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Quadupole Moments Calculation of Deformed Even-Even $^{156\text{-}170}$ Er Isotopes

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I. Introduction

Nuclear moments have been studied since the very beginning of nuclear structure physics. The measurement of nuclear quadrupole moments has always been and still is more difficult and challenging than magnetic moment measurements. It is clear that to understand the nuclear structure; we need to measure as much as possible the properties of nuclei over a large range of isospin or make a detailed investigation of some specific key nuclei.

The properties of a nucleus with several nucleons outside (or holes in) a closed shell will then be described in a first approximation by an inert core (e.g. a doubly magic nucleus) plus some nucleons which can move in a certain configuration space and which interact with the core and each other via a residual interaction (particle-particle and particle-core interactions).

Depending on the chosen model space and residual interactions, one can probe via comparison to several experimental parameters (excitation energy, spin/parity, magnetic and quadrupole moment) the validity of the model and parametrization of the residual interaction. The nuclear moments are often a good check if the parametrization and model space are appropriate. Deviations from the model predictions might indicate the presence of configuration mixing into other orbits (not taken into account in the chosen model space) or the need for other or better parameterized residual interactions [1].

II. Nuclear Quadrupole Moments

Some nuclei have permanent quadrupole moments that can be measured experimentally. It is expected that these nuclei have elliptical shape with a symmetrical axis. With this assumption, we define the intrinsic quadrupole moment Q_0 classically as [2]:

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$$Q_0 = \int (3z^2 - r^2)\rho dz \dots\dots (1)$$

The spectroscopic quadrupole moment Q_s of a nuclear state with spin I is a measure of the deviation of the nuclear charge distribution from sphericity for K=0 bands, gives [3].

$$Q_s = \frac{3K^2 - I(I+1)}{(2I+3)(I+1)} Q_0 \dots\dots (2)$$

The intrinsic quadrupole moment Q_0 and the deformation parameter β have been obtained using the following relations [3]:

$$B(E2; I \to I-2) = \frac{15}{32\pi} \frac{I \;\; I-1}{(2I-1)(2I+1)} {Q_0}^2 (\to I-2) \dots (3)$$

Where B(E2) are the transition probability, and the intrinsic quadrupole moment Q_0.

$$Q_0 = \frac{3}{\sqrt{5\pi}} Z {R_0}^2 \beta \dots\dots (4)$$

Where Z is the atomic number and $R_0 = 1.2\, A^{\frac{1}{3}}$. cm, and A is the mass number.

III. Discussion

The quadrupole moment is an excellent tool to study the deformation of nuclei. For well deformed axially symmetric nuclei, the measured (=spectroscopic) quadrupole moment Q_s can be related to the intrinsic quadrupole moment Q_0 through the relation (2). This is valid in the strong coupling limit, with K the projection of the total spin I onto the symmetry-axis of the deformed nucleus. In the hydrodynamical model of the nucleus (where the nucleus is considered to be a liquid drop), the intrinsic quadruple moment is related to the nuclear deformation parameter β as follows the relation (3). This expression $R_0 = 1.2\, A^{\frac{1}{3}}$ cm. A review of the different definitions of deformation parameters can be found in the relation (4).

In this paper, we will therefore evaluated the intrinsic quadrupole moment Q_0 using equation (3) for the same 7 nuclei, covering the rotation region, as considered in reference [4]. The parameter Q_0 for each nucleus considered, were determined by a least-squares fitting procedure involving the transition probability of three the known spin states.

Table 1 : Calculation of the intrinsic quadrupole moment Q_0 of Er isotopes

Nucleus	Old Quadrupole	New Quadrupole	$R_4 = \frac{E_4}{E_2}$
^{156}Er	4.100	4.924	3.317
^{158}Er	5.920	5.717	2.745
^{160}Er	6.550	6.471	3.095
^{162}Er	7.580	6.114	3.235
^{164}Er	7.500	6.459	3.286
^{166}Er	7.600	6.683	3.272
^{168}Er	7.630	5.746	3.300
^{170}Er	----	5.770	3.304

In table 1, the first column gives our chosen nuclei. The second column gives the old intrinsic quadrupole moment Q_0 which were taken from reference [5], and the third column gives the intrinsic quadrupole moment Q_0 as calculated using the equation (3). The R_4 value $R_4 = \frac{E_4}{E_2}$ for each nucleus is also included. As can be seen, the results are excellent for all nuclei, being, in the vast majority of cases, no better than those predicted by the reference [5]. This is due primarily to the improved fitting of the high spin states.

Table 2 : Calculation of the spectroscopic quadrupole moment Q_s of Er isotopes.

Nucleus	Experimental Quadrupole	Theoretical Quadrupole
^{156}Er		-1.407
^{158}Er		-1.633
^{160}Er		-1.849
^{162}Er	< 0	-1.747
^{164}Er	< 0	-1.846
^{166}Er	-1.9	-1.910
^{168}Er	-2.2	-1.642
^{170}Er	-1.9	-1.649

Table 2 where the second column gives our spectroscopic quadrupole moment Q_s value for each nucleus and the third column gives the experimental spectroscopic quadrupole moment Q_s values for from reference [6, 7]. For almost all cases our Q_s values are at least an order of magnitude smaller than those obtained on the basis of the reference [6, 7].

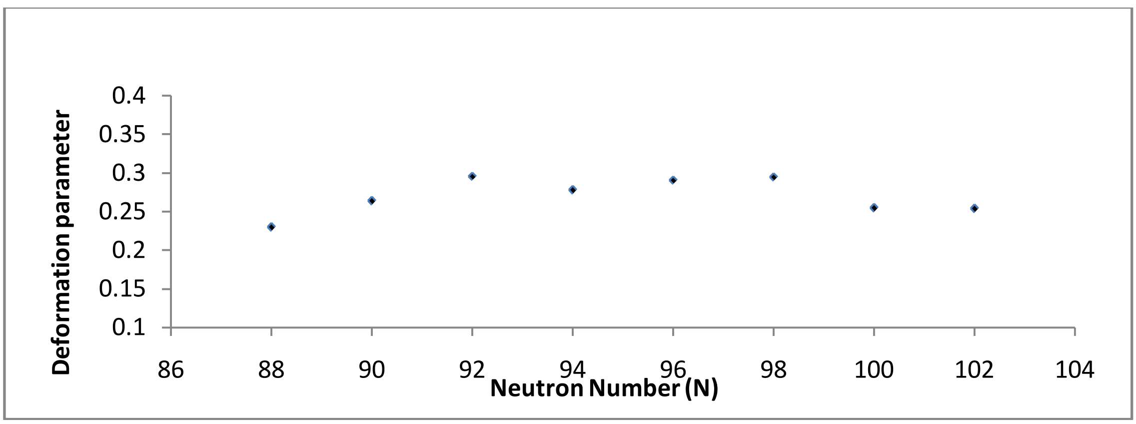

Figure 1 : Deformation parameter changes in terms of Neutron number.

In figure 1, we plot nuclear deformation parameter β as function of the neutron number. As it can be seen from this figure, by increasing neutron numbers, the deformation parameter also increase for some heavier nuclei which means deformation from spherical shape.

IV. Conclusions

In this paper, we have given an overview on a specific topic which attracts much attention in contemporary nuclear structure research, namely the study of the deformation parameter. In particular the paper deals with how one can investigate this property by measuring the electric quadrupole moments of their ground states. The report aims at giving some insight into the nuclear structure properties to which nuclear moments can be sensitive (or not) and to give an overview of the wide variety of nuclear structure properties of Er radioactive nuclei.

References Références Referencias

1. G. Neyens, Rep. Prog. Phys. 66, 633, 2003.
2. S. Mohammadi, Journal of Phys. Conference Series 381, 012129, 2012.
3. P. Ring and P. Schuck, the Nuclear Many- Body Problem, Springer, 2005.
4. D. Bonatsos, Phys. Rev. C 31, No. 5, 1985.
5. M. H. Al-Mallki, Nuclear structure properties of some deformed Nuclei in the Region of Mass Number A≈150, M. Sc. thesis, K. Saud University, 2005.
6. S. Raman, C. W. Nestor, and P. Tikkanen, Atomic Data and Nuclear Data Tables 78, 1, 2001.
7. N. J. Stone, Atomic Data and Nuclear Data Tables 90, 75, 2005.