Observation of Multiple Band Termination in ^{125}I

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Introduction

The termination of collective rotational band is a characteristic quantum property of a finite many-body system such as the nucleus. A rotational band may terminate when all the single-particle angular momenta that is contained in a few valence particles/holes is coupled to its maximum value. The terminating state is characterized by an oblate mass distribution that is symmetric around the rotation axis($\gamma = +\,60^\circ$ according to the Lund convention) [1]. Spectroscopy near band termination enables a study of the balance and interplay between two extreme aspects of nuclear dynamics, collective rotation and single particle alignment. In heavy, well deformed and superdeformed nuclei this terminating spin lies beyond the fission limit. However, this phenomenon can be well studied in the transitional region nuclei.

In transitional nuclei of mass-125 region evidence for band termination have been found in several Xe, Cs and I isotopes, see [2–5] and references therein. In case of iodine nuclei, the configuration is rather limited with only three protons outside the closed Z = 50 shell, and the band termination is observed to occur at relatively low excitation energy. In $\pi h_{11/2}$ based negative parity states of ^{125}I, for example [5], the prolate collective structure which is yrast at low spin is crossed at spin $39/2^-$ by a noncollective oblate state based on five quasiparticle, $\pi[h_{11/2}(g_{7/2})^2]_{23/2^-} \otimes \nu[h^2_{11/2}]_{8^+}$, configuration. The present article reports on the observation of further, negative parity as well as positive parity terminating states in ^{125}I.

Experimental Details

High spin states of ^{125}I were studied making use of heavy-ion fusion evaporation reaction ^{82}Se(^{48}Ca,p4n)^{125}I. The ^{48}Ca beam with an energy of 205 MeV and intensity 4 pnA was provided by the ATLAS accelerator at Argonne National Laboratory(ANL). The target consisted of a 0.5 mg/cm^2, 98.8% enriched ^{82}Se layer evaporated on a 0.5 mg/cm^2 Au backing. The γ-ray coincidence events were measured with the Gammasphere spectrometer. In a beam time of 7 days, a total of 2.8×10^9 events, with a Ge detector coincidence fold of ≥ 5 were collected and stored on magnetic tape.

Results and Discussion

The positive parity states were previously observed up to an excitation energy of 3868 keV and spin $25/2^+$ [6]. Several new transi-

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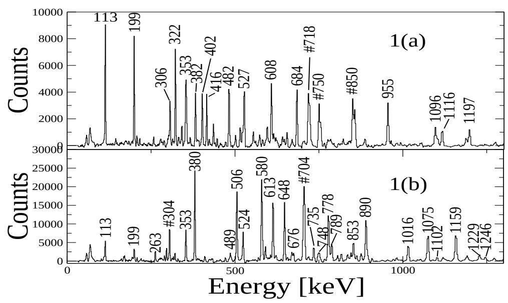

FIG. 1: Summed triple gated γ-ray coincidence spectra showing transitions of (a) positive parity states. (b) negative parity states. Hash marked transitions are unresolved doublet.

tions have been observed extending the previously known level scheme to a spin of $61/2^+$. The negative parity states were previously known upto a spin of $43/2^-$ [5]. The present experiment confirms the previous results and reveals high spin information upto $63/2^-$. Figure 1(a) and 1(b) shows triple gated coincidence spectra showing newly observed transitions of positive and negative parity states, respectively.

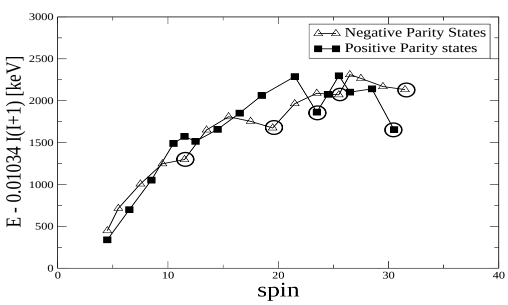

FIG. 2: Energy levels in ^{125}I relative to rigid-rotor reference. Encircled points correspond to favored terminating states.

The low-lying excited positive and negative parity states can be explained by coupling odd-proton in $g_{7/2}$, $d_{5/2}$ and $h_{11/2}$ orbitals, respectively to the vibrational states of even-even ^{124}Te core. At moderate- and high spin, states based on three- and five- quasiparticles excitation involving two and four neutrons from $h_{11/2}$ orbitals, respectively are expected to become yrast. Excitation energy for yrast sequence of positive and negative parity bands in ^{125}I with reference to rotating liquid drop energy have been plotted in Figure 2. Favored termination for these states are clearly visible. The favored low-lying $23/2^-$ and $39/2^-$ levels have been interpreted previously as fully aligned $\pi[h_{11/2}(g_{7/2})^2]^-_{23/2}$ and $\pi[h_{11/2}(g_{7/2})^2]_{23/2^-} \otimes \nu[h^2_{11/2}]_{8^+}$ configuration, respectively resulting in a yrast noncollective oblate state [5]. Further higher in spin, the energetically favored $55/2^-$ state is clearly visible in Figure 2. We suggest a fully aligned $\pi[h_{11/2}(g_{7/2})^2]_{23/2^-} \otimes \nu[h^4_{11/2}]_{16^+}$ configuration for this state. Similar interpretation has been suggested by Paul *et al*. [4] for the state at $55/2^-$ in ^{121}I. The $63/2^-$ state is the highest observed noncollective state which can be associated with $\pi[h_{11/2}(g_{7/2})^2]_{23/2^-} \otimes \nu[(h_{11/2})^6(s_{1/2}d_{3/2})^2]_{20^+}$ configuration representing an oblate shape in which all the particles above ^{114}Sn core are aligned. The favored positive parity $61/2^+$ state can be identified with the $\pi[h_{11/2}(g_{7/2})^2]_{23/2^-} \otimes \nu[(h_{11/2})^5(s_{1/2}d_{3/2})^3]_{19^-}$ configuration. Detailed theoretical calculations to support these configuration assignments is in progress.

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