Level-Crossing Resonance of r-Ray Anisotropy for the 398-keV 9/22 State of 69Ge in Zn Single Crystal

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I. 4 Level-Crossing Resonance of γ-Ray Anisotropy for the 398-keV $9/2^2$ State of ^{69}Ge in Zn Single Crystal

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In a previous experiment[1], we have been successful in observing the in-beam level-crossing resonance for the 398-keV $9/2^+$ isomeric state of ^{69}Ge produced in a Zn single-crystal target by the ^{66}Zn(α,n)^{69}Ge reaction; it has been observed that the anisotropy of the time-integrated γ-ray angular distribution perturbed by collinear magnetic dipole and electric quadrupole fields shows a resonance behavior as a function of the magnetic field. In the present report, we give the results of further study of this resonance: i) effects of non-collinearity of the two perturbation fields, or those of a non-vanishing angle β between the direction of magnetic field and the c-axis of Zn crystal, and ii) the temperature dependence of the resonance magnetic field.

A calculation shows that the non-collinearity of the two perturbation fields has a large effect on the level-crossing resonance; it causes rapid smearing of the resonance, increase in width and decrease in amplitude, with increasing β. The smearing of the resonance for $\beta \neq 0$ can be interpreted as a result of repulsion between the sub-levels that cross each other for $\beta=0$, and the smearing remains insignificant as far as the closest distance between the sub-levels ΔE_{rep} is smaller than the natural width Γ_{nat} of the relevant level. The calculation shows that ΔE_{rep} is equal to Γ_{nat} at $\beta=2.6°$ in the case of the level-crossing resonance for the 398-keV $9/2^+$ state of ^{69}Ge in Zn single crystal. The effect of non-vanishing β on the resonance curves is shown in fig. 1, where closed circles are the experimental data for $\beta=0°$ and open circles are those for $\beta=5°$ ($\Delta E_{res} \simeq 3\Gamma_{nat}$).

Since the resonance magnetic field B_{res} of the level-crossing resonance is highly sensitive to the ratio between the basic quadrupole frequency $|\omega_0|$ and the nuclear g-factor, the experimental determination of B_{res} is expected to be useful for study of the hyperfine interactions. It is sufficient for the determination of B_{res} to measure singles γ-ray spectra with a continuous beam from accelerator, which is a distinct advantage of the present method over other popular ones, e.g. measurement of time-differential perturbed angular distribution or stroboscopic observation of perturbed angular distribution. As an example of application, we have used the level-crossing resonance technique to measure the temperature dependence of the hyperfine electric quadrupole interaction of ^{69}Ge in Zn single crystal. Quadrupole frequencies ν_Q of the 398 keV state of ^{69}Ge in Zn single crystal measured at different temperatures T are shown in fig. 2, where closed circles are the results of the present work, and open circles, squares and crosses

are the results obtained by Christiansen et al.[2], Haas et al.[3] and Schatz et al.[4], respectively. The time-differential method was used in refs. 2) and 3), and the stroboscopic method in ref. 4).

References

1) Fujioka M., Shibuya S., Kawamura N., Matsumoto A., Sugawara M., Hayashibe S., Ishimatsu T., Coussement R., Rots M. and Hermans L., CYRIC Ann. Rep. 1980, p. 66.
2) Christiansen J., Heubes P., Keitel R., Klinger W., Loeffler W., Sandner W. and Witthuhn W., Z. Physik B24 (1976) 177.
3) Haas H., Leitz W., Mahnke H.-E, Semmler W., Sielemann R. and Wichert Th., Phys. Rev. Lett. 30 (1973) 656.
4) Schatz G., Brenn R. and Fossan D. B., Phys. Lett. 57B (1975) 231.

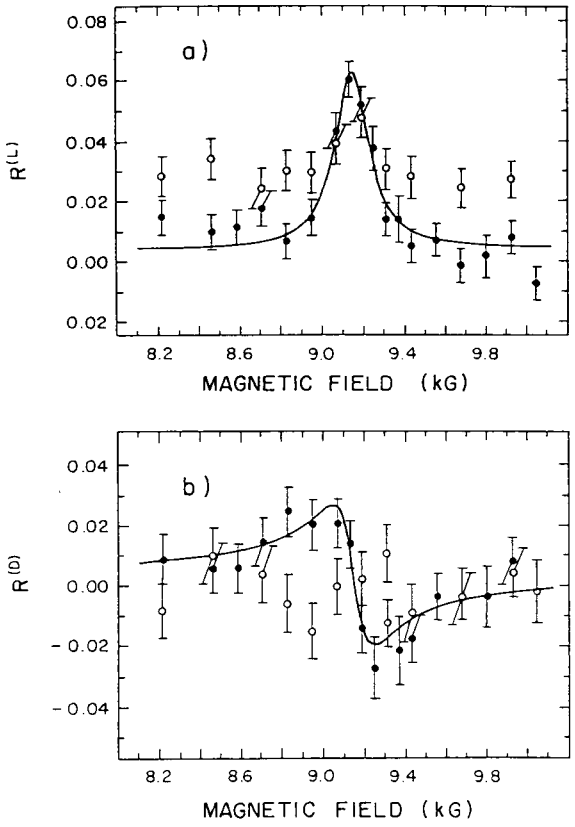

Fig. 1. Level-crossing resonance for the 398-keV $9/2^+$ state of ^{69}Ge in Zn single crystal; a) 0°-90° and b) 45°-135° anisotropies for the 398-keV γ-ray as a function of magnetic field. Closed circles are the experimental data for β=0° and open circles are those for β=5°. Solid curves are the theoretical ones fitted to the experimental data for β=0°.

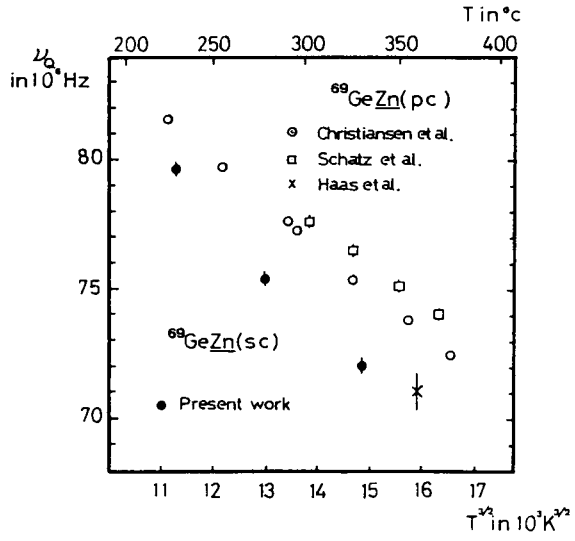

Fig. 2. Temperature dependence of the quadrupole frequency ν_Q of the 398 keV state of ^{69}Ge in Zn single crystal.