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Short note

Five-quasiparticle bands in ^{127}Ba

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Abstract. High spin states in ^{127}Ba have been investigated with the fusion–evaporation reaction ^{96}Zr (^{36}S, 5n) ^{127}Ba at a beam energy of 150 MeV with the GASP-spectrometer at INFN in Legnaro, Italy. The level scheme could be extended to high spins resulting in the observation of five-quasiparticle states. Altogether 15 band structures were placed in the level scheme.

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High spin states in ^{127}Ba were populated using the fusion–evaporation reaction ^{96}Zr (^{36}S, 5n) ^{127}Ba at a beam energy of 150 MeV. The experiment was performed at the XTU Tandem accelerator of the INFN in Legnaro, Italy. The target consisted of two parallel foils of Zirconium enriched to 85.25% in ^{96}Zr (0.5 mg/cm^2). Gamma-ray spectroscopy was performed with the GASP-spectrometer. In the present experiment this array was equipped with 40 compton-suppressed HPGe-detectors and an 80-segment bismuth-germanate-ball (BGO). In four days of beam time, over 10^9 three fold gamma coincidence events were accumulated. The data were sorted into matrices employing the sum-energy and multiplicity information of the BGO-ball in order to separate the reaction channels. The two main reaction products in the present reaction were ^{127}Ba and ^{128}Ba.

The Radware software package [1] was used to construct the level scheme shown in Fig. 1. From the analysis of the coincidence spectra, 54 new γ-transitions were placed in the level scheme, establishing 44 new levels. Thus the known level scheme from the work of Seiffert *et al.* [2] and Ward *et al.* [3] has been extended to higher spins. In addition, one new high spin band, labeled as band (1), could be observed. This band depopulates into band (2) via the 1039 keV γ-transition at the $31/2^-\hbar$ level. All the other known band structures could be extended to higher spins.

The spin and parity assignments of the newly found states could be established from the analysis of the angular-distribution and the ratio of directional correlation of oriented states (R_{DCO}).

$$R_{DCO} = \frac{(I_{\gamma_1}@36^\circ \quad \text{gated by} \quad \gamma_2@60^\circ)}{(I_{\gamma_1}@60^\circ \quad \text{gated by} \quad \gamma_2@36^\circ)} \qquad (1)$$

Details of the method can be found in [4]. Stretched quadrupole γ-transitions were used for gating. Altogether we could assign spin values to 48 new energy levels.

The alignment plots of the observed bands are depicted in Fig. 2. The configuration assignments in the following section are based on the cranked shell model calculations described in [3,5]. The deformation parameters were $\beta_2 = 0.25$, $\beta_4 = -0.015$, $\gamma = 0$ and -20 degrees [3]. Ward *et al.* [3] suggest band (2) as the favored signature partner based on the $\Omega = 5/2$ state of the $\nu h_{11/2}$ orbital. Due to the expected larger signature splitting only the favored signature partner is populated in the reaction. Bands (3) and (4) are signature partners based on the $\Omega = 7/2$ state of the $\nu h_{11/2}$ orbital. The signature partners labeled as band (5), (6) are based on aligned quasiparticles. The decrease in signature splitting in bands (5), (6) in comparison to bands (3), (4) suggests a proton $h_{11/2}$ alignment. Such an effect has been predicted by the cranked shell model calculations for bands based on the $\nu h_{11/2}$ orbital in the γ-soft Xe–Ba–Ce-mass region [5]. The proposed $(\nu h_{11/2})(\pi h_{11/2})^2$ configuration is similar to the one suggested by Ward *et al.* Both signatures of this configuration undergo an upbend close to spin $55/2^-\hbar$. The observed gain in alignment points toward a $\nu h_{11/2}$ alignment.

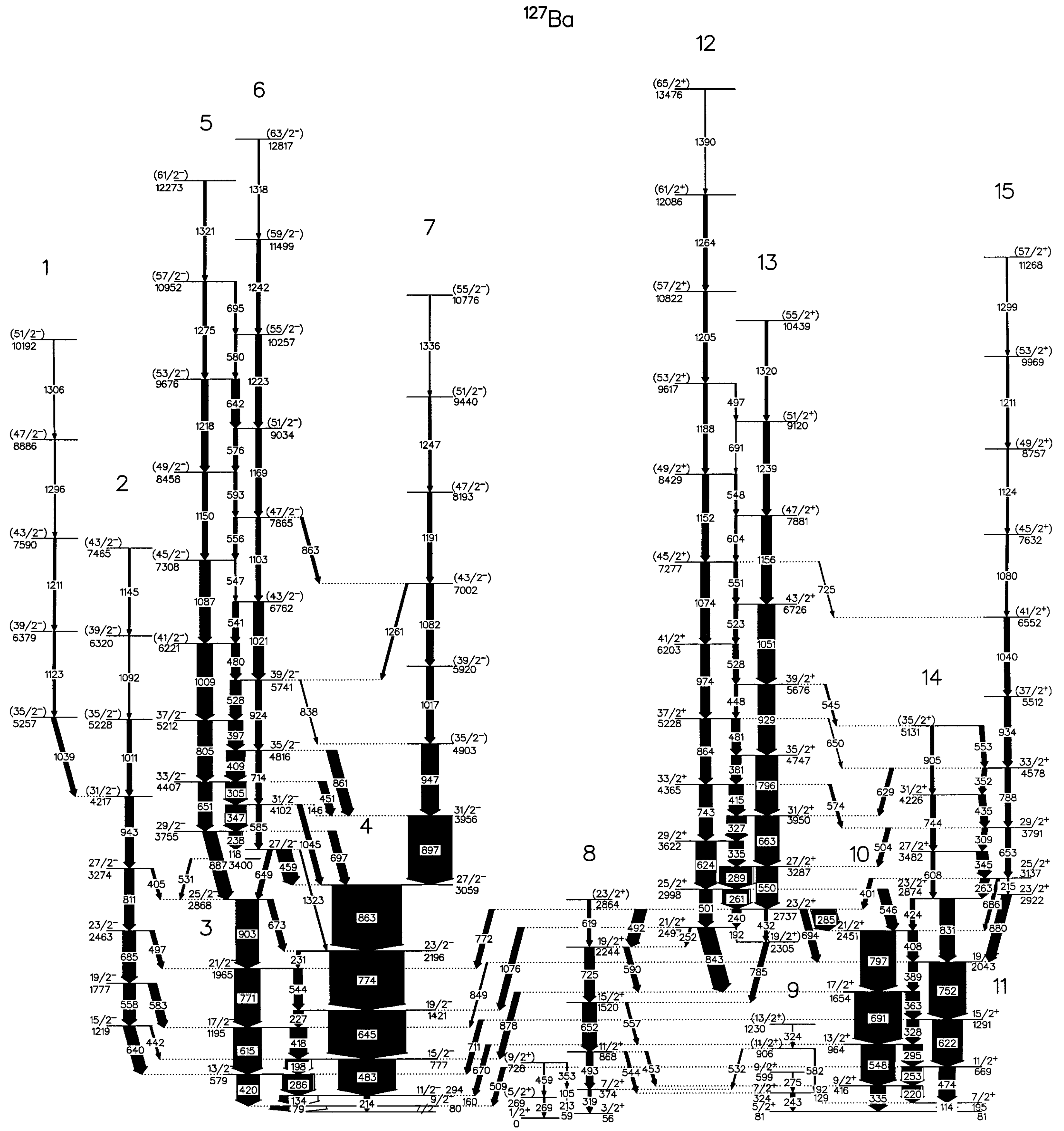

Fig. 1. High Spin level scheme of ^{127}Ba as populated in the ^{96}Zr (^{36}S, 5n) ^{127}Ba reaction

Thus bands (5) and (6) evolve onto five-quasiparticle configurations. The crossing frequency and the observed gain in alignment are consistent with the calculated ones. Band (7) could be extended up to a tentative spin of $55/2^-\hbar$. The spin assignments are unambiguous up to the $31/2^-\hbar$ level. The observed upbend at spin $27/2^-\hbar$ is attributed to the alignment of a $\nu h_{11/2}$ pair. The crossing frequency is consistent with the model prediction ($\sim$ 0.4 MeV/$\hbar$). The non-observation of the signature partner of this band is presumably due to the predicted increase in signature splitting for an aligned oblate $\nu h_{11/2}$ configuration.

The previously known positive parity one-quasiparticle bands are labeled as (8), (9), (10) and (11). Band (8) is based on the $\nu d_{3/2}$ one-quasiparticle state. Band (9) was suggested to be based on the $\Omega = 7/2$ state of the $\nu g_{7/2}$ orbital [6]. Bands (10), (11) are signature partners based on

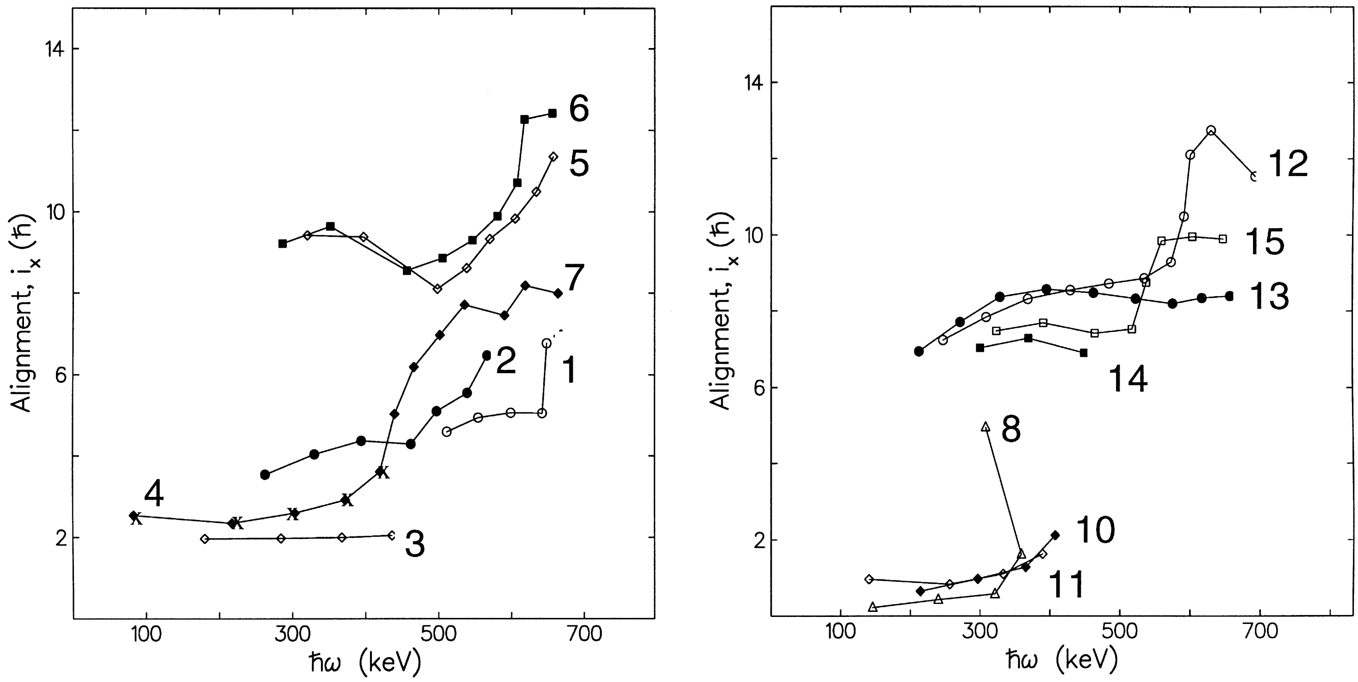

Fig. 2. Alignment plots of the bands in ^{127}Ba calculated with the Harris parameters $J_0 = 17.0\ \mathrm{MeV}^{-1}\hbar^2$ and $J_1 = 25.8\ \mathrm{MeV}^{-3}\hbar^4$

the $\Omega = 5/2$ state of the $d_{5/2}$ orbital. Bands (12), (13) and bands (14), (15) are signature partners based on aligned configurations. Bands (12), (13) consist of yrast states of positive parity; a $(\nu d_{5/2})(\pi h_{11/2})^2(\nu h_{11/2})^2$ configuration is proposed for these bands. Before the second backbend, in the previous study the three-quasiparticle configuration based on aligned protons was suggested for these bands [3]. A clear cut assignment could not be made for bands (14), (15) [3]. It is most likely that they are based on aligned $h_{11/2}$ protons and neutrons coupled to the $\nu g_{7/2}$ orbital.

The similarity of the γ-transition energies (after alignment) in band (1) and (15) suggests that band (1) is based on aligned quasiparticles. Interestingly band (1) is based on a three-quasiparticle configuration while band (15) evolves into a five-quasiparticle configuration at higher spins. The aligned quasiparticles influence the shape and the crossing frequencies in the observed bands [3,5]. Thus the alignment of proton and neutron quasiparticles in the $h_{11/2}$ orbitals for the positive and negative parity bands occurs at different frequencies.

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