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VII–1 Isomer Shift and Quadrupole Moment Ratios in $Hf^{178,180}$

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One of the fruitful applications of the Mössbauer effect in nuclear structure has been the measurements of nuclear charge radii of the low lying states of a pure rotational band in the even-even nuclei. Results[1] of isomer shift (IS) measurements have shown broadly the existence of two extreme categories of rotors, (a) the soft rotors (Sm^{152}, Gd^{154}) possessing a large positive value of $\delta\langle r^2\rangle$ which generally is about a factor of 3 smaller than the theoretical calculations of Marshalek[2] and (b) the hard rotors (W^{182}, Yb^{174}) possessing a negative $\delta\langle r^2\rangle$, a result that disagrees even qualitatively with the theoretical predictions.[2] Recent IS measurements[3] on $Hf^{178,180}$ show that these rotors possess a negative $\delta\langle r^2\rangle$. In the self consistent crancking model calculations[2] the different mechanisms of charge radius change, for the Hf isotopes, each contributes to a positive $\delta\langle r^2\rangle$. Clearly, the present notions of these adiabatic effects in nuclear rotation leave more to be understood.

In the IS measurements on Hf^{178}, the observation of a positive shift between $Hf(Cp)_2Cl_2$ and Hf metal was shown to lead to a negative $\delta\langle r^2\rangle$. This follows from the systematics of IS in Fe, Ru and Os that have revealed a smaller 's' electron density at the metal ion in the dicyclopentadinyl derivatives than in the metal. From an estimate of the 's' electron density change between $Hf(Cp)_2Cl_2$ and Hf metal, we find $\delta\langle r^2\rangle/\langle r^2\rangle(Hf^{178}) = -0.13 \times 10^{-4}$. Measurements on Hf^{180} were performed using sources of Ta^{180m} in tantalum metal and the 93.3 keV gamma ray detected in a Ge(Li) crystal. The results (Fig. 1) show a positive shift of 0.23(4) mm/s between $Hf(Cp)_2Cl_2$ and HfC. In the Hf^{178} experiments, the shift between the same pair of absorbers was found to be positive of magnitude 0.26(6) mm/s. One concludes that $\delta\langle r^2\rangle/\langle r^2\rangle(Hf^{180}) = -0.11 \times 10^{-4}$.

The quadrupole moment ratio $Q_{22}(Hf^{180})$: $Q_{22}(Hf^{178})$ was obtained by measuring the quadrupole interaction strength e^2qQ in hexagonal HfB_2. The results show $e^2qQ(Hf^{178})$: $e^2qQ(Hf^{180}) =$ 7.26(17) mm/s: 6.88(20) mm/s = 1.05(3), in reasonable agreement with a previous measurement.[4]

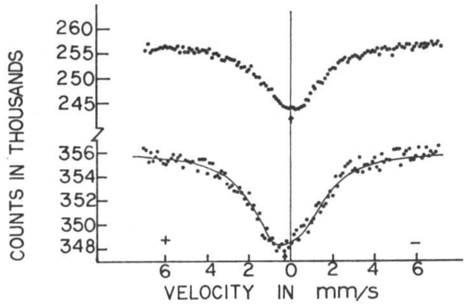

Fig. 1. Mössbauer effect results on Hf^{180}: Top spectrum was taken with a HfC absorber containing 37 mg/cm². Bottom spectrum was taken with a $Hf(Cp)_2Cl_2$ absorber containing 255 mg/cm².

References

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