High-Spin States and Coriolis-Decoupled Bands in $^{190-194}$Hg

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Ground-state bands up to 8^+ and negative-parity bands, in one case up to 15^-, have been established in ^{190,192,194}Hg using (α, xn) reactions. Corresponding bands have been observed in ^{191,193}Hg and are interpreted as Coriolis-decoupled bands.

In the odd-A Hg isotopes ^{195,197,199}Hg, bands have been observed by Proetel *et al.*[1] which show striking similarities to the ground-state bands (gsb) in the neighboring even Hg isotopes. This has been explained[1] in the framework of the Coriolis-decoupling model,[2] where the Coriolis force decouples the odd particle from the core and aligns its angular momentum in the direction of the rotation axis of the nucleus. Here the odd particle is an $i_{13/2}$ neutron. The existence of Coriolis-decoupled bands in odd-A Hg isotopes indicates an oblate deformation.[1] This is in agreement with results from calculations by Faessler *et al.*[3] for even Hg isotopes where small negative deformations for the even Hg isotopes between $A = 198$ and $A = 186$ were suggested.

Another interesting feature in the even Hg isotopes of mass number $A = 192$ to $A = 200$ is the existence of a level sequence of states with spin and parity assignments 5^-, 7^-, 9^- which de-excite into the gsb.[4-7] These states are strongly populated in (α, xn) and (heavy ion, xn) reactions. Lifetime measurements[8] in ^{194,196,198,200}Hg indicate that these negative-parity levels are connected by enhanced $E2$ transitions. It has been suggested by Cunnane *et al.*[4] that they form a collective band. According to Daly *et al.*[5] the intrinsic structure of these levels most probably involves combinations of a decoupled $i_{13/2}$ neutron with low-j neutrons in the adjacent $3p_{3/2}$ or $2f_{5/2}$ orbitals. Stephens has suggested[9] on the basis of the Coriolis-decoupling picture that a corresponding band might exist in the neighboring odd-A Hg isotopes. In the present Letter evidence for the existence of such bands in ^{191}Hg and ^{193}Hg is presented for the first time.

The isotopes ^{191,193}Hg were studied together with the neighboring even nuclei ^{190,192,194}Hg. For the three even isotopes the gsb was previously established up to 8^+ in ^{190}Hg (Inamura *et al.*[10]) and up to 6^+ in ^{192}Hg (Ref. 6) and ^{194}Hg (Refs. 1, 6, 7). Isomeric $\frac{13}{2}^+$ states have previously been observed in radioactive decay work for ^{191}Hg (Beuscher *et al.*[11]) and ^{193}Hg (Lederer, Hollander, and Perlman[12]).

The states in the mercury isotopes $^{190-194}$Hg were populated using $(\alpha, 4n)$ through $(\alpha, 8n)$ reactions. Enriched metallic ^{194,196}Pt targets were bombarded with α particles of 65 to 108 MeV from the Jülich isochronous cyclotron JULIC. The resulting γ radiation was detected in-beam with various Ge(Li) detectors. Excitation functions, γ-ray angular distributions, $\gamma\gamma$-coincidence spectra, and γ-ray spectra time-related to the beam bursts of the cyclotron were measured. The experimental techniques and the methods used for deducing spin assignments have been already described.[13] A γ-ray angular distribution measurement following the reaction ^{181}Ta(^{14}N, $5n$)^{190}Hg at $E_{^{14}\mathrm{N}} = 93$ MeV was also carried out on the Louvain-La-Neuve cyclotron.

As a result of these investigations level schemes for all five Hg isotopes were established. Those parts of the level schemes which are important in the context of this Letter are shown in Fig. 1. The full results and more details about the experiments will be published later.[14]

The gsb of ^{190,192,194}Hg were established up to 8^+. Previous results[1,6-8,10] were confirmed. The fact that higher levels in the gsb were not observed can be understood since in ^{190,192}Hg isomeric 10^+ states have been located just above the 8^+ gsb levels.[14] These isomeric states are preferentially populated since they are yrast states. The negative-parity bands in ^{190,192,194}Hg were observed up to considerably higher spin states—in

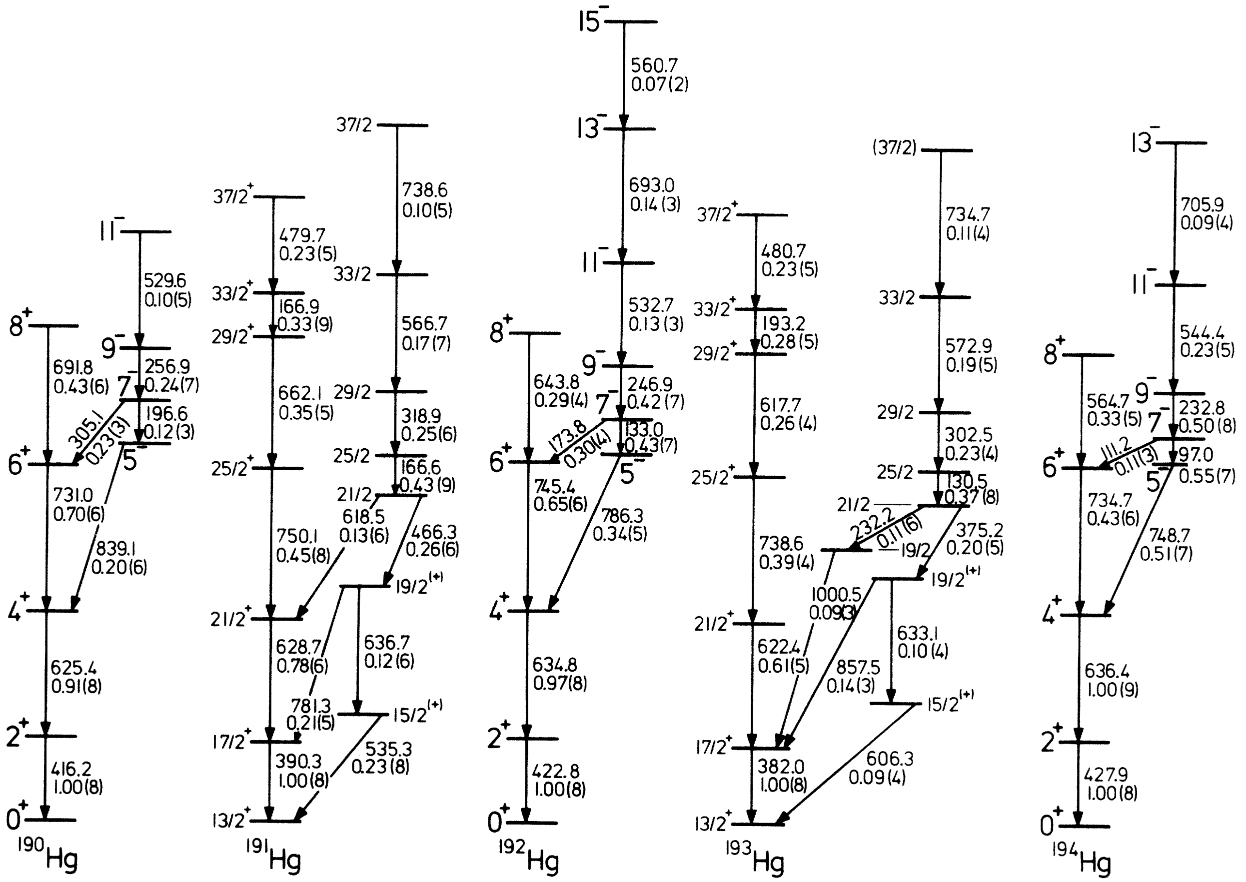

FIG. 1. Level schemes of $^{190-194}$Hg. Energies are given in keV and are accurate to ± 0.3 keV. Transition intensities together with their errors in the last digit are also indicated. It should be noted that the $\frac{13}{2}^+$ states in ^{191,193}Hg are *not* the ground states of these nuclei; in ^{193}Hg the $\frac{13}{2}^+$ state is located at 141 keV (Ref. 12), and in ^{191}Hg this state is expected at a similar excitation energy (Ref. 11).

^{192}Hg as far as the 15^- state. The spin and parity assignments of the excited collective band in ^{190}Hg were concluded from all available data and from the fact that the features of this band and of the interband transitions fit into the systematic behavior of all other even Hg isotopes. The present results for the negative-parity band in ^{190}Hg do not confirm the level assignments of Inamura *et al.*[10] The fact that the negative-parity band could be observed up to 15^- in ^{192}Hg and up to 13^- in ^{194}Hg gives further evidence that these states form a collective band since such high angular momenta cannot be obtained by coupling of any two shell-model states appearing in the Hg region.

In ^{191,193}Hg Coriolis-decoupled bands based on the $\frac{13}{2}^+$ isomeric state were found to be similar to those observed in the heavier odd-A Hg isotopes.[1] The assignment of spin $\frac{13}{2}^+$ to the band head was obtained from the study of the decay of ^{191}Hg produced using the $(d, 8n)$ reaction where only the decay of the $\frac{13}{2}^+$ isomeric state was observed.[11] The decoupled bands in ^{191,193}Hg up to the $\frac{29}{2}^+$ state have very similar level energies as the gsb states of the neighboring isotopes ^{190,192,194}Hg up to 8^+. The energy of the $\frac{33}{2}^+ \rightarrow \frac{29}{2}^+$ transitions in ^{191,193}Hg is considerably smaller than the energy of the lower transitions. The multipolarity of the 193.2-keV transition in ^{193}Hg (the corresponding 166.9-keV transition in ^{191}Hg is a component of an unresolved doublet) was established to be of stretched quadrupole character in the angular distribution measurement. $M2$ character is unlikely for these transitions since the $\frac{33}{2}$ levels decay promptly within the experimental resolving time of 5 nsec.

In ^{191,193}Hg, moreover, a second band consisting of stretched quadrupole transitions was observed. The spin $\frac{21}{2}$ of the lowest level of these bands was determined from the angular distributions of the 781.3- and 466.3-keV transitions in ^{191}Hg and of the 857.5- and 375.2-keV transitions in ^{193}Hg depopulating these $\frac{21}{2}$ levels. Both the 781.3- and the 857.5-keV transitions have stretched dipole character ($|\Delta I|=1$) with a quadrupole admixture of ~10%. Therefore it is most probable that these transitions have $M1+E2$ character and that the parity of the corresponding initial states is positive. The 466.3- and 375.2-keV transitions are both of pure stretched dipole character. From these considerations a spin of $\frac{21}{2}$ was concluded for the lowest level of the second band. The $\frac{15}{2}^{(+)}$ and $\frac{19}{2}^{(+)}$ states appearing in ^{191,193}Hg are probably the unfavored members of the positive-parity bands based on the $\frac{13}{2}^{+}$ state. The present data indicate that the second $\frac{19}{2}$ state in ^{193}Hg might also have positive parity, although the data are not sufficient to draw any more substantial conclusions about this $\frac{19}{2}$ state.

The structure of these second bands in ^{191,193}Hg is remarkably similar to the structure of the negative-parity bands in the neighboring even Hg isotopes. According to Stephens[9] these second bands in the odd-A Hg isotopes may be understood as decoupled bands corresponding to the negative-parity bands in the adjacent even Hg isotopes. The spin $\frac{21}{2}$ of the band head results in this picture from the fact that the decoupled $i_{13/2}$ neutron can only be aligned to $\frac{11}{2}$ along the rotation axis since the 5^- state in the even Hg isotopes is believed to consist of a decoupled $i_{13/2}$ neutron fully aligned along the rotation axis and of a $3p_{3/2}$ or $2f_{5/2}$ neutron.[5]

These decoupled bands in the odd-A Hg isotopes based on the $\frac{21}{2}$ state should have negative parity in the framework of the above coupling scheme. An experimental indication for the negative parity may be obtained from the fact that a $\frac{25}{2} \to \frac{21}{2}^{+}$ interband transition has not been observed, an upper limit for the intensity being 0.05. The resulting branching ratio for the $\frac{25}{2} \to \frac{21}{2}^{+}$ interband to the $\frac{25}{2} \to \frac{21}{2}$ intraband transition of <0.1 is easier to understand if the parity of these decoupled bands is negative.

The existence, therefore, of the bands on these $\frac{21}{2}$ states in ^{191,193}Hg considerably strengthens the applicability of the picture of Coriolis decoupling of particles in high-j orbitals in the Hg region.

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