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8.49 Multi-Tilted Foil Polarization and the Signs of Nuclear Quadrupole Moments

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Following earlier work at our Laboratory on multi-tilted foil atomic polarization and nuclear precession, we have developed in recent years a method for measuring the sign of quadrupole moments of high spin isomers which is based on nuclear polarization with the multi-tilted foil technique. The observation of the quadrupole precession signal also provides a measurement of the induced nuclear polarization. A number of such measurements as well as details of the technique have been described in various publications.[1-6] The measurement of the ^{147}Gd($49/2^+$) isomer, in particular, constitutes the first direct observation of an oblate deformation for a particle aligned very high spin isomer. We present here results for ^{134}Ce(10^+) from a recent measurement where the polarized cerium isomers were embedded in a gadolinium single crystal. The Ce measurement is of particular interest because it is the first such measurement for an isomer which is considered possibly to have a triaxial shape. The quadrupole coupling constant was determined as $e^2qQ/h = +33(3)$ MHz where Q in the nuclear moment and eq is the electric field gradient (EFG) on Ce impurities in a Gd host. No direct information on the sign of the EFG is available for cerium in gadolinium; however the sign of the EFG is known for Gd, W and Ir in Gd and is positive throughout. It is therefore very plausible that the EFG is positive also for Ce in Gd. This would imply a positive sign for the quadrupole moment. In the framework of the triaxial rotor model this corresponds to a γ deformation in the range $-120° \leq \gamma \leq -30°$ in the Lund convention.

The Ce measurement was the first instance in which this method was applied to a state with a relatively small g-factor ($g = -0.187$). As the measurement requires an interfoil travel time long compared to the mean hyperfine period, a small g-factor implies a large interfoil separation, imposing severe constraints on the construction of the foil stack. A special stack was developed for such measurements with the essential feature of having the foils supported at two sides only. The sides facing the target and the crystal are free. A schematic view of the experimental set up with this stack is shown in Figure 1.

As a review of nuclear polarization obtained in such measurements, we present in the table below the relevant data of all such measurements to date. We note that the nuclear polarization routinely exceeds the atomic tilted foil polarization, as expected. We would also like to reiterate at this point that the precession measurements indicate that the atomic polarization decreases markedly with increasing ion velocity.[7-9)]

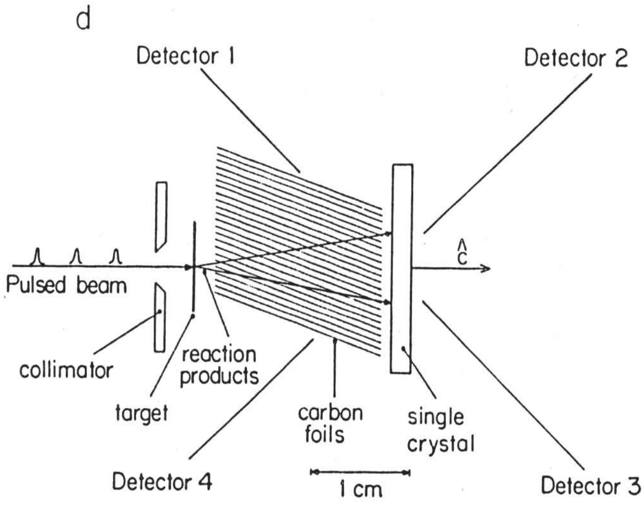

Fig. 1. Experimental set up used in the ^{134}Ce(10^+) study.

Table I. Resumé of polarization data

State	g-factor	Recoil Velocity v/c	Number of foils	Interfoil distance μm	Tilt angle (degrees)	Atomic polarization per foil	Induced nuclear polarization
^{54}Fe(10^+)	0.728	0.018	13	300	60	0.08	0.08(3)
^{54}Fe(10^+)	0.728	0.018	17	300	60	0.08	0.18(5)
^{134}Ce(10^+)	-0.187	0.015	9-10	1500	60		0.11(4)
^{134}Ce(10^+)	-0.187	0.015	11	1800	70		0.13(4)
^{144}Gd(10^+)	1.276	0.018	19	90	60	0.05(1)	0.06(3)
^{144}Gd(10^+)	1.276	0.018	19	150	60	0.05(1)	0.09(4)
^{144}Gd(10^+)	1.276	0.018	19	450	60	0.05(1)	0.10(4)
^{147}Gd($27/2^-$)	0.840	0.016	23	300	60	0.05(1)	0.11(2)
^{147}Gd($49/2^+$)	0.446	0.018	25	450	60	0.05(1)	0.16(3)

The data in this table, other than for ^{134}Ce(10^+), are from ref. 5.

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