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VII-3 Nuclear Moment of 23.8 keV State and Hyperfine Anomaly in ^{119}Sn

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Although the Mössbauer transition in ^{119}Sn originating from the $3/2^+$ excited state to the $1/2^+$ ground state with nuclear magnetic moment of $\mu_g = -1.0411(2)\mu_n$[1] is well known and extensively used in solid state and chemistry work, there is still some discrepancy concerning the nucelar moment of the $3/2^+$ excited state. Whereas Nowik and coworkers obtained a g factor ratio of $-0.2150(5)$ from a Mössbauer study of $Y_{2.9}Ca_{0.1}Sn_{0.1}Fe_5O_{12}$ (YCaIG),[2] resulting in a moment of the excited state of $\mu_e = +0.672(2)\mu_K$, Both *et al.*[3] obtained a ratio value of $-0.2193(5)$. This discrepancy being established in obviously careful and reliable experiments may be due to the influence of spatial distribution of nuclear magnetism on the hyperfine interaction energy, known as Bohr-Weisskopf effect[4] or hyperfine anomaly.

Whereas in both experiments mentioned above not the ratios of the g factors $R(g)$ but those of the splitting constants $R(A)$ have been measured, this paper reports on Mössbauer measurements of $R(g)$ by the splitting of a $Ba^{119}Sn^mO_3$ source in the field of 72.6 kOe of a superconducting magnet with absorbers of $BaSnO_3$, 3% ^{119}Sn dissolved in Pd- and Sn-metal. The spectrum obtained with Sn metal is reproduced in Fig. 1(a), the solid line is the result of a least squares fit giving $g_e/g_g = R(g) = -0.2015(5)$, within the statistical errors the same result as obtained with the other absorbers. The additional small line in the center of the spectrum is produced by some metallic tin contamination in the window of the drive system being at the same field as the source.

The hyperfine anomaly $\Delta = 1 - R(A)/R(g)$ as defined by Bohr and Weisskopf[4] is calculated using the value of $R(A)$ given by Both *et al.* as this result is obviously measured in the system producing the largest field gradient. This gives a value of

$$ {}^{e}\Delta^{24} = -8.8(5)\% \, . $$

To make this effect clearly visible, the spectrum of Fig. 1(a) is shown in Fig. 1(b) fitted with the ratio of the splitting constants $R(A) = -0.2193$ instead of $R(g) = -0.2015$ kept fixed.

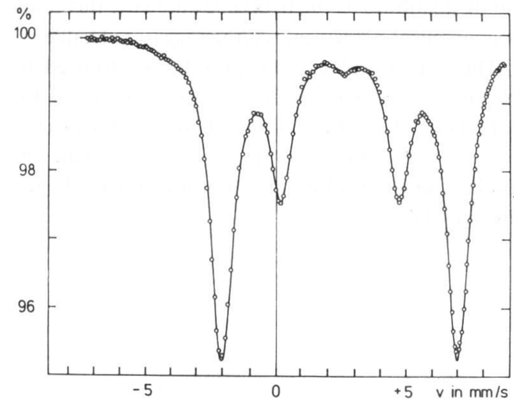

Fig. 1(a). $Ba^{119}Sn^mO_3$ in an external field of 72.6 kOe, absorber: Sn-metal.

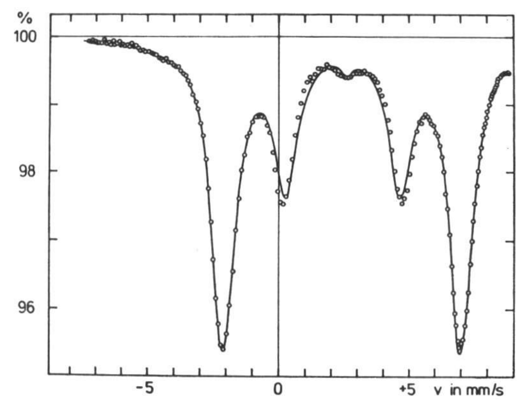

Fig. 1(b). Same as Fig. 1(a), fit with $R(A) = -0.2193$ kept fixed.

For the nuclear moment of the 23.9 keV state a value of

$$ \mu_e = 0.629(2)\mu_K $$

is obtained. Using the shell model with configuration mixing, the nuclear moments of the ground and excited state can well be fitted with mixing parameters $\alpha_g = -0.34$ and $\alpha_e = -0.26$, both values being in excellent agreement with Blin-Stoyle's theoretical estimates $\alpha_g = -0.33$[5] and $\alpha_e = -0.26$.[6] Employing the configurational mixing analysis of the hyperfine anomaly given by Stroke *et al*,[7] a value of $\Delta = -3.3\%$ is calculated using the mixing parameters obtained from the fit of the moments. Considering the necessity of a detailed knowledge of the nuclear structure in calculating such subtle quantities as the hyperfine anomaly, this result is in excellent agreement with the measured value.

The nuclear splitting factor ratio as deduced by Nowik *et al.*[2] may be due to contributions to the hyperfine field at the tin nucleus in YCaIG of electrons of other than s or $p_{1/2}$ type diminishing the gradient of the field being responsible for the hyperfine anomaly.

References

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