HK 16: Nuclear Structure and Dynamics II

Time: Monday 16:30–19:00 Location: H-ZO 60

Invited Group Report HK 16.1 Mo 16:30 H-ZO 60

Nuclear Structure Studies of the Heaviest Elements — •Paul Greenlees — Department of Physics, University of Jyväskylä, P.O.Box 35,*40014 Jyväskylä, Finland

Over the past decade or so, modern γ-ray spectroscopic techniques have enabled the structure of heavy elements to be investigated in detail. A major program of research has been carried out to study the so-called transfermium nuclei in the region of ^{254}No close to the N=152 deformed sub-shell gap. These nuclei are the heaviest for which detailed in-beam and decay spectroscopy can be performed (see Herzberg and Greenlees, Prog. Part. Nuc. Phys. **61**, 674 (2008) for a review).

Initial in-beam measurements in the region focussed on γ-ray spectroscopy of even-even nuclei, studying the ground-state yrast bands and allowing extraction of parameters such as the moments of inertia, and proving the deformed nature of these nuclei. More recently, attention has switched to odd-mass nuclei such as ^{253}No, ^{251}Md and ^{255}Lr, the latter being the heaviest nucleus so far studied in-beam. Rotational bands have been observed in all these nuclei. Non-yrast and K-isomeric states have recently been studied through the use of both in-beam and focal plane decay spectroscopy, yielding data which can be used to determine the excitation energies and configurations of two-quasiparticle states for comparison to the predictions of various theories.

An overview of the most recent results and the experimental techniques used will be presented. Perspectives for the development of new devices for further studies in this region will also be discussed.

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Hyperdeformed Fission Resonances observed in ^{232}U* — •L. Csige[1,3], M. Csatlos[1], T. Faestermann[2], Z. Gacsi[1], J. Gulyas[1], D. Habs[3], R. Hertenberger[3], M. Hunyadi[1], A. Krasznahorkay[1], R. Lutter[3], H.-J. Maier[3], P.G. Thirolf[3], and H.-F. Wirth[3] — [1]Inst. of Nucl. Res. of the Hungarian Acad. of Sciences, Debrecen, Hungary — [2]TU München, Physik Department E12, Garching, Germany — [3]LMU München, Fakultät f. Physik, Garching, Germany

Hyperdeformed (HD) third minima are expected to appear in the potential energy surface of many actinide nuclei according to theoretical calculations. The existence of HD states was experimentally established earlier in the uranium isotopes ^{234,236}U [1,2]. In a recent experiment the fission probability of ^{232}U was measured as a function of the excitation energy using the ^{231}Pa(^{3}He,df) reaction at the Garching Q3D magnet spectrograph. Sub-barrier fission resonances have been observed for the first time in the excitation energy region E=4.5-4.8 MeV and interpreted as being rotational bands with rotational parameters characteristic to a HD nuclear shape ($\hbar^2/2\Theta$ = 1.9 keV). Fission barrier poarameters were extracted and angular distributions of the fission fragments were determined in order to deduce the K value of the rotational bands. According to our new results ^{232}U can be a good candidate to search for discrete γ transitions of hyperdeformed states.

[1] A. Krasznahorkay et al., Phys. Rev. Lett. **80** (1998) 2073. [2] M. Csatlós et al., Phys. Lett. **B615** (2005) 175.

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HK 16.3 Mo 17:15 H-ZO 60

Mass measurements of No isotopes at SHIPTRAP — •Michael Dworschak for the SHIPTRAP-Collaboration — GSI Helmholtzzentrum, 64291 Darmstadt, Germany

The Penning trap mass spectrometer SHIPTRAP at GSI Darmstadt was set up for high-precision mass measurements of heavy radionuclides produced in fusion-evaporation reactions and separated from the primary beam by the velocity filter SHIP. Two interesting regions in the chart of nuclides that can be accessed by this production method are the region around the doubly magic ^{100}Sn and the region of elements heavier than uranium.

Recently, first mass measurements of the three nobelium isotopes $^{252-254}$No (Z=102) - which were produced in the reaction $^{206-208}$PbS(^{48}Ca,2n)$^{252-254}$No - were performed with the SHIPTRAP Penning trap mass spectrometer. These are the heaviest nuclides ever measured with Penning traps. The lowest production cross section was 400 nb (0.6 particles per second). The No nuclides are of importance to benchmark nuclear structure theories and to improve their predictions of the stability of super heavy elements that is caused by shell effects.

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Spectroscopy of Transfermium Isotopes at SHIP — •Stanislav Antalic[1], Fritz Peter Hessberger[2], Sigurd Hofmann[2,3], Dieter Ackermann[2], Sophia Heinz[2], Birgit Kindler[2], Ivan Kojouharov[2], Bettina Lommel[2], Rido Mann[2], Štefan Šáro[1], Branislav Streicher[2], Barbara Sulignano[4], and Martin Venhart[1] — [1]Comenius University, Bratislava, Slovakia — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]Goethe-Universität, Frankfurt am Main, Germany — [4]CEA-Saclay, DAPNIA/SPhN, Gif-sur-Yvette Cedex, France

Recent developments of experimental techniques suited for α-, γ- and CE spectroscopy now allow to study nuclear structure in the region of trans-fermium nuclei. This opened the door to investigate nuclear structure under extreme conditions of heaviest nuclei (Z>100, A>250).

Most interesting examples are studies of K-isomers. Experiments aimed to investigate such phenomena provide important information on the nuclear structure of the heaviest elements and are stringent tests for the quality of nuclear models.

In this contribution the results from studies of multi-quasi-particle isomeric states in ^{253}No and ^{255}Lr performed at SHIP will be presented in detail. Both nuclei are first odd-mass isotopes in the trans-fermium region for which high K-isomers were observed. By decay of the high K-isomer in ^{253}No a rotational band was populated, which was not seen in previous in-beam studies. Additionally, also the recent results on the single particle level systematics for the N = 149, 151 and 153 isotones will be presented.

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Masses and fission barriers of nuclei in the LSD model — •Krzysztof Pomorski — MCS University

Recently developed Lublin-Strasbourg Drop (LSD) [K. Pomorski, J. Dudek, PRC 67, 044316 (2003)] model together with the microscopic corrections taken from Ref. [P. Moeller et al., ADNDT 59, 185 (1995)] is very successful in describing many features of nuclei. In addition to the classical liquid drop model the LSD contains the curvature term proportional to the A^1/3. The r.m.s. deviation of the LSD binding energies of 2766 isotopes with Z,N > 7 from the experimental ones is 0.698 MeV only. It turns out that the LSD model gives also a satisfactory prediction of the fission barrier heights. In addition, it was found in Ref. [K. Pomorski, J. Dudek, IJMPE 13, 107 (2004)] that taking into account the deformation dependence of the congruence energy proposed by Myers and Swiatecki significantly approaches the LSD-model barrier-heights to the experimental data in the case of light isotopes while the fission barriers for heavy nuclei remain nearly unchanged and agree well with experiment. It was also shown in Ref. [J. Bartel et al., IJMPE 16, 459, (2007)] that the saddle point masses of transactinides from 232Th to 250Cf evaluated using the LSD differ by less than 0.67 MeV from the experimental data.

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Electron-capture delayed fission (ECDF) in the lead region — •Martin Venhart[1], Andrei Andreyev[1], Stanislav Antalic[2], Jytte Elseviers[1], Dieter Ackermann[3], Fritz Peter Hessberger[3], Sigurd Hofmann[3,4], Mark Huyse[1], Katshuhisa Nishio[5], Piet van Duppen[1], and Cyrillus Wagemans[6] — [1]IKS, KU Leuven, Belgium — [2]Comenius University, Bratislava — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [4]Goethe-Universität, Frankfurt am Main, Germany — [5]JAEA, Japan — [6]University of Ghent, Belgium

Beta-delayed fission is a rare process in which the beta-decaying precursor populates relatively low-excited state in its decay daughter, which may then fission. This allows to study low-energy fission properties e.g. the isospin dependence of the fission barriers. It is currently believed that the beta-delayed fission process is crucial for understanding the r-process path and for the production of the heaviest elements.

In the presentation, the recent experiments performed at the velocity filter SHIP (GSI) and at the mass-separator ISOLDE (CERN) will be discussed. In these experiments, the ECDF decay was unambiguously observed in several very neutron-deficient nuclides in the Pb region (^{192,194}At and ^{180}Tl). ECDF probability and total kinetic energy were determined. Surprisingly, an asymmetric mass distribution of fission fragments was observed in ECDF of ^{180}Tl. Preliminary analysis also shows that the cold fission (no neutron emission) might be the main decay channel in the ECDF decay of this nucleus.

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Reaction studies about the Q-value influence on the production of superheavy elements — •R. Graeger[1], A. Gorshkov[1], A. Türler[1], A. Yakushev[1], C.E. Düllmann[2], E. Jäger[2], J. Khuyagbaatar[2], J. Krier[2], D. Rudolph[2], M. Schädel[2], B. Schausten[2], J. Dvorak[3], M. Chelnokov[4], A. Kuznetsov[4], J. Even[5], D. Hild[5], J. Kratz[5], J.P. Omtvedt[6], F. Samadani[6], K. Nishio[7], and Q. Zhi[8] — [1]TU München, Garching, Germany — [2]GSI, Darmstadt, Germany — [3]LBNL, Berkeley, USA — [4]FLNR, Dubna, Russian Federation — [5]U Mainz, Mainz, Germany — [6]U Oslo, Oslo, Norway — [7]JAEA, Tokai, Japan — [8]IMP, Lanzhou, China

Superheavy elements only exist due to nuclear shell effects. Theoretical calculations predict maximum stability at doubly-magic spherical nucleus with Z=114 and N=184 and near Z=108 and N=162 with the inclusion of higher orders of deformation. The doubly-magic nucleus 270Hs has been observed for the first time by J. Dvorak, et al. in 4n evaporation channel of the reaction 26Mg + 248Cm [1]. Recently, the formation of 270Hs in a 4n evaporation channel in the fusion reactions with different asymmetry has been studied by theoretical calculations by Liu and Bao [2]. The reactions 48Ca + 226Ra and 36S+ 238U are predicted to result in a higher cross section due to a more negative reaction Q value. The measurement of the nuclear fusion reactions 36S+ 238U at GSI, Darmstadt and 48Ca + 226Ra at FLNR, Dubna has already been started. The first preliminary results will be presented in this contribution. [1]Dvorak et al., Phys.Rev.Lett., Vol97, 242501 (2006) [2]Liu and Bao, Phys.Rev. C, Vol74, 057602 (2006)

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New ideas on the formation of heavy and superheavy neutron rich nuclei — •Valery Zagrebaev[1] and Walter Greiner[2] — [1]FLNR, JINR, Dubna, Russia — [2]FIAS, J.W. Goethe-Universität, Frankfurt, Germany

Nowadays, nuclei far from stability are accessible for experimental study in almost any region of the nuclear map. The only exception is the north-east part where a vast blank spot is still unexplored. This area of the nuclear map can be reached neither in fusion–fission reactions nor in fragmentation processes. The unexplored area of heavy neutron-rich nuclides is extremely important for nuclear astrophysics investigations and, in particular, for the understanding of the r-process of astrophysical nucleogenesis. The study of the structural properties of nuclei along the closed neutron shell N = 126 (Z < 80) would also contribute to the present discussion of the quenching of shell effects in neutron rich nuclei.

A novel idea is proposed for the production of these nuclei via low-energy multi-nucleon transfer reactions with stable beams. The estimated yields of neutron-rich nuclei are found to be rather high in such reactions and several tens of new nuclides can be produced, for example, in the near-barrier collision of ^{136}Xe with ^{208}Pb with a cross section higher than one microbarn. This finding may spur new studies at heavy-ion facilities and should have significant impact on future experiments. Fusion reactions with the use of light and medium mass neutron-rich radioactive beams for the production of heavy neutron-rich nuclei will be also discussed in the talk.