MINIBALL Workshop and Users meeting

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Book of Abstracts

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Detection of X rays in the Neutron-Deficient Polonium Coulomb Excitation Experiments

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Coulomb excitation experiments in inverse kinematics using heavy postaccelerated radioactive ion beams often result in multiple step Coulomb excitation whereby several low-lying excited states are populated. At REX-ISOLDE, the Miniball gamma spectrometer is used for the detection of gamma rays originating from electromagnetic transitions in the investigated nuclei [1]. The nuclear levels populated by Coulomb excitation do not always necessarily decay to a lower-lying energy level by emitting a gamma ray, but also by conversion electrons. Conversion and 0+2⊠0+1 E0 transitions are important in the neutron-deficient lead region due to the high proton number and nuclear structure arguments [2]. Hence, observed gamma ray intensities do not suffice to analyze Coulomb excitation data in the neutron-deficient lead region in a correct way: the decay from populated levels involving electrons should be included as well.

The vacancy created in an atomic shell by the electron is filled by another atomic electron, accompanied by the emission of a characteristic X ray. The Miniball gamma spectrometer can be used to detect the more energetic K X rays. Conversion and E0 transitions are not the only sources of X rays at Miniball. The beta decay of a fraction of the radioactive ion beam scattered in the neighborhood of Miniball can give rise to the detection of X rays and the REX linear post accelerator yields a broad spectrum of 'room background'X rays. These processes are random as they are not related to a beam particle hitting the target. This hints to the fact that it is crucial to do a proper prompt to random scaling when considering the particle gamma coincidences. As the amount of random gammas is large in the X-ray region and the time behavior of these 'random'events in the X-ray region is different than for the atomic X rays from the beam and conversion, the amount of X rays is very sensitive to the prompt to random scaling factor.

A last source for X rays is the creation of a K vacancy induced by the collision of the heavy ion beam with the target. This process gives rise to prompt and Doppler broadened X rays as they are created in the interaction of the projectile with the target. These prompt X rays cannot be distinguished from X rays originating from nuclear effects. In order to determine the number of E0 transitions the cross section for the collision-related X rays has to be estimated. The total cross section for K-shell ionization can be inferred from a theoretical prediction [3]. In the Hg coulex analysis 188Hg is used as a reference point since no E0 transitions are expected there. All the detected X rays, corrected for converted E2 transitions, can then be attributed to the collision between projectile and target [4].
In both the 2009 and 2012 experimental campaigns of the Coulomb excitation of the neutron-deficient polonium isotopes X rays were detected at Miniball. A similar role as 188Hg can be played by 206Po where no E0 transitions are expected.

In this presentation the X-ray evaluation will be discussed in the Coulomb excitation data on 196,198,200,202,206Po.

[1] N. Warr et al, Eur. Phys. J. A 49 (2013) 40.
[2] J.L. Wood, K. Heyde, Rev. Modern Phys. 83 (2011), 1467.
[3] C.M. Romo-Kröger, Phys. Scripta T118 (2005) 9.
[4] N. Bree, to be published.

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Preliminary results from 140Sm Coulomb excitation experiment

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The open-shell nuclei with Z>50 and N<82 are known to have some of the largest ground- state deformations in the nuclear chart. The shape of the nuclei in this region are expected to be prolate, except for a small island of nuclei with Z>62 and N≈78, which are predicted to be oblate. Nuclei near 140Sm are therefore expected to be located in a transitional region between deformed and spherical shapes (as a function of neutron number) and between prolate and oblate shapes (as a function of proton number), and shape coexistence may be expected to occur. Indeed, a low-lying excited 0+ state was tentatively assigned in 140Sm, which could be interpreted as a sign for shape coexistence. The measurement of spectroscopic quadrupole moments and transition strengths represents a sensitive test for theoretical predictions in this region. Due to the occurrence of two isomeric 10+ states of
\pi(h_{11/2})ˆ2 *and*\nu(h_{11/2})ˆ{-2} $ configuration the lifetimes of low-lying states are completely unknown.
A Coulomb excitation experiment with a 140Sm beam on a 94Mo target was performed at ISOLDE with the typical setup comprising Miniball and a DSSD in June/July 2012. The laser- ionized beam of 140Sm was quasi-pure with an average intensity of 2*10ˆ5 particles per second. At least three excited states in 140Sm were populated during the experiment: the 2+ and 4+ states of the ground-state band and the tentatively assigned 0+ state at 990 keV excitation energy. The statistics collected during the experiment allows the analysis of differential Coulomb excitation cross sections as a function of scattering angle. Experimental details and first preliminary results obtained in the analysis with GOSIA2 will be discussed.

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Quadrupole Collectivity in neutron-rich Cd isotopes

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The neutron-rich cadmium nuclei with a proton number of Z=48 are some of the most interesting isotopes in nuclear structure physics due to the proximity to the proton and neutron shell closures at Z=50 and N=82 respectively. The excitation energy of the 2_1⁺-states shows an irregular behaviour when approaching the neutron shell closure. From 124Cd to 126Cd the energy is only slightly increasing and from 126Cd to 128Cd even a drop can be noticed. So far this finding can not be reproduced by shell-model (SM) calculations although the shell closure is near. Only Beyond-Mean-Field (BMF) calculations with a resultant prolate deformation agree with the low excitation energy of 128Cd. The transition strength B(E2, 0gs⁺⟶2_1⁺) in the even isotopes 122-128Cd was measured in Coulomb excitation experiments (IS411, IS477) with MINIBALL at REX-ISOLDE (CERN). Since the values for 122,124Cd coincide with BMF calculations with a resultant prolate deformation 126Cd is better described via SM calculations. Results of the more recent experiment on 128Cd will pursue the picture of the behaviour of the transition strength towards the neutron shell closure. A closer insight into the onset of collectivity and the roles played by different orbits can be obtained by the investigation of the odd isotopes. We started this program with the examination of 123Cd (IS524) where already discrepancies to the literature were evidenced. In this contribution the latest results of the investigation of the B(E2, 0_gs⁺⟶2_1⁺) values of the even 122-128Cd nuclei as well as first findings from the recently performed measurement of 123Cd via Coulomb excitation will be presented. This project is supported by BMBF (No. 06 DA 9036I and No. 05 P12 RDCIA), HIC for FAIR, EU through EURONS (No. 506065) and ENSAR (No. 262010) and the MINIBALL and REX-ISOLDE collaborations.

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Coulomb excitation of neutron-deficient radon isotopes

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The region of proton rich nuclei close to Z=82 is well known for shape coexistence with competition between different spherical, oblate and prolate minima. Data on the light radon nuclei e.g. 198-206Rn is rather limited and largely restricted to information on near-yrast states as inferred from in-beam studies. These studies seem to indicate a change from a largely vibrational behaviour around 212Rn to the onset of deformation around 198Rn. The level schemes are complex and much information is missing.

In order to obtain more detailed information on collectivity in these nuclei, an experiment was performed at REX-ISOLDE to carry out Coulomb excitation of 202Rn and 204Rn. At the time of the experiment, these were the heaviest ISOL beams ever accelerated. The choice of radon nuclei was motivated both by the underlying Physics but also the ability to produce pure, intense beams of these isotopes using a cooled transfer line to remove isobaric contamination. The analysis of the data obtained has been completed and the data have been used to extract matrix elements using the Coulomb excitation code, GOSIA.

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Coulomb excitation of 26Na with MINIBALL at REX-ISOLDE

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Excited states of 26Na were the subject of a Coulomb excitation experiment at REX-ISOLDE employing a radioactive 26Na beam with a final energy of 2.82 MeV/u. De-excitation gamma-rays were detected by the MINIBALL gamma-spectrometer in coincidence with scattered particles in a CD-shaped segmented Si-detector. Reduced transition matrix-elements for the excited states of 26Na at 233 keV and 407 keV were determined for the first time. The obtained values are compared to theoretical predictions from updated shell model calculations using USDA/USDB interactions.

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Coulomb excitation of 29,30Na

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Nuclear shell effects in neutron-rich Na nuclei at the border of the island of inversion around N=20 were studied by measuring reduced transition probabilities, i.e. B(E2) and B(M1) values. To this end Coulomb-excitation experiments, employing radioactive 29,30Na beams with a final beam energy of 2.85 MeV/u, were performed at REX-ISOLDE, CERN. De-excitation gamma rays were detected by the MINIBALL gamma-ray spectrometer in coincidence with scattered particles in a segmented Si detector. The measured B(E2) values agree well with shell-model predictions, supporting the idea that in the Na isotopic chain the ground-state wave function contains significant intruder admixture already at N=18, with N=19 having an almost pure 2p2h deformed ground-state configuration.
This work has been supported by the German BMBF, by the FWO-Vlaanderen, by the IAP Belgian Science Policy (BriX network), by the UK STFC, by the EURONS, and by the ENSAR.

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Welcome

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Probing the semi-magicity of 68Ni via one and two-neutron transfer reactions using TREX+MINIBALL

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Multiple Coulomb Excitation with high intense 72Zn beam at ISOLDE

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Cluster-transfer reactions with radioactive 98Rb and 98Sr beams on a 7Li target

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Overview and Status of MINIBALL at the Munich Tandem Laboratory

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Concluding remarks and discussion