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DETERMINATION OF THE MIXING PARAMETER OF M1 AND E2 RADIATION FOR THE 0.341-MeV TRANSITION IN Ti^{49}

A. P. Bogdanov, V. N. Tadeush, and E. I. Firsov
Physics Institute, Belorussian Academy of Sciences
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As shown in [1,2], measurements of the angular correlation of two cascade γ quanta, the first of which is mixed, can be used to check on the invariance of nuclear forces against the time-reversal operation.

Krupchitskii [3] proposed and calculated in detail an experiment which reduces the error in the determination of the part of the Hamiltonian which is odd with respect to the time-reversal operation. He proposes the use of the cascade transition $1/2^-(M1 + E2)3/2^-(E2)7/2^-$ in the Ti^{49} nucleus. This cascade begins at the 1.719-MeV level, which is de-excited by a cascade transition through the 1.378-MeV level with emission of 0.341 and 1.378 γ rays (Fig. 1). The second transition in this cascade is pure E2, while the first can be M1 or a mixture of

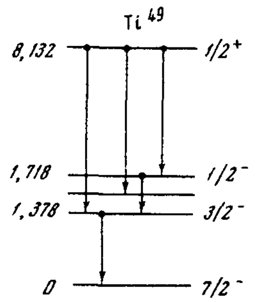

Fig. 1. Fragment of the level scheme of Ti^{49}.

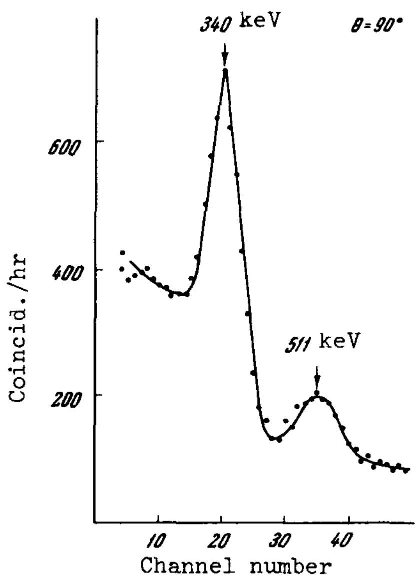

Fig. 2. Spectrum of coincidences with 1.378-MeV γ rays.

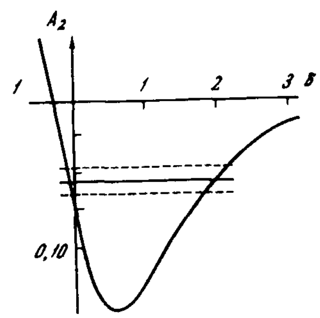

Fig. 3. Coefficient A_2 as a function of the multipole mixing parameter δ.

M1 and E2. The published data on the multipolarity of the 0.341-MeV γ radiation are contradictory. This transition is identified in [4] as an M1 + E2 mixture with mixing parameter δ equal to -0.1 or +2.2. In [5] it is concluded that this is a pure M1 transition.

The present investigation was undertaken to eliminate this contradiction. A target of metallic titanium of 8 mm diameter and 2 mm thick was irradiated by a collimated beam of neutrons with a cadmium ratio 500 from the thermal column of the IRT-2000 reactor of the Belorussian Academy of Sciences. The thermal-neutron flux at the target location was 4×10^6 neut/cm^{2}sec. The γ detectors were two scintillation counters with NaI(Tl) crystals 70 mm in diameter and 70 mm high, connected in a fast-slow coincidence circuit with resolution time $\sim 5 \times 10^{-8}$ sec. The resolving power of both spectrometers is 10% at E_γ = 661 keV.

One of the detectors was stationary, and the other could assume two fixed positions, so that the angle between the crystal axes, which crossed in the center of the target, was 180 or 90°. Priliminary adjustment of the target relative to the neutron beam and the detectors was visual, and the final adjustment was against the counting rate at the 1.380-MeV line in two positions of the movable detector.

Both crystals were shielded against the γ radiation from the reactor channel with 10 cm of lead. The solid angles of the spectrometers were set by conical collimators in the lead shield. With a distance of 10 cm from the center of the target to the input surface of the crystal, and with a crystal-surface diameter of 6 cm seen from the center of the target, the solid angle of each spectrometer was 2.2% of 4π.

The entrance to the conical collimator of the movable detector was covered with a thin layer of boron carbide to absorb the neutrons scattered from the target. The stationary detector, intended for registration of the 0.351-MeV γ radiation, was shielded with a thin layer of Li^6 oxide. Boron carbide will not do in this case, for neutron bombardment of boron results in intense 0.478-MeV γ radiation. The background of the stationary detector does not exceed 10^3 counts/sec over the entire energy interval, and no noticeable crystal activation was noted after prolonged operation. By way of a control experiment we measured the angular correlation for the cascade 1.17 - 1.33 MeV in Ni^{60}, the correlation function of which is well known. The result obtained was in good agreement with the literature data.

Figure 2 shows the spectrum of coincidences with the 1.378-MeV γ rays, after subtraction of the random coincidences, as recorded with an AI-100 multichannel analyzer. The 1.378-MeV line was fixed by the window of a one-channel analyzer. The measurements were made alternately in the two positions of the movable detector, with 60-minute exposure in each position. We recorded simultaneously the total fast-coincidence count and the count in the window of the single-channel analyzer, making it possible to correct the coincidence-counting rate for small changes in the efficiency of the coincidence circuit and for fluctuations of the neutron flux during the measurement time. The coincidence-counting rates measured at 180 and 90° were processed by least squares and reduced to a function in the form

$$W(\theta) = 1 + A_2 P_2(\cos\theta),$$

where $P_2(\cos\theta)$ is the second-order Legendre polynomial. The coefficient A_2 obtained in this manner was corrected for the finite solid angles of the detector by a method described in [6].

The value which we obtained

$$A_{2\,exp} = -0.055 \pm 0.010$$

is in good agreement with the (-0.045 ± 0.015) obtained in [4]. Our experimental value of A_2 is somewhat lower than the theoretical one for a pure M1 transition

$$A_{2\,theor}\,(M1) = -0.071.$$

If we assume the presence of a mixture of the M1 and E2 multipoles in the first transition of the investigated cascade, then the theoretical coefficient A_2 as a function of the multipole-mixing parameter is

$$A_2 = \frac{0.0714\delta^2 - 0.2479\delta - 1}{1 + \delta^2} .$$

Figure 3 shows A_2 as a function of δ for an M1 + E2 mixture in the first transition, as well as the experimentally obtained A_2. We see from Fig. 3 that the first transition in the investigated cascade is mixed. The mixing parameter δ is equal to either -0.06 or +2.0.

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