Eur. Phys. J. A **12**, 135–137 (2001)

THE EUROPEAN PHYSICAL JOURNAL A

Short Note

High-spin states in the deformed ^{122}Ba nucleus

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Received: 10 July 2001/ Revised version: 13 September 2001
Communicated by C. Signorini

Abstract. The even-even nucleus ^{122}Ba was studied via in-beam γ-ray spectroscopy using the ^{40}Ca + ^{92}Mo reaction at 190 MeV. Five bands were observed, four more that can be found in the literature. Configurations were assigned to the various bands from the comparison with the neighboring even-even nuclei.

PACS. 23.20.Lv Gamma transitions and level energies – 21.10.Re Collective levels – 21.60.Ev Collective models – 27.60.+j $90 \leq A \leq 149$

Much progress was recently done in the study of neutron-deficient nuclei in the $A \sim 130$ mass region, thanks mainly to the use of very large γ-ray detector arrays, like EUROBALL, GAMMASPHERE and GASP, in conjunction with charged particle and/or neutron detectors.

In that context particular attention was paid to the Ba isotopes, because of their softness with respect to γ deformation and of the possible presence of octupole correlations [1,2]. Multiple bands were observed in the ^{124}Ba nucleus [3] and very recently the level scheme of ^{120}Ba was established up to very high spin [4]. However, the spectroscopic information on ^{122}Ba, that is available in the literature, dates back to 1974 and only consists of a study by Conrad *et al.* [5], in which the ground-state band was observed up to spin 12^+ following the ^{16}O + ^{108}Cd reaction.

In the present work, high-spin states in ^{122}Ba were populated by bombarding a self-supporting 0.5 mg/cm^2 thick ^{92}Mo target with a 190 MeV ^{40}Ca beam of 5 pnA intensity. The beam was provided by the XTU Tandem accelerator of the Laboratori Nazionali di Legnaro. The experimental setup consisted of the GASP array for γ-ray detection and the ISIS ball for charged-particle detection [6].

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The GASP array with 40 Compton-suppressed Ge detectors and the 80 element BGO ball was used for a γ^n coincidence measurement. The experimental arrangement in GASP has been carefully prepared in order to minimize the absorbtion of the low-energy X-rays. Light charged particles (p, d, t and α-particles) were detected with the ISIS ball, which is composed of 40 $\Delta E - E$ Si telescopes. Events were written on tape when two or more Ge detectors fired in coincidence with at least two BGO detectors. A total of 3.5×10^9 Compton-suppressed events have been collected.

The ^{122}Ba nucleus was populated via the 2α2p channel. The charged particles from each event were identified mainly as protons and α-particles. The events were then sorted according to the number of charged-particle detectors that fired in coincidence. For each charged-particle combination, *e.g.*, 1p, 2p, 3p, 4p, αp, α2p, 2α, 2αp, E_γ-E_γ and E_γ-E_γ-E_γ matrices were produced off-line for further analysis. The level structure of ^{122}Ba has been derived mainly from the analysis of the 2α2p-gated data, in which ^{122}Ba is the dominant channel.

The decay scheme of ^{122}Ba resulting from the present analysis is shown in fig. 1. The spins of the new levels have been inferred (when possible) from a directional correlation orientation (DCO) analysis as described, *e.g.*, in [7].

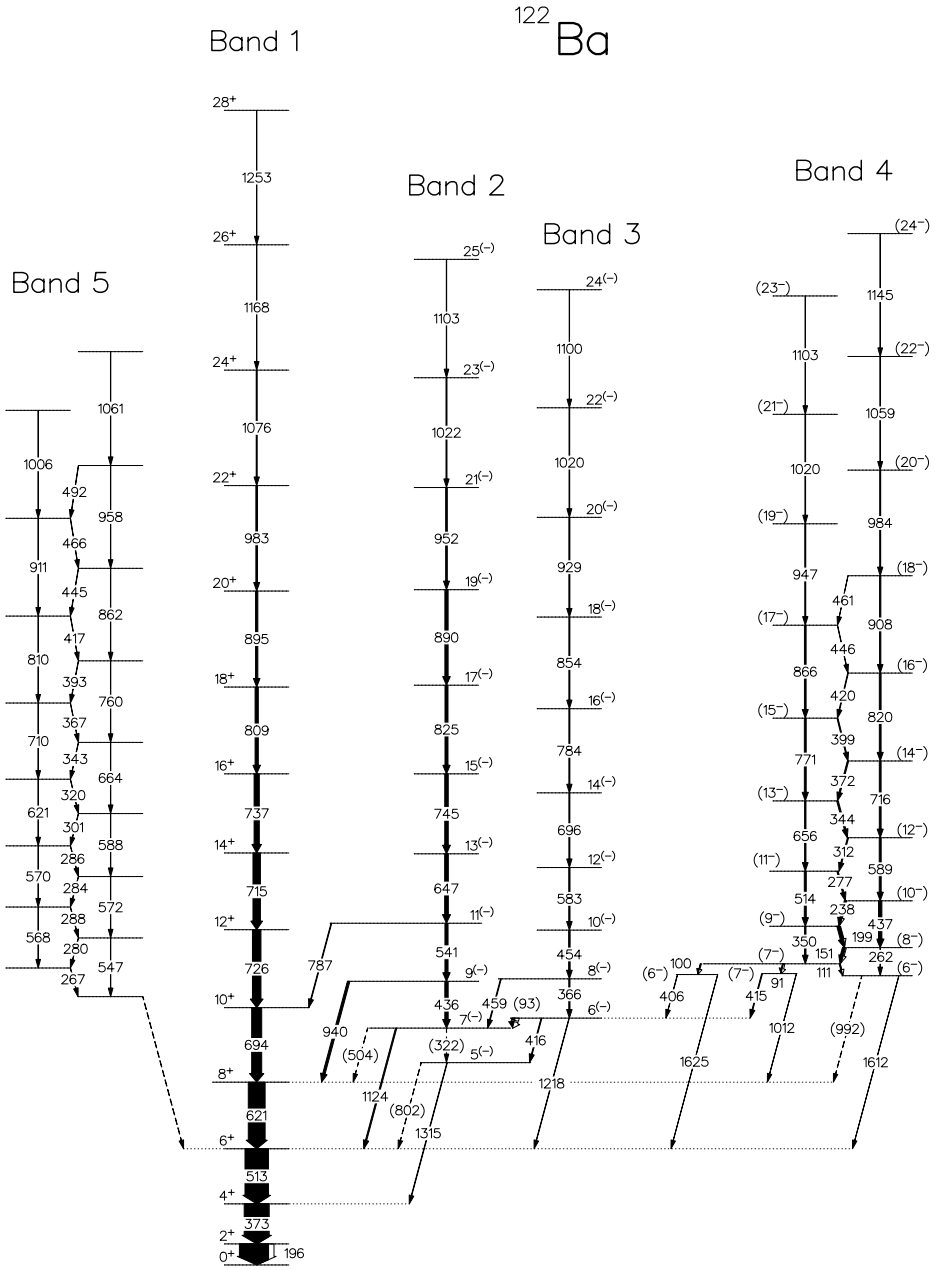

Fig. 1. Level scheme of ^{122}Ba deduced from the present work. The transition intensities are proportional to the width of the arrows. Transitions indicated by dashed lines are tentative. The connection of band 5 to band 1 was not established; the dashed arrow indicates the main decay-out flux.

Coincidence spectra for each of the new identified bands 2, 3, 4 and 5 of ^{122}Ba are given in fig. 2. They show the in-band transitions as well as the connecting transitions to the ground-state band, and are obtained from the 2αp-matrix by gating on selected clean γ-rays. Band 5 was weakly populated and its connecting transitions to low-lying levels could not be established.

The ground-state band is observed up to spin $I = 28^+$ and shows a single crossing at $\hbar\omega \sim 0.36$ MeV. That crossing is very probably due to $h_{11/2}$ quasiprotons, as in the case of ^{124}Ba, where the crossing frequency is almost the same [3].

Bands 2 and 3 are very similar to two bands in ^{124}Ba that were assigned negative parity on the basis of polarization measurements [8]. In ref. [3], on the basis of signature splitting and crossing frequences, the band corresponding to our band 2 is interpreted as the favoured signature of the proton configuration $h_{11/2}[550]1/2^- \otimes g_{7/2}[422]3/2^+$, while the one corresponding to our band 3 is assigned as the unfavoured signature of the same configuration, with a possible mixing of the $d_{5/2}[420]1/2^+$ state. In view of the similar transition energies and of the similar decay pattern to the ground-state band, we assign to bands 2 and 3 the same configurations.

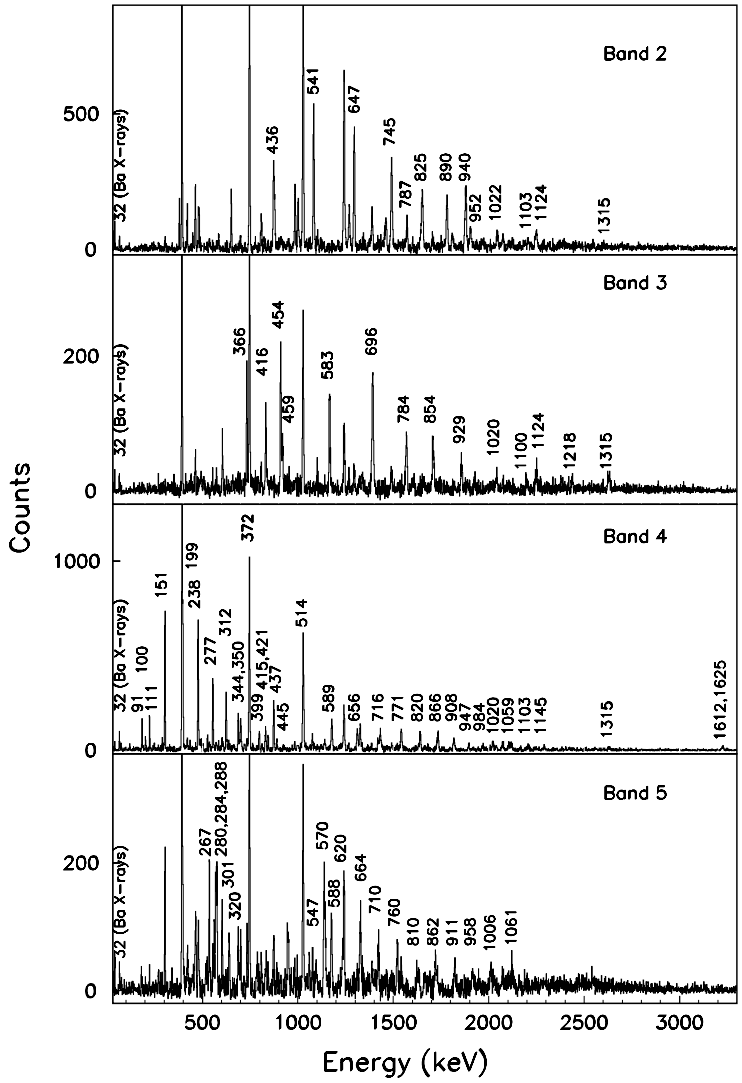

Fig. 2. Coincidence $\gamma\gamma$ spectra obtained from the 2αp-matrix by gating on clean in-band transitions: gates on the 436–1022 keV transitions of band 2, on the 454–929 keV transitions of band 3, on the dipole 111–344 keV transitions of band 4 and on the dipole 280–320 keV transitions of band 5.

The strongly coupled band 4 shows almost no signature splitting. It strongly resembles the $\pi g_{9/2}[404]9/2^+ \otimes h_{11/2}[550]1/2^-$ band that was observed in ^{124}Ba [3], so we assign to it the same configuration.

The remaining strongly coupled band (band 5) has no counterpart in the published level scheme of ^{124}Ba. Since most low-lying proton configurations have already been assigned, band 5 probably is a two-quasineutron band involving the orbitals $h_{11/2}[523]7/2^-$, $d_{5/2}[402]5/2^+$ and/or $g_{7/2}[413]5/2^+$, which have been identified as low-lying configurations in the neighboring odd-A nuclei ^{121,123}Ba [9, 10].

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