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1. INTRODUCTION

At least eighteen superdeformed (SD) bands have been identified in mercury, thallium, and lead nuclei[1-13] since the report[1] of a SD band in ^{191}Hg. Systematic information is beginning to emerge on the properties of the SD bands in this mass region, and comparisons with SD bands in the A = 150 region are now possible.

Recently, data were obtained with the HERA spectrometer at the Lawrence Berkeley Laboratory 88" Cyclotron on SD bands in ^{194}Pb and ^{196}Pb. In these experiments, we bombarded ^{176}Yb with ^{24}Mg and ^{26}Mg. The cross bombardment was necessary to make the assignment of the band to ^{196}Pb certain. These bands are typical of other SD bands in the region in many ways. The gamma rays have energies that range from about 200 to 800 keV. The gamma-ray spacing decreases from about 40 to 30 keV as the transition energy increases. Their intensities gradually increase as the gamma-ray energies decrease over the upper half of the sequence, and then sustain a constant value until the one or two lowest energy transitions.

2. LEVEL SPINS AND MOMENTS OF INERTIA

The spins of the SD band members in the A = 194 region can be determined by fitting the gamma-ray energies[14]. These bands are typically depopulated near spin 10, in contrast to those in the A = 150 region, which are usually depopulated in the range of spin 24 to 28. In the A = 194 region, the spin of the lowest-energy level established in the SD band varies somewhat, with the SD bands in the ^{194,196}Pb nuclei being established down to spin 6. In these two nuclei, the transitions between the spin 8 and spin 6 levels exhibit about one-half of the maximum intensity of the bands. In ^{194}Hg the intense band is almost completely depopulated at spin 10, while a more weakly populated, and presumably excited, SD band is observed to lower frequency than the intense band, indicating that the weaker band exists to lower spin.

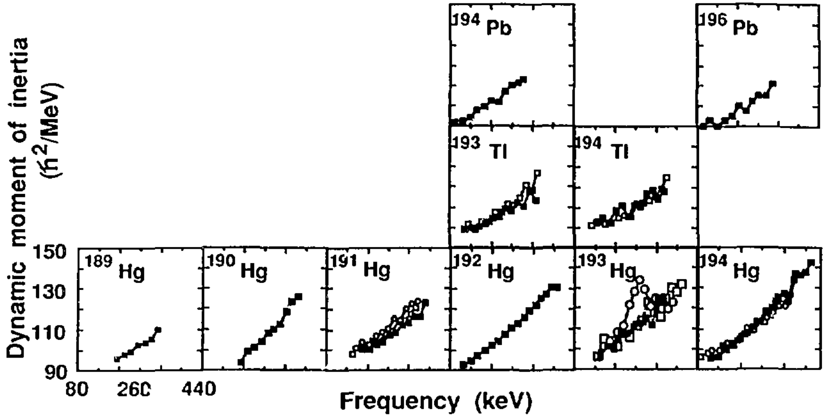

Figure 1. The experimental dynamic moments of inertia for bands in the A = 194 region. Data are from references 1-13. Scales of all plots are identical.

The fact that SD bands persist to lower spins in the A = 194 region than the A = 150 region is consistent with theoretical predictions that the SD minima in the potential energy surfaces of the heavier nuclei are significantly deeper than in the lighter nuclei; thus little angular momentum is required to stabilize the deformation.

Shown in Figure 1 are the dynamic moments of inertia of known SD bands in the A = 194 region. Though individual differences are clearly evident, they show a remarkably consistent overall frequency dependence: they are all increasing with increasing frequency, and the rate of increase is similar for all the bands. The dynamic moments of inertia for ^{194,196}Pb are similar to those of other nuclei in the region. This consistent dependence on frequency for a number of bands in nuclei differing in Z and N is in contrast to the results in the A = 150 region. For those nuclei, the addition of one or two neutrons or protons can result in a SD band with a dramatically different behavior of the dynamic moment of inertia as a function of frequency[15].

3. EXCITATION ENERGY

An important question concerning SD bands is their excitation energies. Transitions that connect the SD bands to normal states have not been identified in either the A = 150 or A = 194 regions. An exception may be a single 4-MeV gamma ray that has been suggested as connecting the yrast ^{191}Hg SD band to the ground-state band[1]. To gain further insight into the excitation energy of the SD bands in these nuclei, we have adopted an estimation procedure used in the A = 150 region, and have applied it to ^{194}Hg. The procedure assumes that the SD band becomes yrast at

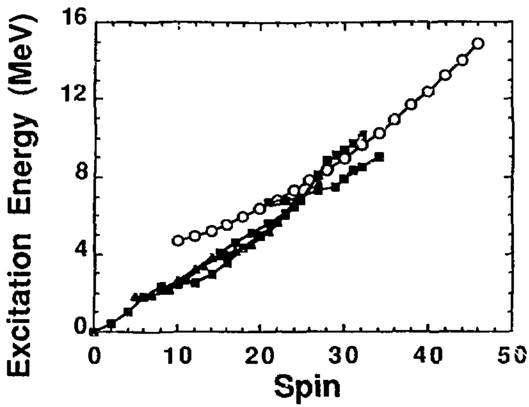

Figure 2. Level energies in ^{194}Hg as a function of level spin The open circles indicate the intense ^{194}Hg SD band positioned relative to the yrast levels.

^{194}Hg the transition with half the maximum intensity connects levels with spins 36 and 34. We have extended the known ^{194}Hg level scheme[16] to approximately spin 34 to aid in positioning the SD band. At this spin, the normal yrast bands have irregular energy spacings, making it more difficult than at spin 52 in the A = 150 region to locate the SD band relative to the normal states. Nevertheless, we find that a reasonable positioning of the SD band results in the spin 10 SD band member being about 2.2 MeV above the lowest 8^+ level (see Figure 2). By extrapolating to spin 0, the SD bandhead is about 4 MeV above the ground state. An uncertainty of as much as 1 MeV could result from use of this estimation procedure. However, if the excitation of the spin 10 SD band member is significantly more than 3.2 MeV above the 8^+ level, we must question the assumption of the relation of the SD band feeding to its becoming yrast. With the present estimate, the SD band energy is lower than in the A = 150 region by several MeV. Three-dimensional microscopic Hartree-Fock calculations[17], which yield a SD minimum 4 to 5 MeV above the ground-state minimum, are in rough agreement with this estimate of the excitation energy for a SD bandhead in ^{194}Hg.

4. FEEDING OF SUPERDEFORMED BANDS

We have used two (HI,5n) reactions to populate SD bands in ^{193}Hg: ^{150}Nd(^{48}Ca,5n) at 200, 205, and 210 MeV, and ^{176}Yb(^{22}Ne,5n) at 110, 116, and 122 MeV. Figure 3 shows the excitation energy of the evaporation residue ^{193}Hg nucleus as a function of the maximum angular momentum available after neutron emission in these two reactions. Also shown is the approximate location of the yrast SD band

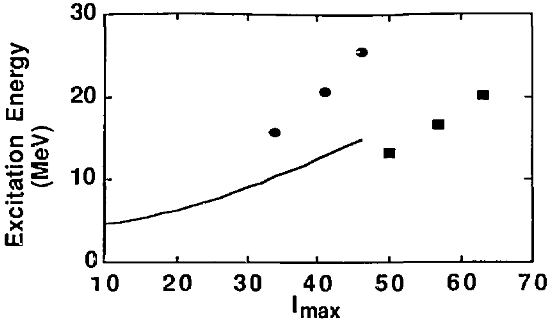

Figure 3. Excitation of the residual ^{193}Hg nucleus as a function of the projectile laboratory energy. The circles (squares) indicate the ^{22}Ne (^{48}Ca) projectiles.

(estimated to be about the same as that of ^{194}Hg). As can be seen, the ^{48}Ca projectile brings in higher angular momentum at all bombarding energies , but results in a lower excitation energy relative to the yrast line. On the other hand, the ^{22}Ne projectile brings in less angular momentum, but leaves the residual nucleus more highly excited, and the excitation energy relative to the yrast line increases rapidly with increasing ^{22}Ne projectile energy because of the kinematics.

The population of the ^{193}Hg SD band (energies 293, 334, ... keV) by these reactions relative to that of the normal states has been determined from the triples coincidence germanium data, with no conditions on the fold or sum energy of the inner ball of the spectrometer. The ratio (in relative units) of the yield of the SD band relative to normal states is plotted as a function of excitation energy (Figure 4a) and maximum angular momentum (Figure 4b). Clearly, the most effective reaction for populating the SD band in ^{193}Hg relative to the normal states is that using the ^{22}Ne projectile at 122 MeV. This reaction leaves the residual nucleus at an excitation energy approximately 14 MeV above the SD yrast line. In contrast, the reaction with ^{48}Ca at 200 MeV, which results in nearly the same maximum angular momentum but about 10 MeV less excitation populates the SD band relative to the normal states only about 15% as strongly. This result is in contrast to the conclusion of Taras et al.[18] concluded that the SD bands in the A = 150 region are best populated in "cold" reactions.

5. POPULATION OF SD BANDS BY LIGHT IONS AND BETA DECAY

Because large angular momenta are not required to stablilize SD bands in the A = 194 region, and the second minima are at relatively low energies, light-ion reactions and even beta decay could be useful probes of this phenomenon. We have begun a series of experiments to study ^{194}Hg and ^{196}Hg with these methods.

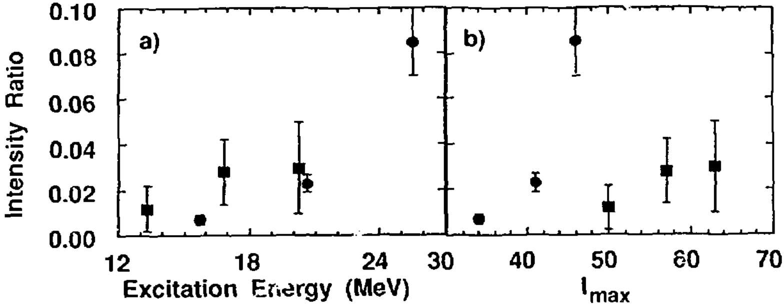

Figure 4 Intensity ratio in relative units for SD bands vs. normal states populated in ^{193}Hg by reactions with the ^{22}Ne (circles) and ^{48}Ca (squares) projectiles a) and a function of the excitation energy in the residual nucleus, and b) as a function of the maximum angular momentum available in the reaction.

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