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Onset of collectivity beyond N=50 studied in zinc isotopes

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Neutron-rich zinc isotopes will be populated in (p,2p) on the MINOS liquid hydrogen target.

Recently the 2+ and 4+ levels of N=52,54 82,4Zn nuclei were measured at RIKEN within the SEASTAR programme [1]. The energies of the newly observed levels suggest the onset of deformation towards heavier Zn isotopes, which has been incorporated by taking into account the upper sdg orbitals in the Ni78-II and the PFSDG-U models. The measured E(4+)/E(2+) ratio is close to 2, characteristic for vibrational nuclei (see figure 1). Here we propose to quantify the collectivity in zinc nuclei beyond the N=50 shell closure, and to obtain direct information on the relevant single neutron orbitals.

The study of the odd-mass 85,83Zn is expected to provide information on the neutron orbitals above N=50. Most importantly it will determine the relative position of the d5/2, d3/2 and s1/2 orbitals. Prediction of two different shell model calculations [2] are shown for 83Zn (N=53) in figure 2. (MCSM has only d5/2 above N=50, so no low lying ½). Systematics of N=51 nuclei suggest that the ½+ state would be very close to the 5/2+, and might become even ground-state. The neutron orbitals beyond N=50 could be studied more directly in 79Ni, populated from 80Cu(p,2p). However, the single-neutron states will be not populated directly, but via higher-lying states [3].

The lifetimes of excited states in 82,84Zn will be determined by line-shape analysis [4]. The expected lifetimes of the 2+ states are around 50 ps, while those of 4+ around 15 ps, therefore, these can be measured from the gamma-ray lineshapes, and the collectivity quantified. We will attempt to get information on excited states also on 86Zn. This has 6 neutrons above N-50, which would fill the d5/2 orbitals. Excited states need neutron excited to the higher lying d3/2 or s1/2 orbitals. The measured level scheme will provide information on this higher lying orbital.

The proposed experiment is feasible, as the 81,82,83,84Zn studied were previously populated with the SEASTAR campaign [1,2]. For example, 84Zn was populated by 85Ga(p,2p). The rate of 85Ga was 7 ion/s (with 30 pnA 238U primary beam on a 3mm Be target). In 24 hours, about 40 counts in the 2+->0+ transition of 84Zn were detected using DALI2. The better energy resolution of MINIBALL++ will compensate for its lower efficiency,and will allow lifetime determination.

Fig.1. Systematics of E(2+), E(4+) (top) and R4/2=E(4+)/E(2+) (bottom) for the Zn isotopic chain, compared with theoretical values. Taken form [1].

Fig.2. Two different shell model calculations compared with the tentative experimental level scheme for 83Zn [2].

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Primary authors: GORSKA, Magdalena (GSI); PODOLYAK, Zsolt (University of Surrey); THE RIKEN-MINIBALL COLLABORATION

Presenter: GORSKA, Magdalena (GSI)

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