BRIEF REPORTS

Brief Reports are short papers which report on completed research or are addenda to papers previously published in the **Physical Review**. *A Brief Report may be no longer than $3\frac{1}{2}$ printed pages and must be accompanied by an abstract.*

High-spin states in ^{76}Br

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High-spin states were excited in ^{76}Br via the reaction ^{63}Cu(^{16}O,$n2p$) at a beam energy of 69 MeV. Several new high-spin states were found, including four levels in a previously unreported rotational band. A previously predicted signature inversion is confirmed.

During the last decade, high-spin spectroscopy of nuclei in the mass range 70–80 has revealed a wealth of interesting phenomena. Many nuclear properties, including shape and pairing correlations, have been found to be strongly dependent on N, Z, and angular momentum. The isotopes ^{74,76}Kr are known[1] to have large quadrupole deformations in the ground state, whereas the light selenium isotopes ^{72,74}Se are near-spherical in the ground state but have low-lying, well-deformed excited states.[2,3] The study of neutron-poor bromine isotopes can increase our understanding of this mass region by providing information of the interplay of one- and two-particle states with collective excitations. Studies of the odd-odd nuclei ^{74,76,78}Br have found well-defined rotational bands built on a variety of configurations.[4–10] In all three cases, a positive-parity band based on an isomeric 4^+ state has been found. This band has been interpreted as being built on a $(\nu g_{9/2})\times(\pi g_{9/2})$ configuration. Studies of ^{72}Br have shown that similar collective features persist to lower neutron number.[11,12]

In ^{76}Br, the first high-spin states were reported by Behar *et al.*[6] and the 4^+ isomeric state was reported independently by Schmidt-Ott *et al.*[7] and Kreiner *et al.*[8] The positive-parity band was extended and the first

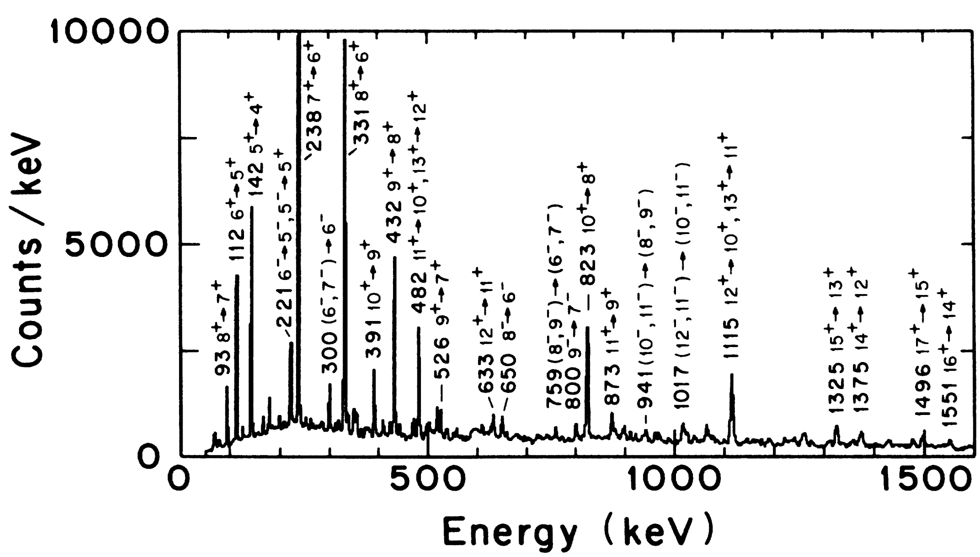

FIG. 1. Gamma-ray spectrum created by gating on positive-parity transitions. Gates were placed on the 112, 142, and 254 keV transitions.

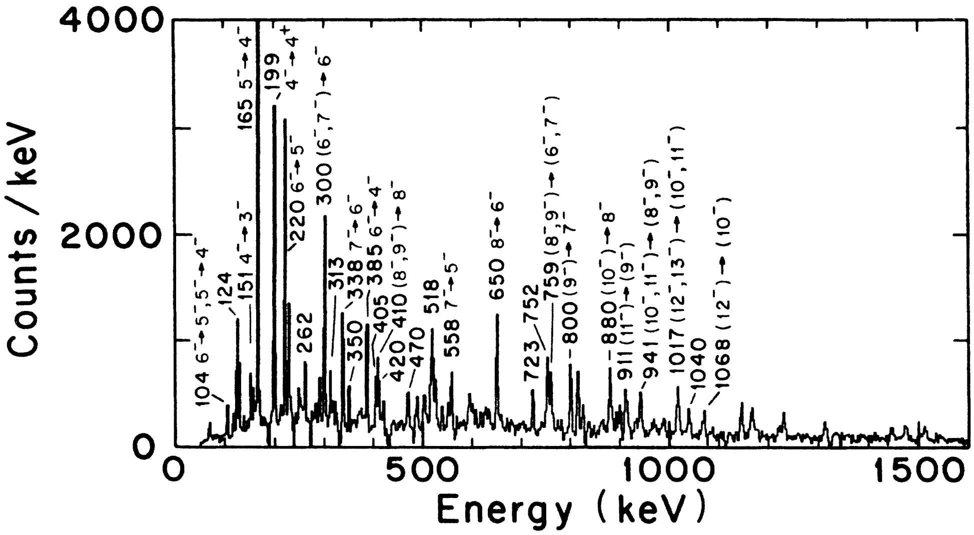

FIG. 2. Gamma-ray spectrum created by gating on negative-parity transitions. Gates were placed on the 150, 199, 386, and 558 keV transitions.

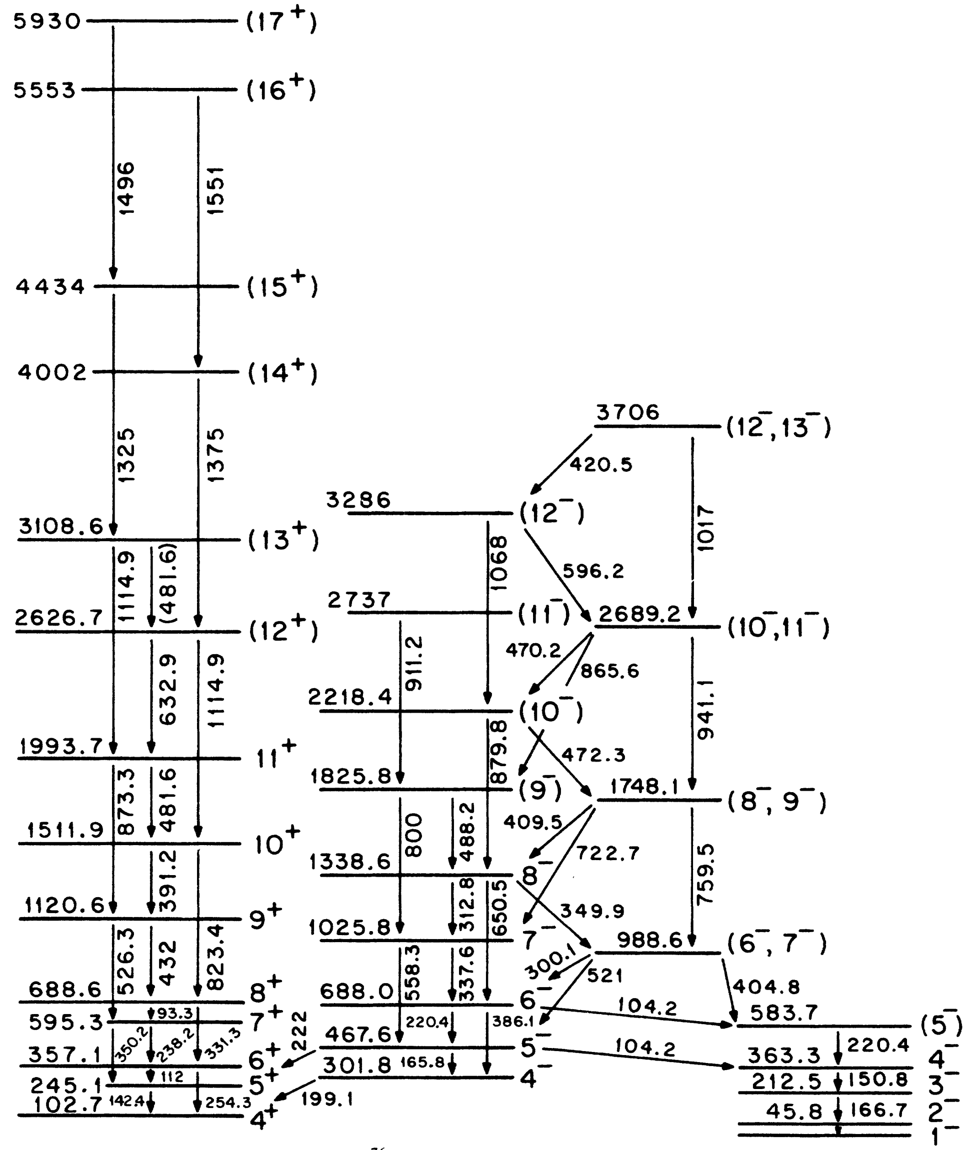

FIG. 3. Proposed level scheme for ^{76}Br showing the bands extended by this work.

negative-parity high-spin states reported by Doring *et al.*[9] Two-quasiparticle plus rotor calculations by Kreiner and Mariscotti[13] predict a signature inversion in the positive-parity band in ^{76}Br. The effect described in Ref. 13 was first observed in ^{108}In (Ref. 14) and was later found in ^{74}Br.[5] The signature inversion was seen in ^{76}Br by Doring *et al.*[9] and is confirmed in this work. Ekstrom and Robertsson[15] interpret the 1^- ground state in terms of a $(\nu g_{9/2})\times(\pi p_{3/2})$ configuration, and Doring *et al.*[9] argue for a $(\nu p_{3/2}$ or $f_{5/2})\times(\pi g_{9/2})$ configuration for the 4^- band. The calculations of Ref. 13 suggest a quadrupole deformation of $\beta_2=0.3$ for this nucleus.

In the present work, high-spin states in ^{76}Br were populated via the reaction ^{63}Cu(^{16}O,$n2p$) using a 69 MeV beam from the University of Pittsburgh three-stage tandem accelerator. γ-γ coincidence data were collected using the Pitt multidetector array,[16] which consists of six Compton-supressed high-purity germanium (HPGe) detectors and a 14 element bismuth germanate sum-energy and multiplicity spectrometer (SMS). Events were defined by the firing of at least two HPGe detectors and at least two SMS elements. Data was collected in event-by-event mode on tape. The HPGe energy data were gain-matched and corrected for Doppler shift. All coincidence pairs were used to construct a symmetric 2500 by 2500 channel γ-γ correlation matrix.

A γ spectrum gated on selected transitions between positive-parity states is shown in Fig. 1. Figure 2 shows a spectrum gated on selected transitions between negative-parity states. A level scheme showing the bands extended by this work is shown in Fig. 3. Included in this figure is a previously unknown band that exhibits strong interband transitions to and from the band built on the 4^- isomeric state at 302 keV. We did not have enough statistics in our angular distribution data to make definite spin-parity assignments for this band. Tentative assignments were made based on the pattern of interband transitions. The strength of the interband transitions leads us to believe that the parity of the new band is negative, and that the band is based on a configuration that is similar to that of the previously observed negative-parity $K^{\pi}=4^-$ band. Calculations of single-particle levels as a function of deformation (see, e.g., Nazarewicz *et al.*[17]) show the $[301]\frac{1}{2}$ and $[303]\frac{5}{2}$ Nilsson orbitals to be very close in energy and close to the Fermi level for $N=41$ at a deformation of $\beta_2=0.3$. This suggests that the two strongly interacting bands observed here might be based on similar configurations constructed from these orbitals.

The positive-parity yrast band in ^{76}Br was previously known to a spin of (13^+). Our work extends this band to (17^+). We do not see the previously reported[9] 1065 keV transition feeding the 10^+ state. Our data suggests that the 1115 keV line is a doublet and represents both the (13^+) to 11^+ and (12^+) to 10^+ transitions (see Fig. 3). The 1115 keV line is twice as strong as the 482 keV $(13^+$ to $12^+)$ line in a spectrum obtained by gating on the 823 keV 10^+ to 8^+ transition. In addition, the 873 keV $(11^+$ to $10^+)$ line is very weak in the spectrum gated on the 1375 keV line and is comparable in strength to the 823 keV line in the spectrum gated on the 1325 keV transition. This indicates that the 1325 keV and 1375 keV transitions do not both feed the (13^+) state at 3108 keV.

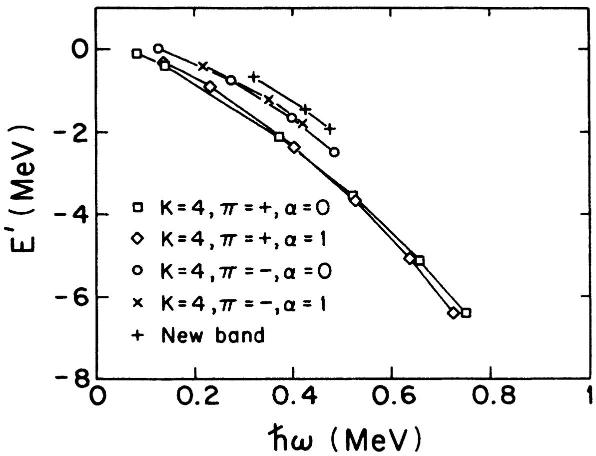

FIG. 4. Experimental Routhians as a function of angular frequency.

A cranked shell-model analysis[18,19] was applied to the data. For the purposes of this analysis, even spin and $K=4$ were assumed for the new band. Plots of experimental Routhians as a function of angular frequency are shown in Fig. 4. These plots represent total Routhians; no reference curve has been subtracted. The signature inversion in the positive-parity band is seen to occur at about 480 keV. Kreiner and Mariscotti[13] predicted this inversion on the basis of a two-quasiparticle plus rotor calculation. The inversion is seen in Ref. 9, but attributed to the γ degree of freedom in the nuclear shape. Calculations by Ikeda and Shimano[20] show that signature inversion in the rare-earth region can be explained in terms of particle-vibration and rotation-vibration couplings.

We are currently carrying out cranked shell-model calculations using a deformed Woods-Saxon potential, Strutinsky shell correction, and a self-consistent treatment of pairing correlations. It is hoped that these will help to determine the nature of the new negative-parity band.

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