Non-collective aligned and anti-aligned states in ^{123}I

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Introduction

The nuclei near N = 70 in the A = 120-125 mass region show a rich variety of excited states with significant variations of shape and deformation. The maximum angular momentum available within the valence space of these nuclei is limited and lies within reach of presently available γ-ray spectrometers. Therefore, these nuclei are ideally suited to study the transition from collective to non-collective excitations and the properties of configurations of small or no collectivity. In a recent spectroscopic study of the nucleus ^{125}I, maximally aligned states involving eleven particles outside the ^{114}Sn core were observed [1]. In addition to three non-collective fully aligned states, non-collective states with one and two particles anti-aligned were also observed in this nuclei. The coupling schemes of anti-aligned states are easy to understand from the sloping Fermi-surfaces diagrams. However, the number of such states which have been observed till date is still very limited. In the present work, we report on results of an in-beam study of high-spin states in ^{123}I with the aim to search for maximally aligned and anti-aligned states in this nucleus.

Experimental Details

High spin states of ^{123}I were studied making use of heavy-ion fusion evaporation reaction ^{80}Se(^{48}Ca,p4n)^{123}I. The ^{48}Ca beam with an energy of 207 MeV and intensity 4 pnA was provided by the ATLAS accelerator at Argonne National Laboratory(ANL). The target consisted of a 0.6 mg/cm^2, 98.8% enriched ^{82}Se layer evaporated on a 0.3 mg/cm^2 Au backing. The γ-ray coincidence events were measured with the Gammasphere spectrometer. In a beam time of 10 days, a total of 2.7 $\times$ 10^9 events, with a Ge detector coincidence fold of $\geq$ 5 were collected and stored on magnetic tape.

Results and Discussion

The positive parity states were previously observed up to an excitation energy of 6863 keV and spin (41/2$^+$) [2]. Several new transitions have been observed extending the previously known level scheme to a spin of 57/2$^+$. The negative parity states were previously known upto a spin of 45/2$^-$ [2]. The present experiment confirms the previous results and reveals high spin information upto 59/2$^-$.

Calculations for the nucleus ^{123}I have been carried out using Cranked Nilsson Strutinsky

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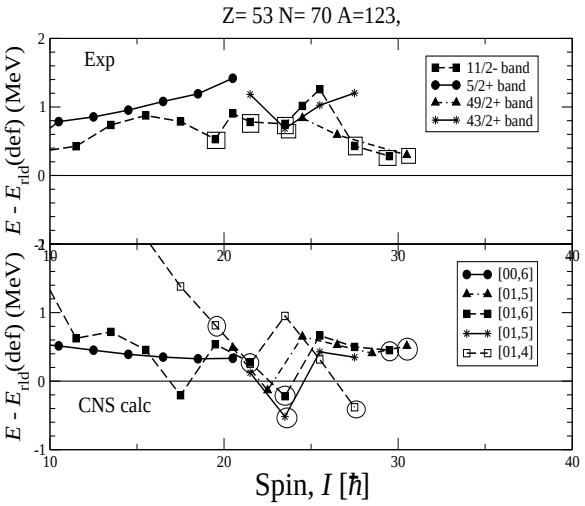

FIG. 1: Low-lying observed (upper panel) and calculated (lower panel) valence-space states for ^{123}I shown relative to the rotating liquid drop energy [3]. The calculated configurations are labeled by the number of $h_{11/2}$ protons and neutrons, respectively. An open square is used to indicate the observed states which are especially low in energy and the calculated states assigned to them are encircled.

(CNS) [4–6] formalism with the A = 110 parameters, which are known to give a good description of the smooth terminating bands in this region [5]. Pairing is neglected in the calculations which means that they are mainly relevant at high spin. In general, there exists a nice correspondence between the favored states, which are formed as maximally aligned spin states in the valence space, and the observed highest-spin states of low collectivity. The highest-spin states with six, five and four $h_{11/2}$ neutrons are formed from the valence particles outside a ^{114}Sn core (Z = 50, N = 64) core as

$\nu(h_{11/2})^6_{18}(sd)^0_0$ $\quad I_{max} = 18^+$
$\nu(h_{11/2})^5_{35/2}(sd)^1_{3/2}$ $\quad I_{max} = 19^-$
$\nu(h_{11/2})^4_{16}(sd)^2_0$ $\quad I_{max} = 16^+$

When combined with the favored aligned proton configuration,

$\pi(dg)^2_6(h_{11/2})^1_{11/2}$ $\quad I_{max} = 23/2^-$

they give rise to low-lying total spin states at I = $59/2^-$, $61/2^+$ and $55/2^-$. The energy of the corresponding configurations are shown up to these fully aligned states in lower panel of Fig. 1. They are compared with the observed states which are shown in the upper panel. Going to somewhat lower spin values, low-energy states are calculated for the $\nu[(h_{11/2})^6]$ configuration with one or two $h_{11/2}$ neutrons anti-aligned and with one neutron anti-aligned for the $\nu[(h_{11/2})^5]$, and $\nu[(h_{11/2})^4]$ configuration. The favored $43/2^-$, $47/2^-$ and $47/2^+$ states can be understood as built with one neutron anti-aligned from $\nu[(h_{11/2})^4]$, $\nu[(h_{11/2})^6]$ and $\nu[(h_{11/2})^5]$ configurations, respectively. The experimentally observed favored state at $39/2^-$ can be associated with $\nu[(h_{11/2})^4]$ configuration with one anti-aligned neutron, however this configuration is coming somewhat higher in energy in calculation. This may be attributed to the fact that with decreasing spin pairing starts to become important. Although, the calculations predict a two neutron anti-aligned state at $35/2^-$ for the $\nu[(h_{11/2})^6]$ configuration, we couldn't identify any such state in the experiment. It is to be noted that in the nucleus ^{125}I such a state was identified at $39/2^-$ [1].

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