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Study of the ^{28}Mg(t,^{30}Mg)p reaction to investigate nuclear shell evolution at the boundary of the N=20 Island of Inversion

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T. Zidar[1], D. Mücher[1], T. Kröll[2], C. Berner[3], V. Bildstein[1], C. Burbage[1], L. Atar[1], L. Gaffney[4], P. Garrett[1], B. Greaves[1], R. Gernhäuser[3], C. Henrich[2], S. Ilieva[2], A. Mentana[5], J. Refsgaard[5], M. Seidlitz[6], C. Svensson[1], N. Warr[6]

[1] Department of Physics, University of Guelph, Guelph, Canada
[2] Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany
[3] Physik Department E12, Technische Universität München, Garching, Germany
[4] School of Eng. & Computing, University of the West of Scotland, Paisley, UK
[5] Instituut voor Kern- en StralingsFysica, K.U. Leuven, Heverlee, Belgium
[6]Institut für Kernphysik, Universität zu Köln, Köln, Germany

In the so called "Island of Inversion" around ^{32}Mg, the ground states of nuclei exhibit a larger binding energy than expected from simple models. Extra binding energy can stem from an onset of deformation. Indeed, the systematics of excitation energies and B(E2) values in the Mg isotopes suggest a softening of the N=20 shell closure and it was suggested [1,2] that the nuclear tensor force has a major influence. On the other hand, shell evolution in the IOI can be understood as an effect of the weakly-bound orbits with small angular momentum [3].
New insight comes from a recent publication [4], where a shell model interaction for the entire sdfp shell model space was deduced using the EKK-theory from realistic nucleon-nucleon interactions without a fit of two-body matrix elements. The new prediction is a drastic change to the earlier belief: the calculations suggest that only 25% of the ground state in ^{30}Mg is made from 0p0h contributions, whereas 50% and 25% are due to 2p2h and 4p4h configurations, respectively. This contrasts with all previous investigations, which all conclude that 2p2h and 4p4h contributions in the ground state of ^{30}Mg are as small as 5%.
We present new data from experiment IS651 at the new HIE-ISOLDE facility, CERN. An intense radioactive beam of ^{28}Mg (1.5x10^{6}pps) was scattered off a radioactive tritium target to populate states in ^{30}Mg after two-neutron transfer. For the first time, the full HIE-ISOLDE beam energy of 9.5 MeV/u was used for a transfer experiment at MINIBALL. The significantly higher beam energy allows a more straightforward interpretation of spectroscopic factors compared to previous transfer experiments performed at ISOLDE (e.g. [5]). Gamma rays were detected with the high-granularity MINIBALL array, and recoiling protons were detected using the T-REX array of silicon detectors, now allowing full particle identification at backward angles.
As the two-neutron transfer into the intruder $2p_{3/2}$ orbital is highly favoured, our experiment allows to extract the amount of intruder configurations in the ground state and excited states in ^{30}Mg, experimentally. We present an unusually strong population of the first excited 0^{+} state in ^{30}Mg, compared to the ground state population and discuss the implications for the EKK-theory and for our understanding of nuclear shell evolution in this region of the nuclear chart.

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Primary author: ZIDAR, T. (Department of Physics, University of Guelph, Guelph, Ontario)

Presenter: ZIDAR, T. (Department of Physics, University of Guelph, Guelph, Ontario)

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