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DECAY OUT OF THE YRAST SUPERDEFORMED BAND IN ^{191}HG

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Abstract: The excitation energies and spins of the yrast superdeformed band in ^{191}Hg have been determined by analyzing the quasicontiniuum spectrum connecting the superdeformed and normal-deformed states. The results from this analysis, combined with that given by one-step decay lines, give confident assignments of the spins and energies of the yrast superdeformed band in ^{191}Hg.

1 INTRODUCTION

The yrast superdeformed (SD) band in ^{191}Hg was the first SD band to be discovered in the A 190 region [1]. There are now more than 175 known SD bands in the A=150 and 190 regions, but only 3 bands in ^{194}Hg[2] and ^{194}Pb[3] have known spins and excitation energies through one-step linking transitions. It is important to obtain these quantities for an odd-A SD band since that gives information on the relative pair correlation energies in normal-deformed (ND) and superdeformed (SD) states, thereby providing a stringent test for theory. So far, the main information has come from J^2 moments of inertia of the SD bands.

An alternative way of setting limits on the spins and excitation energies of SD bands is to analyze the quasicontiniuum decay spectra. It can complement

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results in those cases where one or two decay pathways are known. In most cases, where one-step transitions are not observed, it is the only alternative at present. The method of analyzing the quasicontiniuum spectrum to extract the spin and excitation energy of a SD band has been successfully tested[4] in the case of SD band 1 in ^{194}Hg, where the spins and excitation energies are known from several one-step γ ray transitions connecting the SD band with known ND states.

The Quasi-Continuum Method

Superdeformed states in ^{191}Hg were populated using the ^{174}Yb(^{22}Ne,5n)^{191}Hg-reaction. The experiment was performed using the GAMMASPHERE Ge-detector array, which had 96 detectors at the time of the experiment. The 120 MeV beam was provided by the 88" Cyclotron at Lawrence Berkeley National Laboratory. The 3.1mg/cm^2 ^{174}Yb target had a 6.8mg/cm^2 ^{197}Au backing to stop the recoil nuclei before the decay-out γ-rays are emitted. A total of 2x10^9 triple γ-coincidence events were collected. A method has been developed at Argonne[5, 4] to isolate the quasicontinuum γ-spectrum connecting the SD and ND states. First, the data are sorted with double gates on SD transitions to ensure clean spectra. The background subtraction is done using the FUL method[6]. Corrections are done for summing effects and for neutron interactions in the detectors, which is mostly in the forward detectors. The spectra are then unfolded to eliminate contributions from Compton scattered γ rays and corrected for the detector full-energy efficiency. The area of the spectrum is now normalized to multiplicity by requiring the peak corresponding to the most intense transition in the SD band to have unit area. The discrete peaks

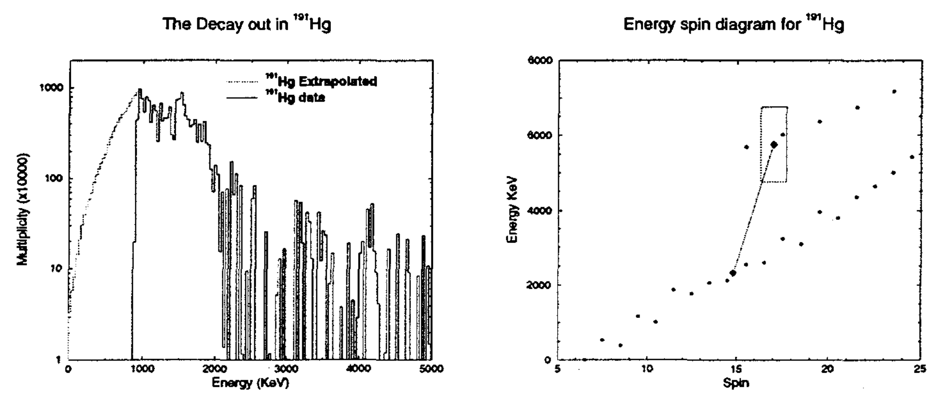

Figure 1 a)The continuum spectrum connecting the superdeformed and normal-deformed states. b)The spin and excitation energy of the level feed by the 351keV SD transition from the quasi continuum analysis (diamond); the box represents the uncertainty. The circles represent results from the one-step lines.

below 1 MeV are removed so that the remaining spectrum contains the sought-after decay-out component, plus feeding components of statistical, quadrapole and M1/E2 nature. To extract the decay-out spectrum we subtract away the feeding components. The feeding statistical spectrum is obtained from a Monte Carlo simulation for ^{192}Hg and renormalized to the high-energy portion of the ^{191}Hg spectrum to account for the different entry conditions in 4 and 5-n channels. Then the quadrapole and dipole feeding components can be extracted by angular distribution analysis in the center-of-mass system. The low-energy region of the decay-out spectrum cannot be extracted due to the presence of the larger E2 and M1/E2 feeding components. The decay-out spectrum below 800keV in Fig. 1 represents a guess.

Monte Carlo simulations suggest that each decay-out γ ray removes $0.5(2)\hbar$ of spin, on the average. By multiplying the average energy and spin removed by each γ ray with the multiplicity, the energy and spin removed by the decay-out component is found to be: $\Delta E = 3.4$MeV and $\Delta I = 2.0\hbar$. From the peak areas of ND transitions, the mean spin and energy at which the cascade enters the known ND level sheme is found. The energy and spin of the level fed by the 351keV SD transition is determined to be $E_{exit} = 5.75 \pm 1$MeV and $I_{exit} = 17.0 \pm 0.7\ \hbar$ see Fig. 1. Contributions to the uncertainty come from the calculated feeding statistical spectrum, the normalization to multiplicity and the extrapolation of the decay-out spectrum to lower γ-energies.

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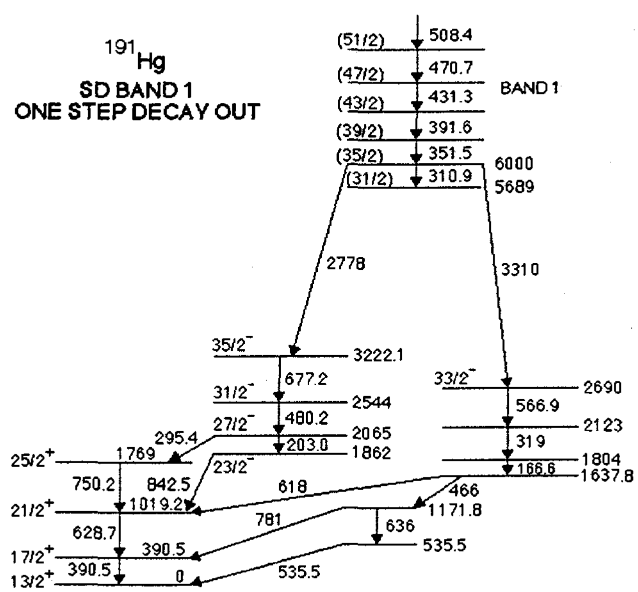

Figure 2. Partial level sheme, showing the one-step decay pathways connecting SD and ND levels.

One-step transitions

Two transitions, at 2778keV and 3310keV, that connect SD and ND states in one step have been assigned[7] on the basis of coincidence data; both place the decay-out level at 6000 keV (see Fig. 2). The angular distribution coefficient of the stronger one-step line (2778 keV), A2= $0.57\pm$ 0.48, is consistent with a $\Delta I = 0$ assignment, suggesting a $35/2\ \hbar$ spin assignment for the decay-out level. We rule out the possibility of it being an E2 transition, because that would require M3 multipolarity for the other one-step transition. The spin is consistent with an assignment[8] of a $j_{15/2}$ particle configuration. However, the experimental data do not allow for a parity assignment. A $j_{15/2}$ particle configuration assignment, would require the one-step lines to be M1 transitions. From neutron capture experiments it is known that 8 MeV E1 transitions are about 5 times more likely than M1 transitions. However, in ^{191}Hg the one-step lines have significantly lower energy $\approx$3 MeV. In fact, M1 transitions around this energy are observed both in neutron capture and also from the decay of the SD band in ^{194}Pb.

Conclusion

The spins and excitation energies of the yrast SD band in ^{191}Hg have been determined by analyzing the quasicontiniuum spectrum connecting the SD and ND states. The results are in good agreement, within the error bars, with that given by the one-step linking transitions. The level fed by the 351 KeV SD transition has $E_x = 6.000$ MeV and $I = 35/2\ \hbar$, i.e. at the main point of decay, the SD state is 2.778 MeV above the yrast line. Extrapolated to 13/2, the spin of the ground state, the excitation energy of the SD band is 4.74 MeV. It is important to obtain these quantities in an odd-even nucleus since that gives information on the relative pair correlation energies in ND and SD states, thereby providing a stringent test for theory. Information on pair quenching in excited states will be obtained by comparing the experimental and theoretical [9] decay-out spectra from SD bands in even-even and odd-even Hg nuclei.

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