V–18

The Static Quadrupole Moments of the First Excited States of ^{148}Sm, ^{150}Sm and ^{152}Sm

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Nuclei adjacent to the $N = 82$ shell closure exhibit properties characteristic of a spherical-deformed shape transition. We have studied the static electric quadrupole moments of the first excited states of even A nuclei of barium,[1] neodymium,[2] and samarium,[3] throughout this shape transition. This paper presents the results of measurements of the relative static electric quadrupole moments in ^{148}Sm, ^{150}Sm, and ^{152}Sm. These measurements utilized a technique we have used in the past to study the moments in the nickel[4,5] and neodymium[2] isotopes. Relative static quadrupole moments are obtained by comparing the yield of de-excitation gamma-rays from several isotopes in a thick natural target following Coulomb excitation with a variety of beam species.

Thick natural samarium discs were Coulomb excited with various energy beams of ^{4}He, ^{16}O, and ^{32}S, and the de-excitation gamma-rays were detected in a 32 cc Ge(Li) detector. Beam energies were chosen to be considerably below the Coulomb barrier to ensure that the interaction was purely Coulomb. The analysis technique is described in detail in refs. 2, 4, and 5. The moments of ^{150}Sm and ^{148}Sm relative to ^{152}Sm are given by the relations $Q_2^{150} = -(0.76 \pm 0.19) - 0.335 \; Q_2^{152}$ e.b. and $Q_{2+}^{152} = -(0.58 \pm 0.27) \; Q_{2+}^{152}$ e.b. Note the moments in ^{148}Sm and ^{150}Sm depend only weakly on the moment in ^{152}Sm. Our relative moments are presented in the Table I assuming the rotor value for the ^{152}Sm moment. A weighted fit of our relative moment results with all available absolute values results in the weighted mean values given in the lowest line of the Table I. Assuming a $B(\mathrm{E2}, 0^+ \rightarrow 2^+)$ for ^{152}Sm of 3.35 (e.b.)^2 results in $B(\mathrm{E2}, 0_1^+ \rightarrow 2_1^+)$ values of 0.706 ± 0.024 (e.b.)^2 and 1.39 ± 0.04 (e.b.)^2, respectively for ^{148}Sm and ^{150}Sm. The neutron number dependence of the static moments in the even neodymium and samarium isotopes is the same. The $N = 86$ and 88 nuclei, which have vibrational type of energy spectra, have static quadrupole moments as large as or larger than the rotor limit. The measured static moments, the E2 properties and level positions of the low-lying levels all exhibit exactly the behavior expected for a spherical to prolate shape transition. The lightest nuclei are soft spherical vibrators with a small β_{rms}, an asymmetry of $\gamma \simeq 30°$ and large β and γ vibrational amplitudes. A secondary minimum develops on the prolate axis which progressively deepens with addition of neutrons. Thus, β_{rms} increases considerably, the asymmetry becomes small, $\gamma \simeq 5°$ and the β and γ vibrational amplitude decreases.[9]

References

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Table I. The static quadrupole moments Q_2(*e*.barns) of the first excited states of ^{148}Sm, ^{150}Sm, and ^{152}Sm

	^{148}Sm	^{150}Sm	^{152}Sm
Spheroidal rotor value	0.762	1.059	1.653
Goldring *et al.*[6]			-1.8 ± 0.6
Simpson *et al.*[7]	-0.73 ± 0.38	-1.22 ± 0.22	
Gertzman *et al.*[3]	-0.24 ± 0.28		
Kaspar *et al.*[8]			-1.65 ± 0.19
Present work	-0.97 ± 0.27	-1.31 ± 0.19	(-1.653)
Weighted mean of data	-0.63 ± 0.18	-1.27 ± 0.15	-1.64 ± 0.16

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