Observation of maximally aligned states in $\pi h_{11/2}\nu h_{11/2}$ band of ^{122}I

Purnima Singh[1],* Somnath Nag[1], K. Selvakumar[1], A. K. Singh[1], Abhijit Bisoi[2], A. Goswami[2], S. Bhattacharya[3], Surender Kumar[4], Kuljeet Singh[4], Jasmine Sethi[5], Sudipta Saha[5], T. Trivedi[5], S. K. Jadav[5], R. Donthi[5], B. S. Naidu[5], and R. Palit[5]

[1]*Department of Physics & Meteorology, Indian Institute of Technology Kharagpur, IN-721302, India*
[2]*Nuclear Physics Division, S. I. N. P., Kolkata - 700064, India*
[3]*Applied Nuclear Physics Division, S. I. N. P., Kolkata - 700064, India*
[4]*Dept. of Physics, Punjab University, Chandigarh - 160014, India and*
[5]*Deptartment of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai - 400005, India*

Introduction

Microscopically, a maximally-aligned state represents a condition where all valence nucleons outside a spherical core are aligned along a common rotation axis, thereby exhausting all the angular momentum available within the valence space. The coupling scheme of these states is rather simple, and they provide valuable information on nuclear structure and excitation modes. In mass A$\sim$125 region maximally-aligned states have been observed in a number of odd-even and even-even isotopes (see [1] and references therein). However, till date there is no evidence of such kind of states in any odd-odd nuclei of this mass region. Therefore, an experiment was performed with the aim to search for maximally-aligned states in the doubly-odd Iodine nucleus ^{122}I. The present work has established both positive and negative parity states upto a spin of $\sim 30\hbar$. Several new γ-rays were identified. In the following, we report mainly on the $\pi h_{11/2}\nu h_{11/2}$ based yrast band of ^{122}I.

Experimental Details

High spin states of ^{122}I were studied making use of heavy-ion fusion evaporation reaction ^{116}Cd(^{11}B,5n)^{122}I. The ^{11}B beam with an energy of 65 MeV and intensity 1.5 nA was provided by the 14 UD pelletron accelerator at TIFR Mumbai. The target consisted of enriched ^{116}Cd of thickness 15 mg/cm^2. The γ-ray coincidence events were measured with the INGA spectrometer consisting of 15 clover detectors [5]. In a beam time of 3 days, a total of 3.12×10^9 two fold coincidence events were collected. For the offline analysis γ^2-matrix and γ^3-cube were constructed.

Results and Discussion

Prior to the present work this nucleus was studied by Kaur *et al.* [2] and Moon *et al.* [3], upto an excitation energy of $\sim$8 MeV and spin ($\sim 25\hbar$). However, there was a disagreement between the two groups regarding the parity and configuration of the yrast band. Kaur *et al.* [2] assigned negative parity to the band and suggested the $\pi g_{7/2}\nu h_{11/2}$ configuration. On the other hand, a positive parity with a band head spin of 10^+ was assigned to the same band by Moon *et al.* [3], and a configuration based on $\pi h_{11/2}\nu h_{11/2}$ was proposed. Their assignment was based on energy systematics for the yrast states in even-even Te and odd-A I nuclei. In our preliminary analysis we have found similar results. Therefore, we support the suggestions by Moon *et al.* [3].

With the results of present experiment we could extend the previously known level-scheme upto spin $30\hbar$ and excitation energy 10.6 MeV. Fig. 1 shows a summed double

*Electronic address: psingh@phy.iitkgp.ernet.in

gated γ-ray coincidence spectra showing transitions of positive parity states. Three new $\gamma-$rays of energy 1100-, 1160-, and 1169- keV have been identified in the present work. In addition, we have been able to determine the DCO ratio of several γ-rays which were although reported in previous work, however, their multipolarity information was missing.

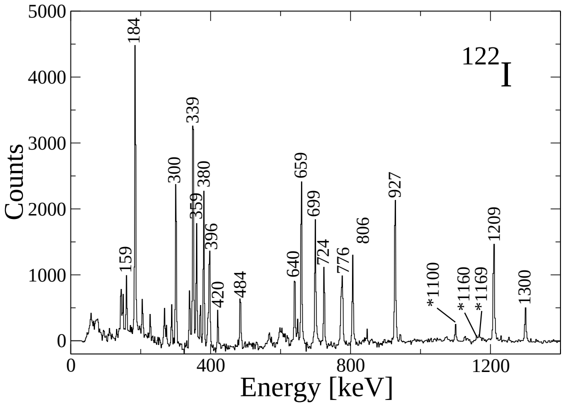

FIG. 1: Summed double gated γ-ray coincidence spectra showing transitions of positive parity states. Asterisk marked transitions are newly observed in the present work.

Fig. 2 (upper panel) shows the excitation energy of the observed states relative to a rotating liquid drop reference [4]. Favored minima is clearly evident at $I^\pi = 22^+$, 25^+, and 29^+. In order to understand the configuration of these states, calculations have been performed using CNS formalism with the $A = 110$ parameters. The results of the calculations are shown in lower panel of Fig. 2. For positive parity, the highest spin state can be formed from the five neutrons and three protons outside the ^{114}Sn core as

$\nu(h_{11/2})^5_{17.5}(s_{1/2}d_{3/2})^0_0$ $\qquad$ $I_{max} = 17.5^-$

and

$\pi(d_{5/2}g_{7/2})^2_6(h_{11/2})^1_{5.5}$ $\qquad$ $I_{max} = 11.5^-$

These two favored neutron and proton configurations combine to give low-lying maximally aligned state at $I^\pi = 29^+$. Another low energy state is calculated at $I^\pi = 22^+$ for the $\nu(h_{11/2})^5$ configuration with one neutron anti-aligned. Thus, the observed favored state at 22$\hbar$ could be associated with this configuration. The favored state at 25$\hbar$ is most probably associated with the $\nu(h_{11/2})^3(s_{1/2}d_{3/2})^2$ configuration as the $\nu(h_{11/2})^5$ configuration is not predicting a low-lying 25$\hbar$ state.

Detailed analysis is in progress.

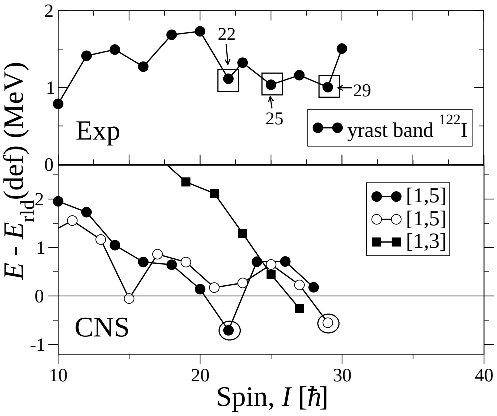

FIG. 2: Low-lying observed (upper panel) and calculated (lower panel) valence-space states for ^{122}I shown relative to the rotating liquid drop energy [4]. The calculated configurations are labeled by the number of $h_{11/2}$ protons and neutrons, respectively. An open square is used to indicate the observed states which are especially low in energy and the calculated states assigned to them are encircled.

Acknowledgments

The authors are thankful to the pelletron operations staff of TIFR. Financial assistance from CSIR is acknowledged.

References

[1] P. Singh *et al.*, Phys. Rev. C **82**, 034301 (2010).

[2] H. Kaur *et al.*, Phys. Rev. C **55**, 2234 (1997).

[3] C. B. Moon *et al.*, J. Korean Phys. Soc. **43**, S100 (2003).

[4] K. Pomorski and J. Dudek, Phys. Rev. C **67**, 044316 (2003).

[5] R. Palit, Proceedings of DAE Symposium on Nuclear Physics, Vol. **55**, I11 (2010).