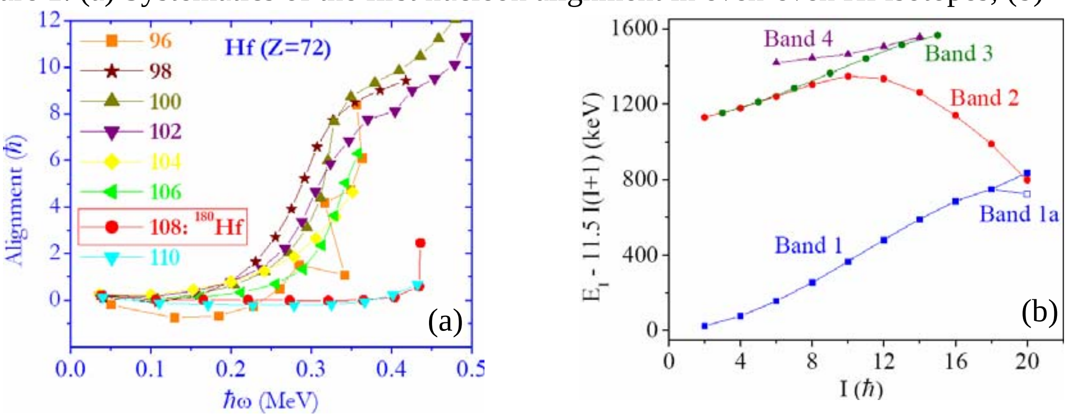
Competing Shapes and Alignments in Neutron-Rich Hafnium Nuclei*

U.S.Tandel[1], S.K. Tandel[1], P. Chowdhury[1], S. Sheppard[1], D. Cline[2], C.Y. Wu[2], M.P. Carpenter[3], R.V.F. Janssens[3], T.L. Khoo[3], T. Lauritsen[3], C.J. Lister[3], D. Seweryniak[3], S. Zhu[3]
[1]Department of Physics, Univ. of Massachusetts Lowell, Lowell, MA 01854, USA.
[2]Nuclear Structure Research Laboratory, Univ. of Rochester, Rochester, NY 14627, USA.
[3]Argonne National Laboratory, Argonne, IL 60439, USA.

Shape competition as a function of spin, and the role of nucleon alignments in this context, is a dominant theme in nuclear structure. The few examples of coexisting and competing oblate and prolate shapes at low spins involve low potential energy barriers in the triaxial degree of freedom. The typically lower moments of inertia of oblate collective rotation makes this mode more energetically unfavored with increasing angular momentum. There are no examples of collective oblate rotation becoming energetically favored over collective prolate rotation at high spins in a well-deformed, prolate, gamma-rigid nucleus. A long-standing prediction of a “giant backbend” in ^{180}Hf at high spins (~26η), which develops following alignments of particles in an oblate minimum [1], as well as a significantly delayed alignment of the first pair of nucleons in the prolate minimum, provided dual motivation for a prompt spectroscopic study of ^{180}Hf (the most neutron-rich stable isotope). The results from the latest experiment using deep inelastic reactions with Gammasphere and the heavy-ion detector CHICO, bombarding a thin ^{232}Th target with a ^{180}Hf beam ~25% above the Coulomb barrier, will be presented. This builds on our earlier work on the same nucleus using a ^{136}Xe beam on an enriched ^{180}Hf target [2]. The low-K high-spin structure of this nucleus is extended to I = 20η via multiple bands. The first nucleon alignment in the prolate minimum, as well as the predicted novel physics of the favoring of oblate collective rotation at high spins is observed. The competition is mediated via the alignment of valence neutrons in an oblate minimum, and identified through a mixing of the oblate collective rotation with gamma vibrations built on the prolate shape.

Figure 1: (a) Systematics of the first nucleon alignment in even-even Hf isotopes; (b)



Relative energies (with a rigid rotor reference subtracted) of the prolate ground state band (Band 1), and the proposed oblate band (Band 2 at high spins) upto I =20η. Bands 2 and 3 (at low spins) are the even and odd signatures of the gamma vibrational band.

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