future work.

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Lifetimes in the Ground-State Band of ^{184}Hg

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The ground-band level sequence in ^{184}Hg has been identified to spin 10^+ and possibly to 14^+. Lifetimes for the 2^+, 4^+, and 6^+ states have been measured. The results imply the onset of a permanent deformation above the 2^+ level.

Isotope-shift measurements on the odd-mass mercury isotopes reveal a sudden increase in nuclear volume between $A = 187$ and $A = 185$.[1,2] This suggests that a dramatic shape change occurs in the Hg isotopes which might be associated either with a transition from a spherical to a deformed shape or from a spherical shape to a spherical shell or bubble nucleus.[3-5] The ground-state band of ^{186}Hg has been identified by Proetel *et al.*[6] They found the first 2^+ state at 405 keV, similar to the situation for the heavier Hg isotopes, and it seems unlikely that ^{186}Hg is deformed in its ground state. Hornshøj *et al.*[5] have studied the α decay of ^{188}Pb and they conclude that the 2^+ level in ^{184}Hg must be higher than 300 keV to account for the absence of fine structure in the α spectrum.

In a series of experiments at the Chalk River MP tandem Van de Graaff we have identified the ground-state band of ^{184}Hg by applying the techniques of in-beam γ-ray spectroscopy to the reaction ^{156}Gd(^{32}S, $4n$)^{184}Hg. The yield was found to peak at about 156 MeV bombarding energy, about as expected for the evaporation of four nucleons from the compound nucleus. To corroborate the mass assignment, recoils from the target were stopped downstream and their γ rays were counted with a large-volume Ge(Li) detector shielded from direct target radiation. Essentially all of the γ rays seen were from the known $A = 184$ decay chain.[7] The Z identification was made by showing that the cascade γ rays from the ground-state band were in coincidence with Hg K x rays. γ-γ coincidences were used to establish the coincidence relationships in the cascade. The angular distributions were those expected for a stretched sequence of $E2$ transitions. The sequence of γ-ray energies is unusual in that both the $4^+ \to 2^+$ and $6^+ \to 4^+$ transitions are lower in energy than the $2^+ \to 0^+$. This ordering is clear from the relative intensities in Table I and is confirmed by decay curves measured by the recoil-distance

TABLE I. Properties of levels in ^{184}Hg.

Transition	E_γ (keV)	Relative intensity	τ (psec)	$B(E2)$ ($10^{-48}e^2$ cm^4)	Deformation[a]
$2 \to 0$	366.7	100	30 ± 7	0.39 ± 0.09	0.15 ± 0.02
$4 \to 2$	287.9	85	32.8 ± 3.4	1.13 ± 0.12	0.22 ± 0.01
$6 \to 4$	340.1	73	8.1 ± 3.1	2.1 ± 0.8	0.28 ± 0.05
$8 \to 6$	418.3	52	<8	...	...
$10 \to 8$	489.3	40	...	...	...

[a] As derived from the rigid-rotor model (Ref. 8).

method (Fig. 1).

By means of the recoil-distance techniques described in Rudd *et al.*[9] and Ward *et al.*,[10] lifetimes for the $8 \to 6$, $6 \to 4$, $4 \to 2$, and $2 \to 0$ transitions were obtained. As can be seen in Fig. 1, each decay curve approaches a constant value at large distances. The data can be fitted quite well by assuming that an isomer of relative intensity 10 (in the units of Table I) feeds into the 8^+ or higher level. Fitted lifetimes were found with a computer program that describes the decay of five cascading levels with arbitrary sidefeeding rates for each level. Intensities for the sidefeeding were taken from the experiment (cf. Table I). The presence of the isomer limited the accuracy with which we could extract lifetimes because it causes each decay curve to flatten at about 0.1 (see Fig. 1). Consequently, there is considerable covariance between the lifetime values for the level and its sidefeed. The uncertainties quoted in Table I allow for this effect.

From the experimental reduced transition probabilities, we have derived the corresponding deformation parameters β according to the rigid-rotor model.[8] The results, summarized in Table I, show that the deformation increases very rapidly above spin 2 and that there is a well-developed rotational band starting at spin 4^+. This is reflected in the level energy spacings shown in Fig. 2. The behavior of ^{186}Hg[6] is rather similar except that in this case the rotational band develops at spin 6^+. Whether or not there is a band head in ^{184}Hg at about 240 keV as suggested by Fig. 2 will be difficult to determine since the expected $2^+ \to 0^{+1}$ transition will compete very unfavorably with the $2^+ \to 0^+$ transition on account of the $E5$ factor in the $E2$ transition probability.

Evidently the potential for ^{184}Hg is either very soft against deformation or there is a deformed second minimum in it. The interaction between the soft ^{184}Hg core and the odd neutron in ^{185}Hg could give rise to a permanent deformation in the ground state and thus explain the anomalous isotope shift between ^{185}Hg and ^{187}Hg.

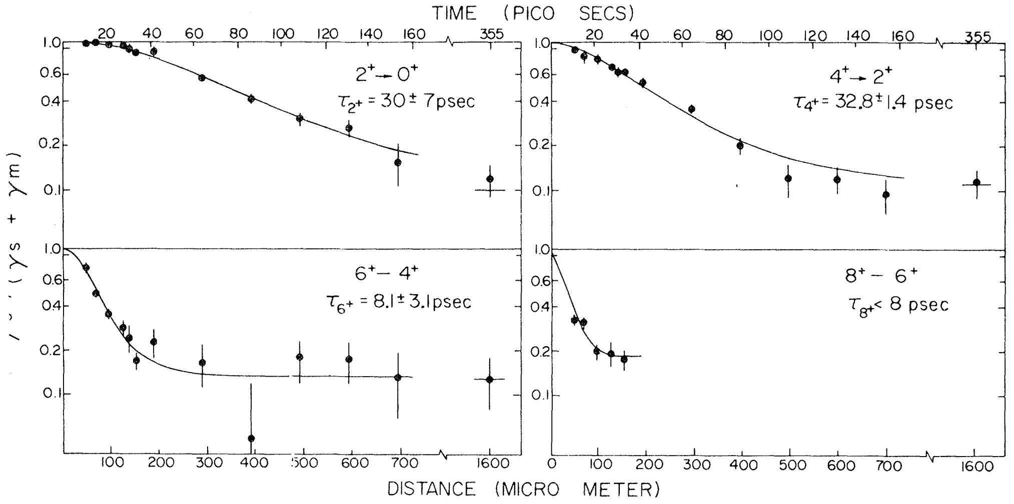

FIG. 1. Recoil-distance decay curves in the reaction ^{156}Gd(^{32}S, $4n$)^{184}Hg at 156 MeV. The ordinate gives the ratio of stopped to stopped-plus-moving γ-ray intensities (cf. Ref. 7).

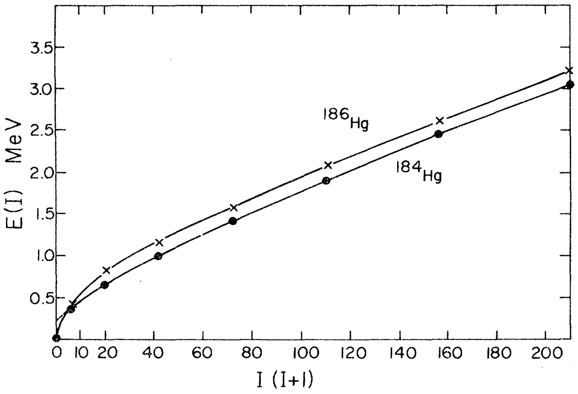

FIG. 2. Level systematics for ^{184}Hg and ^{186}Hg. The 12^+ and 14^+ points in ^{184}Hg are tentative ($12^+ \rightarrow 10^+ = 551$ keV, $14^+ \rightarrow 12^+ = 604$ keV). A well-developed rotational band seems to develop at 4^+ in ^{184}Hg and at $\sim 6^+$ in ^{186}Hg.

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Strongly Oscillating Angular Distributions in the Reaction ^{32}S(^{16}O, ^{12}C)^{36}Ar at $E_{\text{c.m.}} = 30$ MeV

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The elastic scattering of ^{16}O on ^{32}S and the reaction ^{32}S(^{16}O, ^{12}C)^{36}Ar have been measured at $E_{\text{c.m.}} = 30$ MeV. The elastic-scattering angular distribution exhibits a smooth Fresnel-type diffraction pattern, whereas for the (^{16}O, ^{12}C) reaction we observe strong oscillations in the ground-state transition.

Heavy-ion–induced transfer reactions usually exhibit characteristically bell-shaped angular distributions at energies not too far above the Coulomb barrier and for medium-mass target nuclei[1,2] ($A \geq 20$). These angular distributions can be qualitatively understood by the following simple semiclassical argument. The maximum transfer probability will occur for grazing collisions corresponding to the scattering angle θ_{gr}. For collisions with smaller inpact parameters, i.e., for scattering angles $\theta > \theta_{\text{gr}}$, the transfer cross section decreases because of the strong absorption of the colliding nuclei; for larger impact parameters, i.e., $\theta < \theta_{\text{gr}}$, the decrease of the cross section is due to the exponential falloff of the overlap of the bound-state wave functions in the initial and final channels. The corresponding elastic scattering angular distributions exhibit smooth Fresnel-type diffraction patterns.[3]

Qualitatively different angular distributions have been observed for energies far above the Coulomb barrier and for light target nuclei ($A \leq 20$). For these cases strongly oscillating angular distributions have been measured both for the transfer and for elastic scattering.[4,5]

Only very recently a few exceptions from these cases have been reported for target nuclei $A \geq 20$.[6-9] These "anomalous" angular distributions exhibit a rise of the transfer cross section towards smaller angles and show more or less pronounced oscillations. It is the aim of this paper to give further evidence for the occurrence of strongly oscillating transfer angular distributions at energies a few MeV above the Coulomb barrier. This has been observed for the reaction ^{32}S(^{16}O, ^{12}C)^{36}Ar at 45-MeV incident energy.

The experiment was carried out with the ^{16}O beam of the Heidelberg MP tandem Van de Graaff accelerator. Cadmium-sulfide targets of approximately 150 μg/cm^2 thickness evaporated on thin carbon backings have been used. Particle identification has been done in two different ways: For