Effect of crystal orientation on a angular correlation in 166Er

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Effect of Crystal Orientation on a $\gamma\gamma$ Angular Correlation in ^{166}Er

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Measurements were reported [1], [2] on the perturbed angular correlation of the 1380–81 keV $\gamma\gamma$ cascade in the decay of ^{166}Ho to ^{166}Er. The paramagnetic Ho ions were magnetically diluted in single crystals of lanthanum ethylsulphate (LaES) and yttrium ethylsulphate (YES). The experimental values of the attenuation coefficients G_2 and G_4 of the angular correlation were not compatible with the expected values for an axially symmetric hyperfine interaction of the ^{166}Er ions, provided relaxation effects are absent at 6°K [2].

The aim of the present work was first to see wether radiation defects could be responsible for this deviation, and also to search, with improved accuracy, for effects of crystal orientation on the angular correlation.

In the previous measurements the crystals were grown from aqueous solutions. With this method of growing, the seed and the solution were exposed to a very intense β radiation (activities between 0.5 and 1.5 Curie). To avoid any irradiation effects, we have prepared the samples in the following way: hydrated Ho chloride was irradiated with 4.10^{13} neutrons/cm^2 sec. After irradiation the chloride was dissolved in water and evaporated to dryness a few times to eliminate any hydrochloridric acid. The salt was then dissolved in 100–150 µl of saturated LaES solution. Small drops of a few µl of this solution were applied to a natural surface of LaES single crystals during 20–30 sec and then removed. Activities of about 300 µCi were obtained. The crystals were oriented optically and mounted in the He cryostat with the symmetry axis either perpendicular to the plane of the detectors or parallel to the axis of the high energy detector. The surface containing the activity was always perpendicular to both, the detector plane and the front plane of the high energy counter. With this arrangement the measured γ rays of 1380 keV are emitted almost parallel to strings of Ho and La ions, and we can expect a reduction or an elimination of recoil effects.

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The measurements were performed with two $3'' \times 3''$ NaJ(Tl) detectors, two conventional fast-slow coincidence set ups for true and chance coincidences, a 400 channel analyzer with a magnetic tape recorder. Three different crystals were studied at 6 °K, two for the perpendicular case and one for the parallel case. The correlation was measured at five different angles.

The table 1 gives the averaged values of the attenuation coefficients G_2 and G_4 for the two orientations. The small contribution of the 1580–81 keV correlation was taken into account. These values are rather close to the previous results [2]. From this we conclude that possible radiation effects in the earlier measurements are insignificant.

Table 1
Attenuation factors at zero magnetic field for different orientations of the crystalline axis.

Preparation of the crystals	Crystal orientation[a])	Temperature °K	G_2	G_4	Reference
deposition on a natural surface	$\updownarrow$	5.5 ± 0.5	0.156 ± 0.027	0.125 ± 0.014	Present work
	$\leftrightarrow$	5.5 ± 0.5	0.294 ± 0.029	0.110 ± 0.015	
growing from aqueous solutions	$\updownarrow$ [b])	6 ± 1	0.151 ± 0.036	0.103 ± 0.019	[2]
	$\leftrightarrow$ [b])	5.5 ± 0.5	0.288 ± 0.030	0.151 ± 0.015	

a) $\updownarrow$: c axis perpendicular to the detector plane;
$\leftrightarrow$: c axis parallel to the axis of the high energy detector.
b) mean values of previous measurements with 4 different chemical procedures (Ref. [2]).

Comparing the values for the two crystal orientations, we find:

$$G_2(\leftrightarrow) - G_2(\updownarrow) = +0.138 \pm 0.039 ,$$

$$G_4(\leftrightarrow) - G_4(\updownarrow) = -0.015 \pm 0.021 .$$

We conclude that a dependence on the crystal orientation has been observed. One plausible reason for not observing the expected values of G_2 and G_4 for axially symmetric hyperfine interaction could be that all the Ho^{3+} ions might not have reached Er^{3+} ionic ground state after β decay, in such organic crystals. It may be advantageous to use inorganic single crystals, e.g. holmium chloride in lanthanum chloride.

REFERENCES

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