Survey of low-lying fingerprint states of odd-mass nucleus near proton drip line – ^{111}I

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Introduction

Odd-mass nuclei in the mass A~120 region show a wide range of structural features in the low-lying yrast states. Two significant features observed in odd-mass iodine nuclei are ΔJ=1 bands built on $\pi g_{9/2}$ orbital extruding from below the Z=50 shell gap and ΔJ=2 decoupled bands based on $\pi h_{11/2}$ orbital intruding from the N=5 oscillator shell. Such bands have been consistently observed from neutron rich ^{127}I down to neutron deficient ^{113}I isotopes. The single particle Nilsson diagram shows that a low-lying $9/2^+$ state is expected with moderate deformation in these iodine nuclei. The same diagram also predicts a $11/2^-$ state at a relatively higher excitation energy. In ^{113}I the ΔJ=1 strongly coupled band has been reported up to $49/2^+$ state. In ^{111}I this band has not been reported [1] experimentally. However a low-lying yrast $9/2^+$ state has been observed. The band based on $11/2^-$ has been experimentally reported up to $35/2^-$ spin state. These two features have been observed significantly in all the odd-mass iodine and has been theoretically investigated using PRM for ^{115}I and ^{121,123}I [2]. We have therefore used PRM to investigate the band structure of the low-lying fingerprint states of ^{111}I near proton drip line.

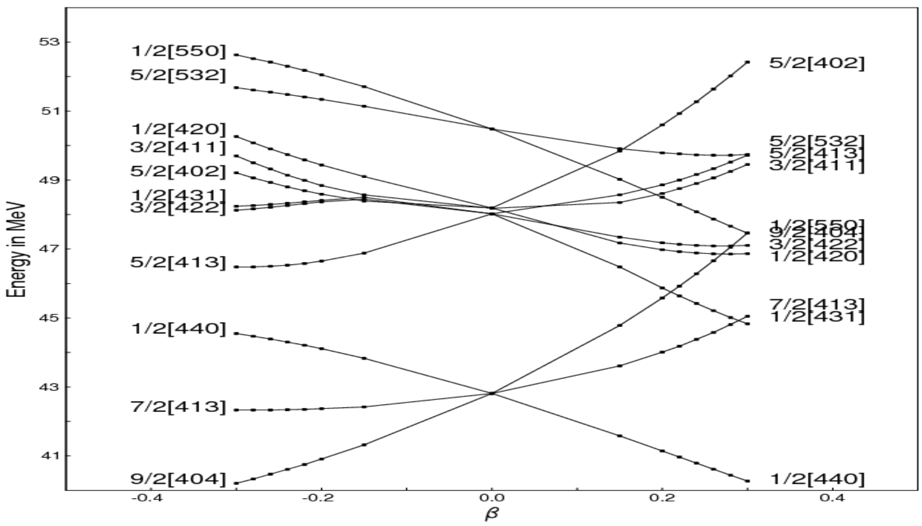

Fig. 1 Relevant Nilsson diagram

Formalism

The band structures of ^{111}I have been studied using Particle Rotor Model (PRM) where the experimental energies of the neighbouring (A-1) cores has been used directly as input parameters. Calculation using axially symmetric Nilsson potential with prolate deformation shows that for ^{111}I near proton drip line one expects both the ΔJ=1 and ΔJ=2 bands based on low-lying $9/2^+$ and $11/2^-$

states (Fig.1). In the present model the Hamiltonian for the odd-A system can be written as

$$H = H_{qp}^{\ 0} + c\,\vec{R}.\vec{j} + E_c(\vec{R}) \qquad (1)$$

The first term is the Hamiltonian of a single quasiparticle and is given by

$$H_{qp}^{\ 0} = \sum E_k a_k^{\ +} a_k \qquad (2)$$

With

$$E_K = \sqrt{(\varepsilon_k - \lambda)^2 + \Delta^2} \qquad (3).$$

The ε_k is the energy of a single particle moving in a standard axially Nilsson potential. The pairing gap and the Fermi level are represented by Δ and λ respectively. The middle term of Eqn (1) describes the rotational dependence of the interaction between the core and the quasiparticle and the last term describes the collective part of the Hamiltonian. The Nilsson single particle parameters μ and κ are taken to be 0.48(0.54) and 0.07(0.056), respectively, for the N=4(5) proton oscillator shell. Earlier calculations on odd-mass iodine nuclei predict the deformation β for these two bands to be around 0.20. The present calculation however predicts deformation β to be 0.28. The pairing gap parameter is estimated from the expression $\Delta = 12/\sqrt{A}$ MeV. The Fermi level λ is chosen close to the ground state band after obtaining the best fit to the relative band head energies of the $h_{11/2}$ and $g_{9/2}$ bands. The core energies of the neighbouring even Te and Xe cores have been used directly as input parameters.

Results and Discussions

The theoretical calculation predicts the band based on ½[550] Nilsson orbital up to $35/2^-$ state. The alternate signature partner at much higher excitation energy could not be observed experimentally. This band is dominantly based on 3/2[541] orbital and reported theoretically up to $37/2^-$ state in our work. The strongly coupled band based on $\pi g_{9/2}$ orbital and populated up to fairly high spin in all the neutron rich and neutron deficient odd-mass iodine isotopes is significantly absent in ^{111}I. Our theoretical calculation predicts this band up to $21/2^+$ state. This non-observance is probably due to the onset of other modes of deformation hitherto unobserved.

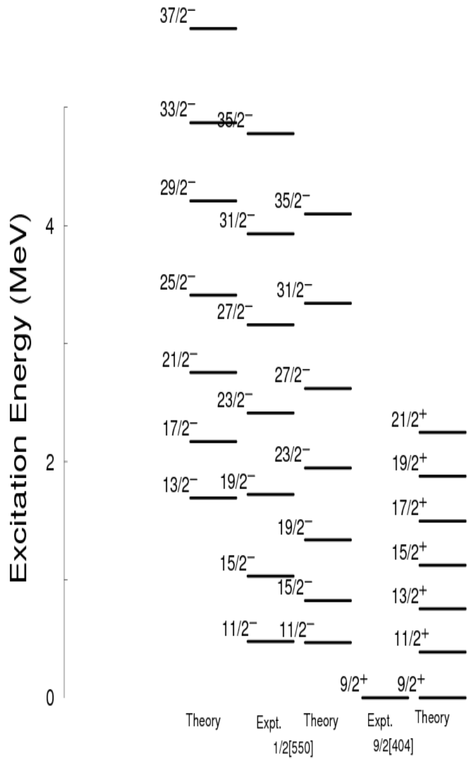

Fig. 2 Comparison of calculated and experimental level schemes of ^{111}I.

References

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