650 mg/cm$^2$ Pb target at the entrance of the separator for producing fission fragments. Forward emitted fragments were isotopically identified in the first part of the FRS. These fully identified fission residues impinged onto a 2.6 g/cm$^2$ beryllium target located at the intermediate focal plane. The fragmentation products were also identified in the second section of the separator. In this contribution we will present the measured production cross sections of this two-step reaction residues that will be compared to direct production in $^{238}$U fission and $^{136}$Xe fragmentation, and with different model calculations.

[1] K. Helariutta et al., Eur. Phys. J. A, 17 (2003) 17
[2] EURISOL WEB page: `http://www.ganil.fr/eurisol`

HK 36.6 Tu 17:45 H-ZO 40

**Transfer reactions with $^{8}$Li** — •Elisabeth Tengborn for the IS446-Collaboration — Subatomic Physics, Chalmers University of Technology, Sweden

Exotic light nuclei are being studied through a campaign of transfer-reaction experiments at REX-ISOLDE, CERN. The present aim is to investigate the structure of neutron-rich lithium isotopes. The scientific motivation for these studies is manifold. First, the isotopic chain of lithium ends in the emblematic two-neutron halo nucleus $^{11}$Li. Second, spectroscopic factors for known and hitherto unobserved excited states are being predicted by *ab-initio* and shell model calculations and can thus be tested experimentally. Third, these loosely bound systems present a challenge to our modelling of reaction mechanisms.

The project described here is a benchmark experiment where a beam of $^{8}$Li was impinging on a deuterated polypropylene target in inverse kinematics. This mainly gives information on $^{9}$Li through a one neutron pick-up reaction, which in the inverse kinematics corresponds to a (d,p)-reaction. However, the reaction channels (d,d) and (d,t) can

also be studied. The goal of the experiment is to study the reaction mechanism and the coupling to the continuum.

All steps (calibration of the detectors, background subtraction, acceptance corrections, excitation energies and simulations) leading up to angular distributions on an absolute scale have been performed. The angular distributions have been compared with theoretical models and the presentation will include a discussion about the reaction mechanism of direct versus compound reactions.

HK 36.7 Tu 18:00 H-ZO 40

**Halo effects in the Scattering of 11Li on heavy target** — •Olof Tengblad[1], Maria Jose Garcia Borge[1], Joaquin Gomez Camacho[2], and Ismael Martel Bravo[3] — [1]IEM-CSIC, Madrid, Spain — [2]Univ. Sevilla, Spain — [3]Univ. Huelva, Spain

Halo nuclei are composed by a core nucleus and one or two loosely bound neutrons. Due to the loosely bound structure, they should be easily polarizable. Thus, in the presence of a strong electric field, the nucleus will be distorted, so that, with respect to the centre of mass of the nucleus, the halo neutrons will move opposite to the electric field, while the positively charged core will move in the direction of the field. The B(E1) distribution is a measurement of the importance of polarizability.

The phenomenon of dipole polarizability affect strongly the elastic scattering of halo nuclei on heavy targets, even at energies below the Coulomb barrier, where the nuclear force should not be important. Two effects are relevant: First, Coulomb break-up will reduce the elastic cross sections. Second, the distortion of the wave function generated by the displacement of the charged core with respect to the centre of mass of the nucleus will reduce the Coulomb repulsion, and with it the elastic cross sections.

We report here on an experiment, performed in October 2008 at the ISAC-II facility at TRIUMF Vancouver Canada, measuring the elastic differential cross section of 11Li on 208Pb at 2.2 to 3.0 MeV/u laboratory energy. We have observed and quantified the reduction of the differential cross sections compared to the Rutherford cross section.

HK 36.8 Tu 18:15 H-ZO 40

**Photo-induced fission at the S-DALINAC*** — •Alf Göök[1,2], Roman Barday[1], Maksym Chernykh[1], Christian Eckardt[1], Ralph Eichhorn[1], Joachim Enders[1], Franz-Josef Hambsch[3], Peter von Neumann-Cosel[1], Andreas Oberstedt[2], Stephan Oberstedt[3], Yuliya Poltoratska[1], Achim Richter[1,4], and Markus Wagner[1] — [1]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [2]Akademin för naturvetenskap och teknik, Örebro universitet, Sweden — [3]EC-JRC Institute for Reference Materials and Measurements, Geel, Belgium — [4]European Centre for Theoretical Studies in Nuclear Physics and Related Areas, Trento, Italy

In line with the ongoing photofission program at the superconducting Darmstadt linear electron accelerator S-DALINAC, whose ultimate goal is to study parity violation, experiments are taking place in January 2009. The purpose of these experiments will be the investigation of photo-induced fission of $^{238}$U and $^{234}$U. A twin Frisch grid ionization chamber will be used to determine fragment energy- and mass distributions via the 2E-technique. Status and preliminary results of these experiments will be presented.

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**Color transparency and short-range correlations in exclusive pion and nucleon removal reactions from nuclei** — •Wim Cosyn — Ghent University, Ghent, Belgium

A relativistic and quantum mechanical framework to compute nuclear transparencies for pion and nucleon production reactions is presented [1-3]. Final-state interactions for the ejected pions and nucleons are implemented in a relativistic Glauber eikonal approach. The proposed model can account for the color-transparency (CT) phenomenon and short-range correlations (SRC) in the nucleus. Results are presented for kinematics corresponding to completed experiments for $A(\gamma,\pi^+n)$ and $A(e,e'\pi^-)$, $A(p,2p)$ and $A(e,e'p)$. The influence of CT and SRC on the nuclear transparency is studied. Both the SRC and CT mechanisms increase the nuclear transparency. The two mechanisms can be clearly separated, though, as they exhibit a completely different dependence on the hard-scale parameter. Recent $A(e,e'\pi^+)$ results [4] point towards the early onset of the CT phenomenon in pion production processes. The similarities in the trends and magnitudes of the computed nuclear transparencies compared to semi-classical models indicate that they are not subject to strong model dependences.

[1] W. Cosyn, M. C. Martínez, J. Ryckebusch, and B. Van Overmeire, Phys. Rev. C74, 062201(R) (2006) [2] W. Cosyn, M. C. Martínez, and J. Ryckebusch, Phys. Rev. C77, 034602 (2008) [3] B. Van Overmeire, W. Cosyn, P. Lava and J. Ryckebusch, Pys. Rev. C73, 064603 (2006) [4] B. Clasie et al. Phys. Rev. Lett. 99, 242502 (2007).

HK 36.10 Tu 18:45 H-ZO 40

**Effect of spin-spin interactions on polarisation observables from nucleon-nucleus scattering** — •Elizabeth Cunningham, Jim Al-Khalili, and Ronald Johnson — University of Surrey, Guildford, U.K.

With the new GSI/FAIR facility currently under construction there is a vital need for nuclear reaction theory calculations to make predictions of observables relevant to the proposed experiments. In order to do this for the exotic nuclear species planned to be created at FAIR, it is necessary to determine accurate optical models to describe nucleon elastic scattering from non-zero target spin, $\mathbf{I}$.

The possible existence of a spin-spin interaction in nucleon-nucleus scattering was first proposed by Feshbach [1] who suggested the inclusion of a spherical $\mathbf{I}\cdot\sigma$ and tensor $\mathbf{S}_{12}$ term into the optical potential. The effects of these terms have since been the subject of much theoretical and experimental interest, but it was not until the work of McAbee [2] that a generalised spin-spin tensor was proposed.

In this work we evaluate the $\mathbf{I}\cdot\sigma$ term within the Distorted Wave Born Approximation and apply it to proton scattering from $^{10}$B, for which relevant IUCF data exist. The effect on spin observables, specifically the polarisation transfer coefficient $D_{NN}$ will be presented. New insight is obtained into the relationship between the spherical spin-spin interaction and $D_{NN}$.

[1] H. Feshbach, Ann. Rev. Nuclear Sci. 8, 49 (1958)
[2] T. L. McAbee et al., Nucl. Phys. A509 (1990) 39