Study of the ^{130}Ba Nucleus with the (p,t) Reaction

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1. Introduction

The nucleus ^{130}Ba belongs to a transitional region which has been discussed within many different structure models. Among these, very interesting are the interpretations with the interaction boson model (IBM). Thus, Ba isotopes around mass 130 were proposed as either close to the dynamical limit O(6) [1], or as nuclei that pass through an intermediate structure situated on a transition from vibrational (U(5)) nuclei towards deformed (SU(3)) nuclei, which resembles indeed the O(6) symmetry, but differs from it in a subtle way [2]. In the same region, ^{134}Ba is a candidate for the critical point symmetry E(5) (transition between vibrational, U(5) and γ-unstable, O(6) nuclei) [3].

To be able to discern between different interpretations, such as O(6) or U(5)-SU(3) transition, good experimental data are needed. In particular, extremely relevant are the properties of the excited 0^+ states in these nuclei, which are notoriously difficult to be reproduced by the nuclear structure models.

The direct (p,t) reaction is known as a tool especially suited to reveal 0^+ states in the even-even nuclei. Such a study was previously made for ^{132}Ba and ^{134}Ba, in which a large number of 0^+ states was observed [4]. The present study of the ^{132}Ba(p,t) reaction extends the systematics of the monopole excitations to the lighter isotope ^{130}Ba, and provides new information on low-spin, low-energy states in this nucleus.

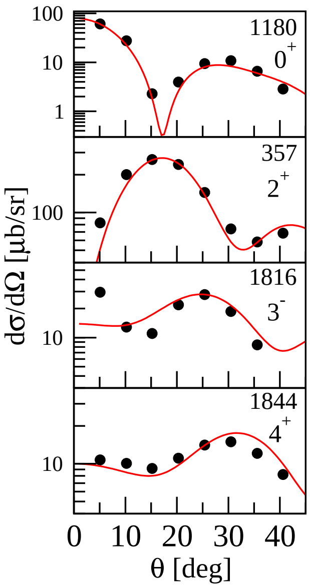

Fig. 1: Angular distributions representative for different transfers in the ^{132}Ba(p,t)^{130}Ba reaction at 25 MeV. The curves are DWBA calculations. Numbers are energy in keV and assigned spin, parity.

2. Experiment

The experiment was performed with a 25 MeV proton beam delivered by the Munich MP Tandem accelerator. The ^{132}Ba(p,t)^{130}Ba reaction was measured with the Q3D spectrograph and the focal plane detector with cathode strip readout. The target was 60 μg/cm^2 ^{134}Ba deposited on a 40 μg/cm^2 carbon backing, and was produced at the SIDONIE Orsay isotope separator starting from $BaCO_3$ material with 11.9 % enrichment in ^{132}Ba. Angular distributions were measured at 8 angles between 5° and 40°, with two magnetic settings of the spectrograph to cover excitation energies up to 2.6 MeV. Examples of different measured angular distributions are shown in Fig. 1, where the continuous curves represent DWBA calculations performed with the code CHUCK3 and a two-nucleon cluster formfactor which assumes a simple configuration. Thus for the positive parity states the assumed configuration was of the type $(nlj)^2$, with n, l, j denoting the shell model orbital from where the two neutrons are extracted. Up to 2.6 MeV excitation we have identified 29 excited states, among which five 0^+, nine 2^+, and three 3^- states (one tentative).

3. Discussion

The number, distribution in energy, as well as the 2n-transfer intensity for the 0^+ states up to the pairing gap is similar to that observed for the ^{132}Ba and ^{134}Ba isotopes [4]. We note the following features: (i) the 0_2^+ state (in ^{130}Ba at 1180 keV) is weakly excited in all these isotopes (1 - 2 % of the g.s.), then a group of states is observed close to the pairing gap, among them stronger excited states ($\sim$ 3% to 10% of the g.s.), one of them very likely corresponding to the collective (0_3^+) state; (2) the 2_3^+ state in ^{130}Ba (1558 keV) is very weakly excited; (iii) more than one 3^- state was observed, indicating a certain fragmentation of the low-lying octupole mode. These features correspond, qualitatively, to the O(6) dynamical symmetry. A good description of ^{130}Ba, including the known electromagnetic decay scheme of the low-lying states, is given by IBM parameters close to the O(6) limit, such as that given in Ref. [5].

References

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