Role of $\pi i_{13/2}$ orbital for the structure of nuclei near Z = 82 magic gap

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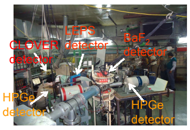
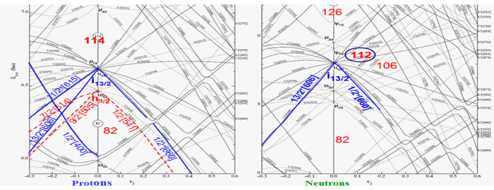
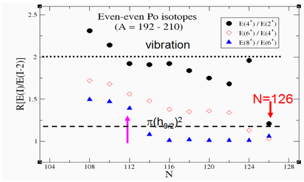
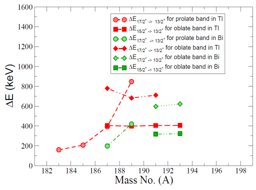








Systematic of the ratios of the excitation energies E(I)/E(I-2), for angular momentum I = 4,6 and 8 for even-even Po (Z = 84) isotopes.

➢The nuclei around mass A ~ 190 region is crucial laboratories to observe interesting nuclear structure phenomena and to test a variety of nuclear models.

➢The valence protons and the neutrons in these mass regions occupy the high-j orbitals with competing prolate and oblate driving effects. This competition results into triaxiality and shape co-existence [1] in such nuclei.

➢**Single particle structure and Intruder rotational bands structure.**

❖In even-even Po (Z = 84) isotopes, the ratio of excitation energies of 4^+ and 2^+ remains close to the vibrational limit until N = 112 [2], below which it starts to increase towards the rotational limit.

❖These clearly indicates a structural change around N = 112 .

❑ **The odd proton nucleus ^{195}Bi [3], with neutron number N = 112, is an interesting transitional nucleus whose two immediate odd-A neighbors on either side have different shapes at low excitation energies. Spherical shape dominates in ^{197}Bi and deformed bands (built on $\pi h_{9/2}$ and $\pi i_{13/2}$ levels) observed for ^{193}Bi.**

❑ **In other words, the neutron magic gap at N = 126 seems to reinforce the Z = 82 magic gap until at least N = 114 to induce spherical shapes in the heavy Bismuth nuclei.**

❑ **It is, however, an open question whether the effect of this reinforcement continues up to even lower values of the neutron number or breaks down due to the onset of deformation in the Bi isotopes at N = 112, where deformed shell gap exists in the Nilsson diagram.**

❑ **On the other hand, rotational band based on the intruder $\pi i_{13/2}$ orbital have been observed in lighter odd-mass Tl nuclei but this state has not yet been identified above ^{193}Tl (N= 112) [4]. So, it is interesting to study the intruder $\pi i_{13/2}$ orbital above ^{193}Tl.**

❑ **Therefore, for detailed understanding of the effect of $\pi i_{13/2}$ orbital, we have studied the high spin states in ^{195}Bi and ^{197}Tl nuclei, i.e, above and below the Z = 82 shell closures.**

High Spin Spectroscopy of ^{195}Bi

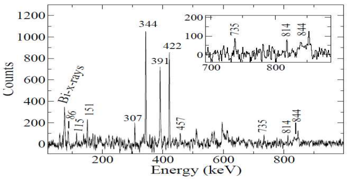
Experiment

Indian National Gamma Array (INGA) at VECC

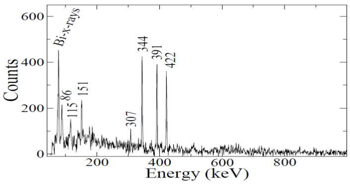
^{20}Ne + ^{181}Ta → ^{195}Bi + 6n at 145 MeV (from K130 cyclotron)

Detectors: 8 Compton Suppressed Clover Ge Detectors.

γ-γ coincidence matrix, DCO, Polarization.

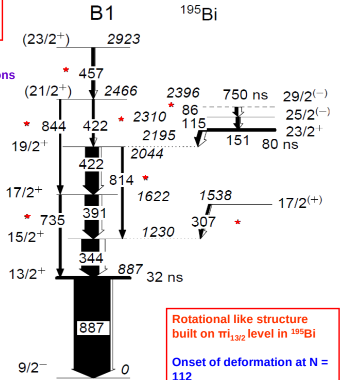


Prompt coincidence spectrum gated by an 887-keV γ line



Delayed coincidence spectrum gated by an 887-keV γ line

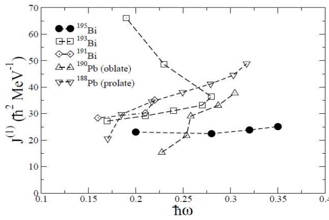
Level scheme of ^{195}Bi: from the present work



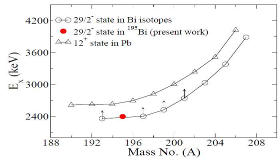
Rotational like structure built on $\pi i_{13/2}$ level in ^{195}Bi

Onset of deformation at N = 112

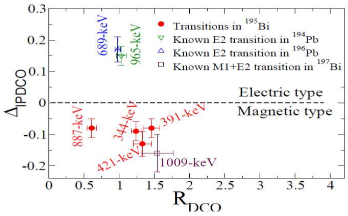
H. Pai, et al., Phys. Rev. C 85, 064317 (2012).



Kinematic moments of inertia (J (1)) as a function of rotational frequency ħω for the proposed rotational band based on the 13/2+ state in ^{195}Bi along with those for neighboring odd-A bismuth and even-even Pb



Systematic of the excitation energy of the 29/2⁻ isomeric state in odd-odd Bi nuclei (open circle) and that of the 12+ state in even-even Pb nuclei (open triangle). The arrows indicate that the values are the lower limit. The excitation energy of the 29/2⁻ isomer in ^{195}Bi from the present work is shown as a solid circle.



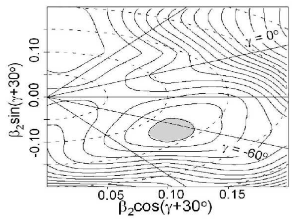
The DCO and the IPDCO ratios for the γ rays in ^{195}Bi and for a few known transitions in ^{194,196}Pb obtained from the present work. The DCO values are obtained by gating on a quadrupole transition except for the 887-keV γ ray which was gated by a dipole transition.

Total Routhian Surface (TRS) calculations for the 13/2+ configuration in ^{195}Bi :

❖ **Configuration dependent Hartee-Fock-Bogoliubov code [5].**

❖ **Deformed Wood-Saxon potential, BCS Pairing.**

❖ **Total energies calculated in the β_2 - γ plane (minimized in β_4).**



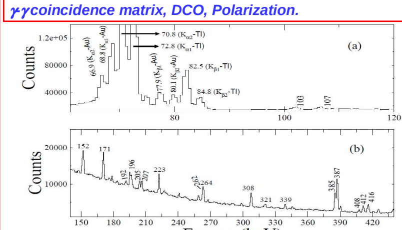
High Spin Spectroscopy of ^{197}Tl

Experiment at VECC

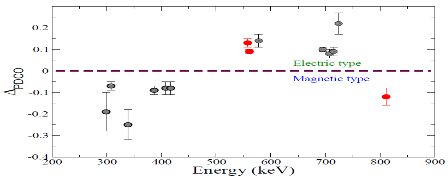
^{4}He+^{197}Au → ^{197}Tl + 4n at 48 MeV (from K130 cyclotron)

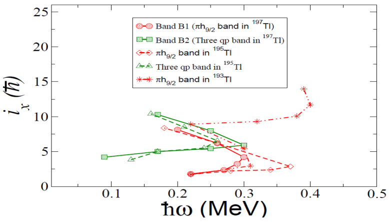
Detectors: 2 HPGe, 1 LEPS (Low energy Photon spectrometer),1 Clover HPGe, 50 element BaF2 detectors (for γ-ray multiplicity).

γ-γ coincidence matrix, DCO, Polarization.



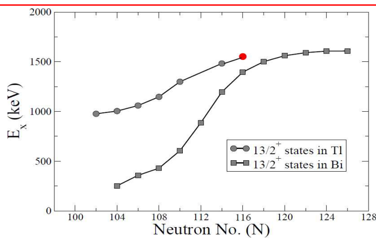
Singles in-beam gamma ray spectra ((a) lower energy and (b) higher energy part) for one segment of the LEPS detector.



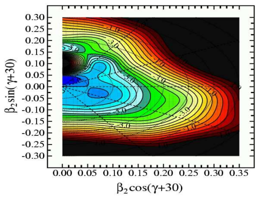


Experimental alignments (i_x) as a function of the rotational frequency (ħω) for the $\pi h_{9/2}$ band in ^{193}Tl, ^{195}Tl and ^{197}Tl along with three quasiparticle (qp) band in ^{195}Tl and ^{197}Tl.

13/2$^+$ state based on $\pi i_{13/2}$ orbital has been identified



Excitation energy (E_x) of 13/2+ state in Tl and Bi isotopes as a function of neutron number. The excitation energy of the 13/2+ state in ^{197}Tl from the present work is shown as a red circle.



β_2 ~ 0.08, γ = -50°

Contour plots of the total Routhian surfaces (TRSs) in the β_2 - γ deformation mesh for the $\pi i_{13/2}$ configuration of the 13/2+ state in ^{197}Tl.

Summary

- **Rotational band built on $\pi i_{13/2}$ level has been identified in ^{195}Bi. Which, indicate the onset of deformation takes place at neutron number N = 112.**
- **In ^{197}Tl, the intruder $\pi i_{13/2}$ state could be identified for the first time.**
- **We have assigned negative parity for band B2 in ^{197}Tl from polarization and DCO measurements .**
- **TRS calculations show oblate deformation for $\pi i_{13/2}$ configuration in ^{197}Tl and ^{195}Bi.**
- **Oblate shape is gradually dominating with increase in neutron number after midshell for intruder $\pi i_{13/2}$ level in Tl and Bi nuclei.**

Acknowledgements

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➢**The effort of the cyclotron operators at VECC and all the participating group in the CLOVER Array Collaboration are acknowledged.**

References

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