Quadupole Moments Calculation of Deformed Even-Even 156-170 Er Isotopes

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Abstract

We have developed a special computing code for calculation of nuclear quadrupole moments versus deformation parameter ?. For some even-even isotopes, it has been seen that by increasing neutron number, deformation parameter also increase, which means more deformation from spherical shape.

Index terms— even-even nuclei, quadrupole moment and deformation parameter

1 Introduction

uclear 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].

2 II.

3 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 classically as [2]:

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The spectroscopic quadrupole moment 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].

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

Where B(E2) are the transition probability, and the intrinsic quadrupole moment Where Z is the atomic number and cm, and A is the mass number.

4 III.

5 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 can be related to the intrinsic quadrupole moment 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 ? as follows the relation (3). This expression In this paper, we will therefore evaluated the intrinsic quadrupole moment using equation (3) for the same 7 nuclei, covering the rotation region, as considered in reference [4]. The parameter for each nucleus considered, were determined by a leastsquares fitting procedure involving the transition probability of three the known spin states. ?? 0 ?? 0 = ?(3?? 2 ? ?? 2)?????? ? ? (1) ?? ?? = 3?? 2 ? ??(?? + 1) (2?? + 3)(?? + 1) ?? 0 ? ? (2) ??(??2; ?? ? ?? ? 2)= 15 32?? ?? ?? ? 1 (2?? ? 1)(2?? + 1) ?? 0 2 (? ??? 2)? (3) ?? 0 = 3 ?5?? ???? 0 2 ?? ? ? (4) ?? ?? ?? 0 ?? 0 . ?? 0 = 1.2 ?? 1 3 c m .

?? 0 ?? 0 = 1.2 ?? 1 3 cm. A review of the different definitions of deformation parameters can be found in the relation (4). In table 1, the first column gives our chosen nuclei. The second column gives the old intrinsic quadrupole moment which were taken from reference [5], and the third column gives the intrinsic quadrupole moment as calculated using the equation (**??**). The value 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 where the second column gives our spectroscopic quadrupole moment value for each nucleus and the third column gives the experimental spectroscopic quadrupole moment values for from reference [6,7]. For almost all cases our values are at least an order of magnitude smaller than those obtained on the basis of the reference [6,7]. In figure 1, we plot nuclear deformation parameter ? 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.?? 0 ?? 0 ?? ??

IV.

6 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. [1]

Figure 1:

1

Nucleus 156 Er	Old Quadrupole	New Quadrupole	?? ?? ?? ?? = ?? ??
	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

Figure 2: Table 1 :

2

??	??
??	??
??	??

Figure 3: Table 2 :

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