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INELASTIC α PARTICLE SCATTERING IN THE RARE EARTH REGION
AND DETERMINATION OF β_4

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H. Duhm, J. Mahoney, and J. Saudinos

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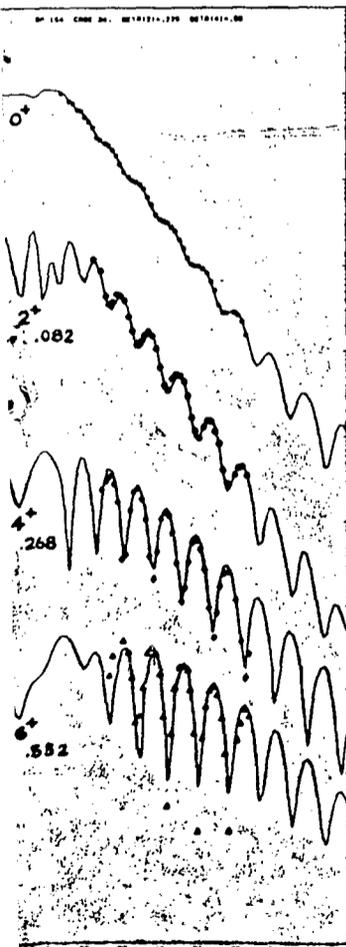
Inelastic Alpha Particle Scattering in the Rare Earth Region and Determination of β_4

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The analysis of the scattering of 50 MeV alpha particles¹ from Sm¹⁵² and Sm¹⁵⁴ showed that the multiple nuclear excitation mechanism² reasonably explains the angular distributions of excited states. Extension of the scattering work to other permanently deformed rare earth nuclei gives new information about levels belonging to the ground state rotational band. In particular, the interference between direct and multiple excitation modes yields reliable measurements of higher order deformations in these states.

The experiments consisted of detection in 4 cooled lithium drifted silicon detectors of 50 MeV alpha particles provided by the Berkeley 88" cyclotron which were elastically and inelastically scattered by thin metallic foils of the isotopically enriched rare earths. The resolution was sufficient and backgrounds were low enough to obtain data for states up to 6^+ levels of the ground state band. The data were analysed using a complex coupled rotational model coupled-channels calculation. The inclusion of Coulomb, as well as nuclear, excitation up to 6th order in the interaction (requiring use of partial waves up to $l=90$) was necessary for reproduction of details of the angular distributions. The amount of higher order deformations was then sensitively determined by the angular distributions to the higher spin states. The quality of the resulting fits is shown in fig.1 for Sm¹⁵⁴, where we find $\beta_4 = +0.05 \pm 0.01$. The qualitative difference for Yb¹⁷⁶ is seen in fig. 2, where preliminary calculations indicate that a $\beta_4 = -0.04$ is necessary. Table I lists our results to date, most of which are tentative.

These results may be understood on the basis of a calculation similar to that performed by Harada³ in the actinide region. β_4 is determined by a perturbation calculation using Nilsson orbitals and a $r^4 Y_{40}$ interaction; the result is shown in fig. 3. Although there is a rather arbitrary choice of zero, corresponding to a selection of contributing orbitals, the trend towards more negative β_4 deformation is unequivocal and in agreement with the experimental results. In order to compare the β values from the scattering work with those derived from EM experiments, a scale factor of about 1.5 must be applied. This should be noted in comparing fig. 3 with Table I.



Nuclide	Sm ¹⁵²	Sm ¹⁵⁴	Gd ¹⁵⁸	Yb ¹⁷⁴	Yb ¹⁷⁶	Hf ¹⁷⁸
β_2	0.205	0.225	0.230	0.245	0.240	0.245
β_4	+0.045	+0.050	+0.045	-0.040	-0.040	-0.045

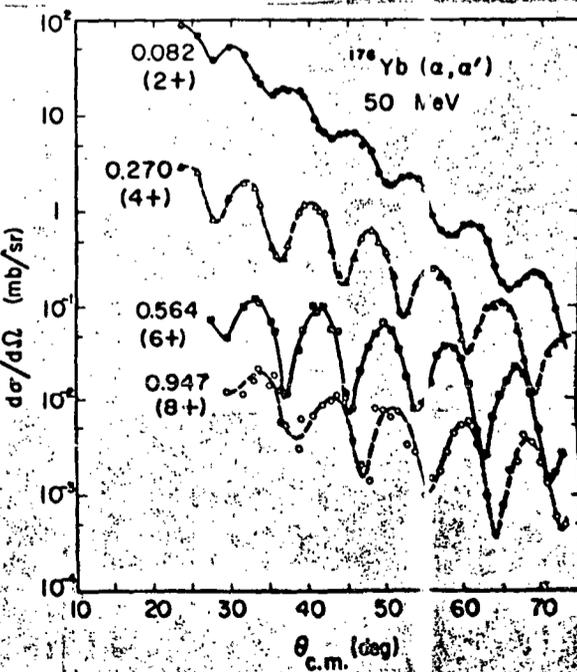
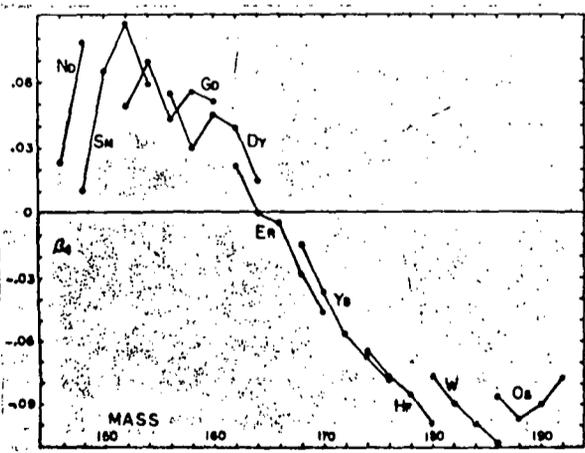


Fig. 3 (above) Calculation of β_4 .

Fig. 1 (left) Data and coupled-channels fit for Sm¹⁵⁴.

Fig. 2 (right) Data for Yb¹⁷⁶.

1) B.G. Harvey, D. L. Hendrie, O.N. Jarvis, J. Mahoney, J. Valentin, Phys. Lett. 24B, 43(1967).
2) N. Austern and J. S. Blair, Ann. Phys. 33, 15 (1965).
3) K. Harada, Phys. Letters 10, 80 (1964).

