Nuclear structure at high-spins in the mass region A $\sim$ 100-130

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Introduction

In the A$\sim$130 mass region, the active positive parity proton orbitals are $g_{7/2}$, $d_{5/2}$, and the $g_{9/2}$ extruder, and neutron orbitals are $g_{7/2}$,$d_{5/2}$, $d_{3/2}$, $s_{1/2}$. In addition,there are the unique parity high-j $h_{11/2}$ intruder orbital in both the proton and neutron valence space, which induce a quadruple nuclear deformation and exert strong and specific shape-driving forces on the core. The proton Fermi surface lies in the lower $h_{11/2}$ subshell, while the neutron Fermi surface scans through the $h_{11/2}$ subshell. Indeed, γ-ray spectroscopic investigations in the odd-Z nuclei in this region have revealed collective and non-collective structures representing diverse nuclear shapes. Interesting features such as the coexistence of prolate and oblate collective bands originating from the $\pi h_{11/2}$ orbital, abrupt and smooth shape transition from collective prolate to non-collective oblate ($\gamma = -60°$) (band termination), and delayed $\nu h_{11/2}$ pair alignment in the intruder $\pi h_{11/2}$ yrast band, have been observed. Similarly nuclei with $A \sim 100$ in the vicinity of the Z= 50 closure have been an interesting subject of study due to existence of both the spherical and deformed shapes. The structure of these nuclei is guided by valence hole-like protons in the high-Ω $g_{9/2}$ extruder orbital across the $Z \sim 50$ gap and valence particle-like neutrons in the low-Ω $d_{5/2}$, $g_{7/2}$, $h_{11/2}$ orbitals above the N=50 gap. Triaxial deformation in both the A$\sim$130 and $\sim$100 mass regions have been inferred from the observed rotational-alignment frequencies, staggering behaviour, M1 reduced transition probabilities and chiral-twin bands. Chiral bands have been observed in various odd-A and odd-odd nuclei with multiquasiparticle configurations that have substantial angular momentum components along the three principal axes.

The ^{129,131}Cs nuclei

The ^{122}Sn(^{11}B, 4n) fusion-evaporation reaction at E_{lab} = 60 MeV was used to populate excited states in ^{129}Cs [1] and the deexcitations were investigated using in-beam γ-ray spectroscopic techniques. The level scheme of ^{129}Cs is established up to $\sim$ 8 MeV excitation energy and $47/2\hbar$ spin. The observed band structures are interpreted for their configurations in the framework of Cranking model calculations and systematic of the neighboring $_{55}$Cs isotopes. A negative-parity $\Delta I = 1$ coupled band has been assigned the $\pi h_{11/2} \otimes \nu(h_{11/2})^2$ configuration as solution of the tilted-axis cranking, which coexists with the $\pi h_{11/2}$ yrast band resulting from the principal-axis cranking. A new band has been identified as γ-vibrational band built on the $\pi h_{11/2}$ orbital. Two strongly coupled positive-parity bands exhibiting similar features are assigned different unpaired three-quasiparticle configurations involving the $\pi h_{11/2} \otimes \nu h_{11/2}$ component. The previously identified unfavored signature partners of the $\pi d_{5/2}$ and $\pi g_{7/2}$ bands are reassigned as γ-vibrations of the core coupled to the $\pi g_{7/2}$ single-particle configuration, and the favored signature of the $\pi d_{5/2}$ band, respectively.

Excited states in ^{131}Cs [2] were investigated through in-beam γ-ray spectroscopic techniques following its population in the ^{124}Sn(^{11}B,4n) fusion-evaporation reaction at a beam energy of 46 MeV. The previously known level scheme has been substantially extended up to $\sim$ 9 MeV excitation energy and 49/2 $\hbar$ spin with the addition of seven new

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band structures. The present level scheme consisting of fifteen bands exhibits a variety of collective features in this nucleus at intermediate spin. The excitation energies of the observed levels in different bands and the corresponding ratios of transition strengths, *i.e.,* B(M1)/B(E2), have been compared with the results of projected deformed Hartree-Fock calculations based on various quasiparticle configurations. A strongly coupled band has been reassigned a high-K three quasiparticle $\pi h_{11/2} \otimes \nu(h_{11/2} d_{3/2})$ configuration based on the properties of this band and that of its new coupled side band. The configurations of these bands are also discussed in the framework of Tilted Axis Cranking model calculations and the systematics of the odd-A Cs isotopes. Additional three energetically closely placed coupled bands have been assigned different unpaired three-quasiparticle configurations. Gamma vibrational bands coupled to the $\pi h_{11/2}$ and $\pi g_{7/2}$ single particle configurations have been reported in this nucleus. Observation of new E1 transitions linking the opposite-parity $\pi h_{11/2}$ and $\pi d_{5/2}$ bands provides fingerprints of possible octupole correlations. Level energies and B(M1)/B(E2) ratios have been reproduced for the assigned configurations based on low-lying intrinsic states of one and three unpaired nucleons.

The ^{106,107}In nuclei

Excited states of the $^{106,107}_{49}$In nucleus were populated through the ^{78}Se (^{32}S, pxn) fusion-evaporation reactions at beam energy, E_{lab} =125 MeV. The deexcitations were studied using in-beam γ-ray spectroscopic techniques involving Compton-suppressed clover detector array. The level scheme of ^{106}In [3] has been extended up to 7 MeV of excitation energy for the negative parity states constituting four dipole bands. In ^{107}In [4], level scheme consisting of about seven bands is established up to spin $\sim 45/2\hbar$ with the addition of 25 new transitions. Spins and parities of various levels have been assigned through the DCO and polarisation measurements. Projected deformed Hartree-Fock calculations were carried out in order to understand the configurations of different bands in these isotopes. In ^{106}In, two closely spaced dipole bands has been assigned two quasiparticle configurations with $K^{\pi} = 4^-$ and 5^- based on $\pi g_{9/2}$ and $\nu h_{11/2}$ orbitals, originating from slight rearrangement of the last proton in $g_{9/2}$ orbital. Various bands in ^{107}In are reproduced in band mixing calculations with the configurations involving high-Ω $\pi g_{9/2}$ and $\nu d_{5/2}$ orbits, and low-Ω $\pi g_{7/2}$, $\nu g_{7/2}$ and $\nu h_{11/2}$ orbits.

The ^{99}Pd nucleus

The ^{75}As(^{28}Si, p3n) fusion-evaporation reaction at E_{lab}= 120 MeV was used to populate excited states in ^{99}Pd [5] and the deexciting γ-rays were detected using the INGA-2008 equipped with 18 clover detectors mounted in five rings configuration. The level scheme of ^{99}Pd is established up to $\sim$ 10 MeV excitation energy and $49/2\hbar$ spin with the addition of 60 new transitions. The signatures of octupole collectivity, i.e., E1 transitions between the levels of $\pi h_{11/2}$ band to $\pi d_{5/2}$ band have been observed in the present work. The level structures observed in ^{99}Pd have been interpreted in the framework of a microscopic theory based on the deformed Hartree-Fock (HF) and angular momentum projection techniques.

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