Conf-

ANL/CP--76489

DE92 016775

ENTRANCE CHANNEL DEPENDENCE IN THE POPULATION OF THE SUPERDEFORMED BANDS IN ^{191}Hg AND A MODEL FOR THE FEEDING MECHANISM

T. Lauritsen[1], F. Soramel[1,2], T.L. Khoo[1], R.V.F. Janssens[1], I. Ahmad[1], M.P. Carpenter[1], Y. Liang[1], B. Fornal[3], I. Bearden[3], Ph. Benet[3], P. Daly[3], Z.W. Grabowski[3], R. Maier[3], D. Ye[4], U. Garg[4], W. Reviol[4], M.W. Drigert[5]

[1]Argonne National Laboratory, Argonne, IL 60439, USA. [2]On leave from Padova University, I-35131 Padova, Italy. [3]Purdue University, West Lafayette, IN 47907, USA. [4]University of Notre Dame, Notre Dame, IN 46556, USA. [4]INEL, EG&G Idaho Inc., Idaho Falls, ID 83415, USA.

Abstract: The population of the superdeformed bands in ^{191}Hg has been measured for two reactions with different mass asymmetry. No entrance channel effect was observed, in contrast to similar measurements in the A=150 region. To further elucidate this problem, the entry distribution for the superdeformed band in ^{192}Hg was measured and a Monte Carlo model for the feeding was developed. The simulations suggest that the decision on trapping in the superdeformed well is made at the barrier between the normal and superdeformed wells rather than at the entry point.

Recent measurements of the total intensity flowing through the superdeformed (SD) bands of the A=150 region[1,2] suggest the existence of an entrance channel effect: mass-symmetric reactions have been reported to enhance the population of SD bands. This has been explained by invoking a dynamic effect in the entrance channel, i.e., the time formation of the compound nucleus is longer for symmetric reactions than for asymmetric ones, favoring neutron evaporation over fission.

We have investigated this problem in the A=190 region by comparing SD bands yields in ^{191}Hg produced either in the ^{130}Te(^{64}Ni,3n) or ^{160}Gd(^{36}S,5n) reactions. The experiments were carried out using ATLAS beams and the Argonne–Notre Dame γ-ray facility comprising 12 ACS Ge detectors and a 50 element inner BGO array.

For the symmetric and asymmetric reactions, the SD bands in ^{191}Hg were found to have 3.0(8)% and 3.7(5)%, respectively, of the ground state intensity. The results for each SD band (there are 3 known SD bands[3,4]) and for the total SD yield in ^{191}Hg are compared in fig.1a. The yields measured are the same within errors for the two reactions, in contrast to the observation near A=150. This is illustrated in fig.2 where the SD intensities as a function of the "degree of symmetry" parameter, $S=A_{beam}/A_{target}$, are shown. We conclude that no enhancement is observed in the A=190 region.

These results do not rule out the possibility of an entrance channel effect, though they underline the importance of other effects which should also be examined carefully. In particular, since the SD band population is very sensitive to the higher partial waves of the l-distribution, it becomes very important to measure the (K,E) entry points for the different reactions. We measured both E (sum energy) and K (fold) for the two reactions leading to ^{191}Hg. As can be seen in fig.1b, the experimental entry points for normal deformed (ND) and SD states are very close in the two cases; this ensures that the same partial waves are involved in the two reactions and rules out the possibility of an entrance channel effect at least in this mass region. It would be useful to have similar data for the nuclei in the A=150 region in order to understand if the increase in SD bands population observed in this case reflects an entrance channel memory or, more likely, can be attributed to differences in the tails of the l-distributions involved in the reactions. Our results can be understood within the framework of a model describing the formation and decay of the SD bands. This is discussed below.

Entry distributions both for the γ cascades feeding the SD and ND bands in ^{192}Hg have been measured. The nucleus was populated with the reaction ^{160}Gd(^{36}S,4n)^{192}Hg at 162 MeV. Double coincidence gates were placed on the Ge spectra and the coincident fold (K) and energy (H) measured in the inner array were recorded. The responce function for the inner array was measured and used to unfold the (K,H) distribution. Finally the entry distribution was constructed using the mean angular moment removed per photon, obtained from an analysis of the quasicontinuum γ ray. Thus, we have measured the population distribution in spin and energy from where the γ cascades start after the last neutron has been evaporated (and after successful competition with fission).

The entry distributions were measured, *both* in coicidence with the SD lines and ND lines. They are shown in fig.3a,b. It is seen that the SD band starts at higher spin and somewhat lower energy than the ND band. As the double gates on the ND transitions were placed on γ transitions which are also fed in the decay of the SD band, the ND entry distribution is the total entry distribution for *all* γ cascades in ^{192}Hg.

A model was developed to follow, by a Monte Carlo approach[5,6,7], the γ cascades starting from this measured total entry distribution. The model has two wells, ND and SD, separated by a barrier. The states in the nucleus are considered to be either in one or the other well. The initial selection of the well in which a γ cascade starts, is based on the relative level densities in the two wells at the given spin and energy. In order to calculate the γ transitions, the Γ–decay widths in the two wells are computed and the levels in the two wells are allowed to mix as decribed by Vigezzi et al[8,9]. The mixing allows the nucleus to change shape while it γ decays. Thus, γ cascades can be followed from the entry point till they enter a region close to the ND or SD yrast lines. By tracing back the sub–set of the γ cascades that feed the SD well, the entry distribution for the SD band can be found. This is shown in fig.3c. The principal feature, viz. that the SD states originates from the higher spin portion of the normal states, is clearly seen; but some differences in details are apparent (fig.3c,d).

The model contains the excitation energy of the SD band, the barrier between the ND and SD wells and the quadrupole moments and levels densities in the two wells as parameters. We have determined the best values of the parameters in order to reproduce the following observables: the SD entry distribution, the intensity of the SD band and its variation with spin and the energy of the quasicontinuum γ rays. All observables are reproduced only for a narrow range of SD excitation energies and barrier heights. Thus, the model allows us to set constraints on these parameters. The excitation energy over the normal yrast line for the SD band at spin 10 is 3.3–4.3 MeV and the barrier height at spin 40 is 3.5–4.6 MeV (assuming a barrier frequency of $\hbar\omega$=0.6 MeV[8]). The model also shows that the decision on trapping in the SD well is made near the barrier between the two wells rather than at the entry point. It was found that $\approx$ 95% of the cascades that feed the SD well started out from ND states.

In summary, we have measured the population of the SD bands in ^{191}Hg with two reactions having different mass-asymmetry. No entrance channel effect was seen, in contrast to results in the A=150 region. For ^{191}Hg, the average entry points and spin distributions (not shown here) have been determined to be very similar. The results indicate that it is unlikely that there is a memory of the entrance channel when trapping in the SD well occurs. This is not unexpected since the time when trapping occurs is around 10^{-13} s, which is much later than the characteristic time for shape relaxation of the compound nucleus (commonly thought to be around 10^{-20} s, although it could be as long as 10^{-18} s) or the time for emission of the last neutron ($\approx 10^{-18}$ s). There is a good possibility that the observed effect in the A=150 region is due to an angular momentum effect, i.e. due to differences in the high-l tails in the different reactions. This possibility should be checked by measurements of the entry points or, preferably, of the entry distributions, so that a distinction can be made between a memory or angular momentum effect. The entry distributions for both the ND and SD cascades in ^{192}Hg have been measured and a Monte Carlo model has been developed to follow the γ cascades. The model is able to reproduce all observables associated with SD γ cascades in the nucleus, and indicate that trapping in the SD well occurs 10^{-13} s after formation of the compound nucleus. In addition, the model puts constraints on the excitation energy of the SD band and on the barrier between the ND and SD wells.

This work was supported by the Department of Energy, Nuclear Physics Division, under contracts Nos W-31-109-ENG-38, DE-AC07-76ID01570 and DE-FG02-87ER40346 and by the National Science Foundation under grant PHY91-00688.

References:

[1]G. Smith et al., Phys. Rev. Lett. **68**(1992)158
[2]S. Flibotte et al., Phys. Rev. **C45**(1992)R889
[3]E.F. Moore et al., Phys. Rev. Lett. **63**(1989)360
[4]M.P. Carpenter et al., Phys. Lett. **B240**(1990)44
[5]R. Holzmann et al., Phys. lett. **195**(1987)321
[6]K. Schiffer et al., Z. Phys. **A332**(1989)17
[7]K. Schiffer et al, Nucl. Phys. **A520**(1990)521c
[8]E. Vigezzi et al., Phys. Lett. **249**(1990)163
[9]S. Bjørnholm et al., Rev. Mod. Phys. **52**(1980)725

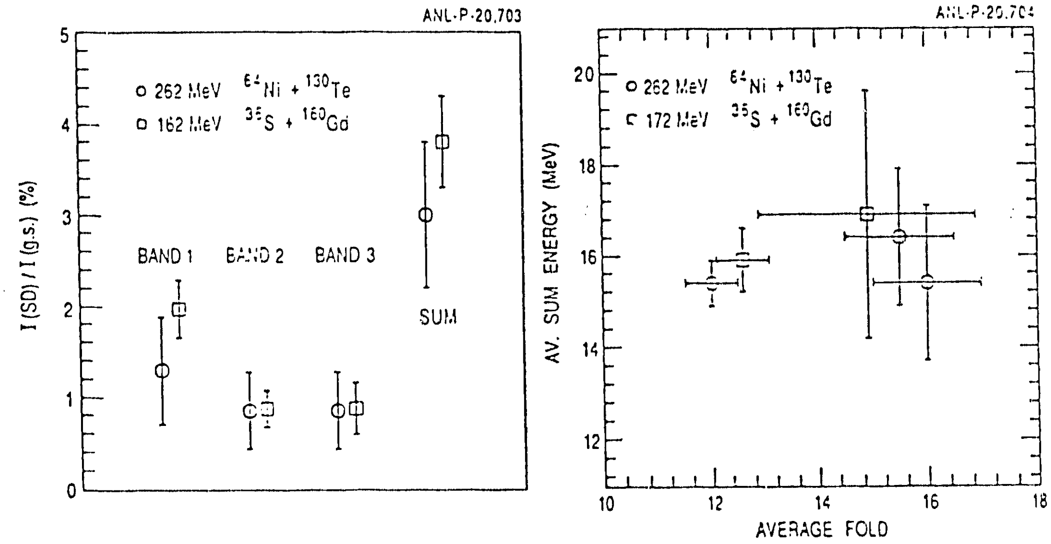

Figure 1: a: Relative intensities of each SD band and total SD flux in ^{191}Hg for different reactions. b: Experimental entry points for ND and SD states.

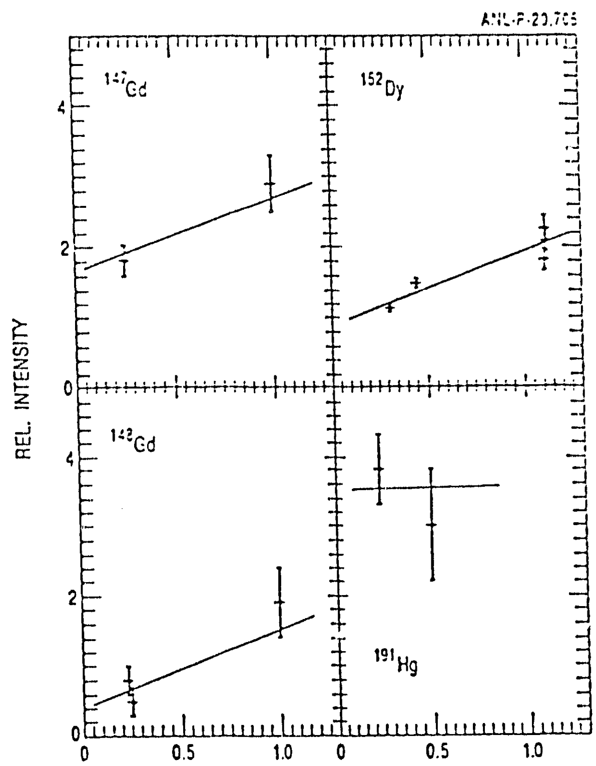

Figure 2: Total SD intensity in various nuclei as function of the "degree of symmetry" of the reaction. The lines are drawn to guide the eye.

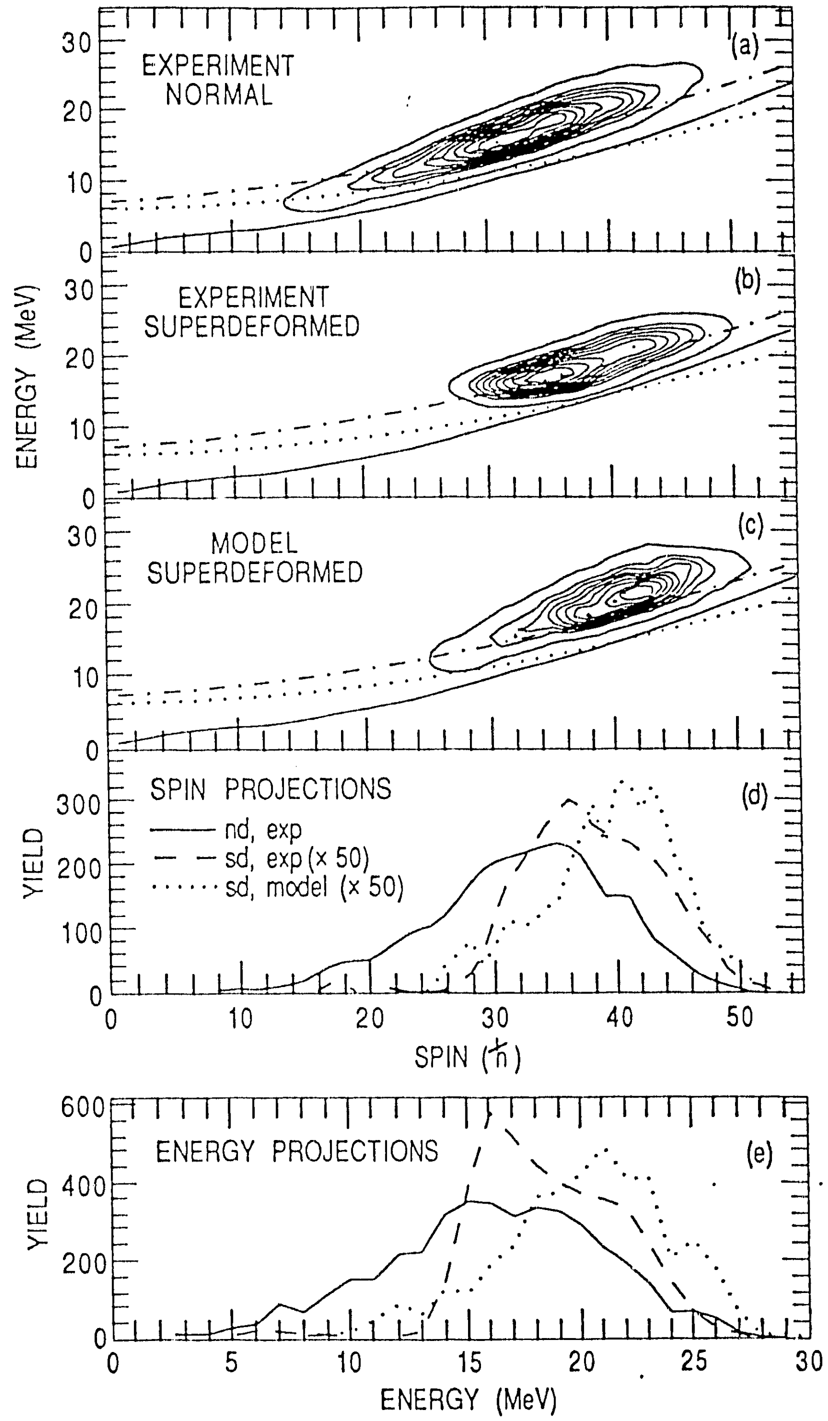

Figure 3: a,b: measured entry distribution in ^{192}Hg for ND and SD cascades, respectively. Each contour represents a change of 10% of maximum value. c: calculated entry distribution. d,e: projections of the entry distributions on the spin and energy axes, respectively.

DATE
FILMED
8 / 14 / 92