RAPID COMMUNICATIONS

PHYSICAL REVIEW C VOLUME 33, NUMBER 1 JANUARY 1986

Quadrupole moment of $^{107}Ag^m$ determined by level mixing resonance on oriented nuclei

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(Received 2 October 1985)

The quadrupole moment ratio of $^{107}Ag^m$ to $^{109}Ag^m$ has been determined as $Q(^{107}Ag^m)/Q(^{109}Ag^m) = 0.960(10)$ with the level mixing resonance on oriented nuclei technique. Using the previously established electric field gradient of silver in zinc, $Q(^{107}Ag^m) = 0.98(11)$ b has been deduced. The results are in agreement with the theoretical predictions.

The precision of the electric quadrupole moments, determined through hyperfine interactions in solid matrices, is limited on account of the experimental error on the electric field gradients. Nevertheless, the recently developed technique of level mixing resonances on oriented nuclei (LMR/ON) allows the determination of the quadrupole resonance frequency to a high precision,[1-3] and thus to establish an accurate ratio of quadrupole moments. This feature is particularly interesting, when the nuclear quadrupole moment varies smoothly from one isotope to another, as in the case of silver isotopes for which a smooth increase of the prolate deformation versus mass number is predicted by a macroscopic-microscopic calculation of Möller and Nix.[4] The predicted quadrupole moments of some silver isotopes have been confirmed in a previous paper,[5] but the experimental errors are rather high: $Q(^{108}Ag^m)$ and $Q(^{110}Ag^m)$ are established by optical spectroscopy[6] and corrected for the Sternheimer effect, $Q(^{106}Ag^m)$ was obtained from low temperature nuclear orientation of ^{106}Cd in zinc, and the isotope $^{109}Ag^m$ was measured by LMR/ON.[5] For the evaluation of this latter measurement we used the electric field gradient determined from the low temperature nuclear orientation of $^{110}Ag^m$ in zinc.[5] The convolution of the errors of each measurement leads thus to a limited absolute precision on Q. As $^{107}Ag^m$ is also open to LMR/ON, we measure this resonance in a single crystal sample $^{107}CdZn$.

Natural silver foils were irradiated with the 28 MeV deuteron beam of the synchrocylotron of the University of Lyon. The ^{107}Cd(6.5 h) activity was separated chemically from the silver foil, electrodeposited onto a Zn single crystal cut perpendicularly to the c axis. The quality of each crystal has been checked previously by Laue backscattering. The carrier-free ^{107}Cd activity was diffused into the crystal at 300 °C during 3 h under H_2 atmosphere, then the remaining activity was cleaned from the surface.

In order to assure that $^{109}Ag^m$ and $^{107}Ag^m$ experience the same electric field gradient, we tried to introduce ^{109}Cd and ^{107}Cd into the same crystal. On account of the high inactive carrier concentration of ^{109}Cd, it was not possible to diffuse ^{109}Cd and ^{107}Cd together, during only a few hours. (In our previous investigation[2] ^{109}Cd has been diffused during 24 h.) The evaporation and the diffusion of ^{109}Cd, followed by that of the ^{107}Cd activity, introduced ^{107}Cd and ^{109}Cd to very different depths, and LMR/ON showed an appreciable line broadening, which can be due to imperfections in the crystal sites. So, it was preferable to introduce ^{107}Cd alone into the Zn single crystal.

The $\Delta m = 2$ and 3 resonances on $^{107}Ag^m$ have been ob-

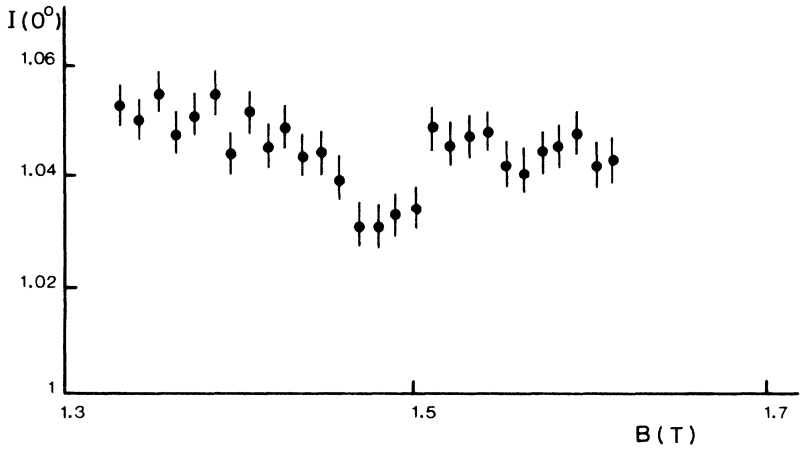

FIG. 1. The $\Delta m = 3$ LMR/ON resonance on $^{107}Ag^mZn$ observed at a temperature of 6.7 mK. The tilting angle between the magnetic field and the electric field gradient was 7°.

served in a dilution refrigerator on several samples (Fig. 1). The positions of the resonances between various samples showed scattering up to about $\pm 1\%$. This scattering is higher than that observed in our previous investigation on $^{109}Ag^m$, where the long lifetime of ^{109}Cd allowed for a long diffusion and more careful annealing of the samples. We thus find for $^{107}Ag^m$ in zinc

$$eQV_{zz}/\mu = 2.96(3) \text{ T} ,$$

and with $\mu = 4.398(5)$ from Ref. 7

$$\nu_Q(^{107}Ag^m Zn) = eQV_{zz}/h = 99.2(10) \text{ MHz} .$$

Reevaluating with the new magnetic moment value of Ref. 7

$$\nu_Q(^{109}AgZn) = 103.3(7) \text{ MHz} .$$

Using the electric field gradient of silver in zinc of Ref. 5 we find

$$Q(^{107}Ag, \tfrac{7}{2}^+) = 0.98(11) \text{ b} , \quad Q(^{109}Ag, \tfrac{7}{2}^+) = 1.02(12) \text{ b} .$$

The errors on Q are mainly due to the error on the electric field gradient.

The ratio of the electric quadrupole moments, exempt of this error

$$Q(^{107}Ag, \tfrac{7}{2}^+)/Q(^{109}Ag, \tfrac{7}{2}^+) = 0.960(10) ,$$

is almost one order of magnitude more precise than the numerical value of Q, and it is in excellent agreement with the theoretical estimation of the ratio of the intrinsic quadrupole moments 0.95 of Möller and Nix.[4] The absolute value of the intrinsic quadrupole moment $Q_0(^{107}Ag^m) = 2.1(2)$ b also agrees fairly well with the theoretical value of 1.8 b.

The authors are kindly indebted to Mr. L. Vidal for source preparation, Mr. R. Bouvier and Mr. F. Rochigneux for synchrocyclotron irradiations, and Mr. J. P. Hadjout and Mr. S. Morier for technical support.

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