Multiple Superdeformed Bands in Sm Isotopes:
Transition from Large Deformation to Superdeformation

H.-Q. Jin\textsuperscript{a,b}, C. Baktash\textsuperscript{a}, M.J. Brinkman\textsuperscript{a}, D. Rudolph\textsuperscript{a}, C.-H. Yu\textsuperscript{a}, R.M. Clark\textsuperscript{d}, M. Devlin\textsuperscript{e}, P. Fallon\textsuperscript{d}, D.R. LaFosse\textsuperscript{c}, I.Y. Lee\textsuperscript{d}, F. Lerma\textsuperscript{c}, A.O. Macchiavelli\textsuperscript{d}, D.G. Sarantites\textsuperscript{c}

\textsuperscript{(a)} Physics Division, Oak Ridge National Laboratory\textsuperscript{*}, Oak Ridge, TN 37831
\textsuperscript{(b)} Department of Physics, University of Tennessee, Knoxville, TN 37996
\textsuperscript{(c)} Chemistry Department, Washington University, St. Louis, MO 63130
\textsuperscript{(d)} Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720

Heavy Sm nuclei fall in an interesting region which bridges the island of large-deformation nuclei (A ∼ 130) on one hand, and superdeformed (SD) nuclei (A > 140) on the other. Therefore, they are expected to provide insight into the question of evolution of deformation from axis ratios of about 3:2 in the lighter nuclei to ∼2:1 in the heavier systems. So far, however, in this mass region only two SD bands have been reported in \textsuperscript{142}Sm \cite{1}. The properties of these two bands support the presence of a SD neutron shell gap at N = 80 \cite{2}.

Here we report results of superdeformation studies in \textsuperscript{142,143,144}Sm nuclei. The experiment was performed at the LBNL 88\textsuperscript{th} cyclotron using the \textsuperscript{100}Mo\textsuperscript{(48}Ca, xn) reaction at a beam energy of 205 MeV. About 15\% of the products of this reaction involved emission of charged particles (protons and alphas), which were cleanly separated using the Microball, a 4π array of CsI charged-particle detectors. Gamma rays were detected using 57 Ge detectors of the Gammasphere. A total of 2 × 10\textsuperscript{9} four-fold and higher \(\gamma\)-correlated events were recorded. Analysis of the \(\gamma\)-\(\gamma\)-\(\gamma\) cubes created for the xn channels revealed at least eight rotational bands with \(\gamma\)-ray energy spacings of ∼60 keV, characteristic of the SD bands in this region. On the basis of the known \(\gamma\) transitions between the low-lying states, three of these bands were tentatively assigned to \textsuperscript{143}Sm and four to \textsuperscript{144}Sm. The latter set constitutes the first observation of high-spin SD bands in a stable nucleus. We also observed the known yrast SD band \cite{1} in \textsuperscript{142}Sm, but the reported excited band in this nucleus could not be identified, mainly due to the close similarity of the transition energies in this band to those in the yrast SD band of \textsuperscript{144}Sm.

The \(\mathcal{J}(2)\) moments of inertia of these bands are plotted as a function of rotational frequency in Fig. 1. They generally fall in the range of 60-70 MeV\textsuperscript{-1}, intermediate between the \(\mathcal{J}(2)\) values of the large-deformation bands in the A ∼ 130 region, and the SD bands in the heavier Gd isotopes. One of the bands in each of the \textsuperscript{143}Sm and \textsuperscript{144}Sm nuclei show a low-frequency crossing at \(\hbar \omega \sim 0.5\) MeV, which is similar to the crossing observed in \textsuperscript{144}Gd \cite{3}. A second band in \textsuperscript{143}Sm (triangles) shows a sharp crossing at \(\hbar \omega \simeq 0.7\) MeV. Both of these crossings may be attributed to the \(\nu\tau_1\) neutron crossings.

*Oak Ridge National Laboratory is managed by Lockheed Martin Energy Research Corp. for the U.S. Department of Energy under the contract No. DE-AC05-96OR22464.

\cite{3} S. Lunardi et al., Phys. Rev. Lett. 72 (1994) 1427.

**Fig. 1: Dynamic moments of inertia, \(\mathcal{J}(2)\), as a function of rotational frequency for the eight observed SD bands in \textsuperscript{142,143,144}Sm.**