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Magnetic Moments of ^{127}Te and ^{129}Te

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§1. Introduction

The ground states of ^{127}Te and ^{129}Te are assumed to be mainly of $d_{3/2}$ one-quasiparticle character. Pairing-plus-quadrupole theory[1] predicts only small phonon contributions to the magnetic moments of these two ground states. In ^{123}Te and ^{125}Te however, the $3/2^+$ state is the first excited state due to the quadrupole force, and the collective contributions to the magnetic moment are supposed to be important. Hence a comparison of $\mu_{3/2}$ of the ground states with those of the first excited states will test the predictions about the phonon contributions to these magnetic moments. For ^{123}Te and ^{125}Te, the $\mu_{3/2^+}$ has already been reported.[2,3] We determined $\mu_{3/2^+}$ of ^{127}Te and ^{129}Te in nuclear orientation experiments.

§2. Source Preparation and Experimental Set-Up

The ^{127g}Te and ^{129g}Te activity was produced by neutron irradiation of highly enriched ^{126}Te and ^{128}Te. The activity was implanted by isotope separator into a high-purity iron foil: the total dose was less than 0.2 at %. Tests on equivalent Te sources indicate that the Te atoms are substitutionally imbedded as dilute impurities in the lattice.

Nuclear orientation was performed using a high-power helium isotope refrigerator: the temperature of the radioactive sources was held for several days in the region 14 mK $< T <$ 50 mK. The iron foil was saturated by a superconducting split-coil magnet. Gamma-rays were detected at 0° and 90°, with 30 cm^3 high resolution Ge(Li) detectors. The γ-spectra were stored in a multichannel system based on a PDP11/20 computer (Digital). The stability of the temperature and of the Ge(Li) counters could be tested without disturbing the accumulation of data, using the priority-interrupt structure of this computer.

§3. Measurements and Results

The ^{127}Te(Fe) and ^{129}Te(Fe) sources were oriented during two different runs: each run consisted of a dozen of periods of several hours at a constant temperature. The temperature was continuously monitored by the anisotropy of the 136 keV γ-ray of ^{57}Co(Fe). For each period, the anisotropies of all γ-rays were measured. The angular distribution of the γ-radiation is given by the general formula:

$$W(\theta) = 1 + \sum_{k=2,4} B_k U_k F_k Q_k P_k(\cos\theta)$$

the B_k are temperature dependent parameters which are function of the magnetic moment of the parent nucleus.

^{127}Te decays primarily by β-decay to the $5/2^+$ excited state (417.9 keV) of ^{127}I. The mixing ratio of the 417.9 keV γ-ray from this level to the ground state is known: $\delta = -.008 \pm .003$.[4] The anisotropy as a function of temperature of this gamma ray is shown in Fig. 1, a least squares fit resulted in $\mu_{3/2} = (.66 \pm .05)\mu_N$.

Although ^{129}Te does have a similar decay scheme, no gamma-rays with known spins and multipolarity were available for the $\mu_{3/2}$ determination. ^{129}Te decays primarily to the 487.4 keV excited state of ^{129}I. From the anisotropy of the 487.4 keV γ-ray to the $7/2^+$ ground state, the spin of this level was uniquely determined to be 5/2. Now the mixing

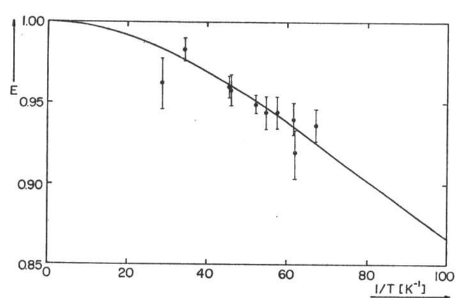

Fig. 1. The anisotropy $W(0)/W(90)$ for the 417.9 keV γ-ray of ^{127}Te vs $1/T$.

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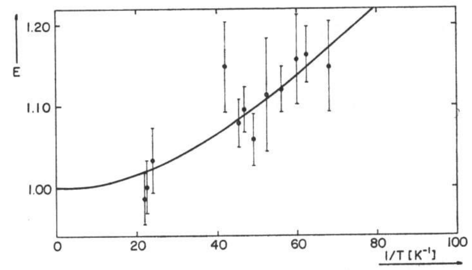

Fig. 2. The anisotropy $W(0)/W(90)$ for the 209 keV γ-ray of ^{129}Te vs $1/T$.

ratio of the 209 keV γ-ray deexciting this level to the $3/2^+$ level at 278.4 keV could be determined in an angular correlation experiment[5]: $\delta = -.225 \pm .047$. The anisotropy of the 209 keV γ-ray as a function of temperature is given in Fig. 2, resulting in $\mu_{3/2} = (.64 \pm .05)\mu_N$. From the anisotropy of the 1084 keV γ-ray, the spin of the 1111.8 keV level was uniquely determined to be 5/2, and independent of the multipolarity of the 1084 keV γ-ray, a minimum of $(.70 \pm .05)\mu_N$ was derived for $\mu_{3/2}$. Combining the information from both γ-rays yield: $\mu_{3/2} = (.67 \pm .05)\mu_N$.

§4. Discussion

In the spherical region, the odd-mass magnetic dipole moments are given by the pairing-plus-quadrupole model:[1]

$$\mu_j = (C^j_{joo})^2 \mu^c_{cp} + \mu_f = \mu_0 + \mu_f$$

C^j_{joo} is the amplitude of the one-quasiparticle component in the wave function describing this state. μ_f is the phonon contribution and μ^c_{cp} is the quasi-particle magnetic moment corrected for small admixtures of higher seniority configurations due to a residual spin-spin δ-function interaction. The results of the calculations, compared to the experimental results, are assembled in Table I.

The experimental values are consistent with theory. No trend is obvious however, and the experimental accuracy does not allow yet to separate quasiparticle and collective contributions to the magnetic moment.

References

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Table I. Comparison of experimental $\mu_{3/2}$ with theory.

Isotope	$\mu^c_{q.p.}$	μ_0	μ_f	$\mu^{1)}_{th}$	μ_{exp}	ref.
^{123}Te	.65	.43	.27	.70	.72 ± .12	2)
^{125}Te	.64	.48	.16	.64	.60 ± .02	3)
^{127}Te	.64	.52	.05	.57	.66 ± .05	this work
^{129}Te	.66	.52	.03	.56	.67 ± .05	this work