INSTITUTE FOR STRUCTURE AND NUCLEAR ASTROPHYSICS
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Chiral Wobbling in ^{135}Pr

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Introduction

Triaxial nuclear shapes are very rare. Their experimental observation is aided by two fingerprints:

Wobbling - Harmonic oscillation of one of the principal axes about the space fixed *J* [1].

Signatures:

- n_w = 0, 1, 2, … rotational bands
- Δn_w = +1 transitions
- Interband transitions are ΔI = 1, E2

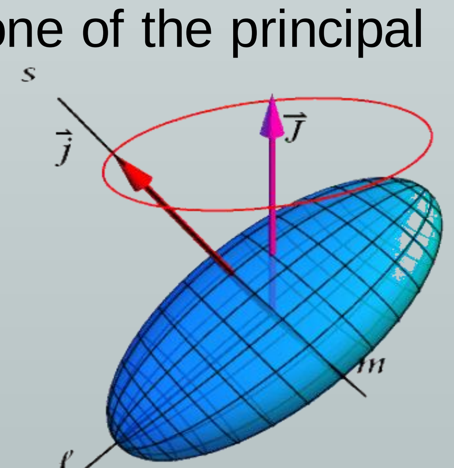

Fig. 1. Schematic of nuclear wobbling motion

Chirality – Occurs when the axis of rotation lies outside all the three principal planes of the triaxial rotor and the nucleus starts exhibiting handedness [2].

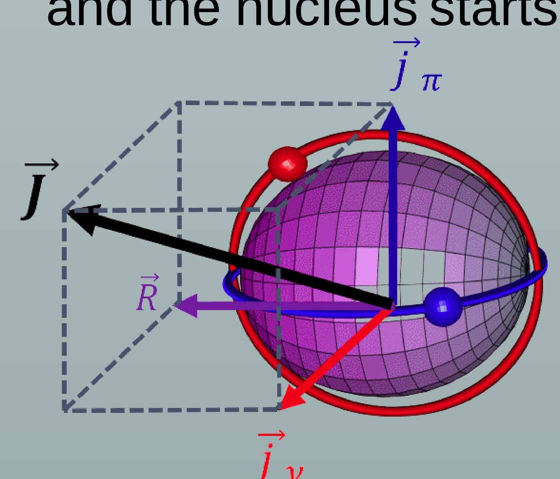

Fig. 2. Schematic of chiral rotation

Signatures:

- Two ΔI = 1 bands with same excitation energy and parity.
- Nearly constant staggering
- Identical B(M1)/B(E2) ratios

Experimental Details

- Experiments performed using Gammasphere facility at Argonne National Laboratory.
- Reaction: ^{123}Sb(^{16}O,4n)^{135}Pr at 80 MeV
- Target: 634 μg/cm^2 ^{123}Sb foil with a 15 μg/cm^2 front Al layer

Fig. 3. Gammasphere array at ANL

Exp No.	No. of detectors	No. of triple coincidence events
1	83	1.5 x 10^{10}
2	63	1.0 x 10^{10}

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Level Scheme

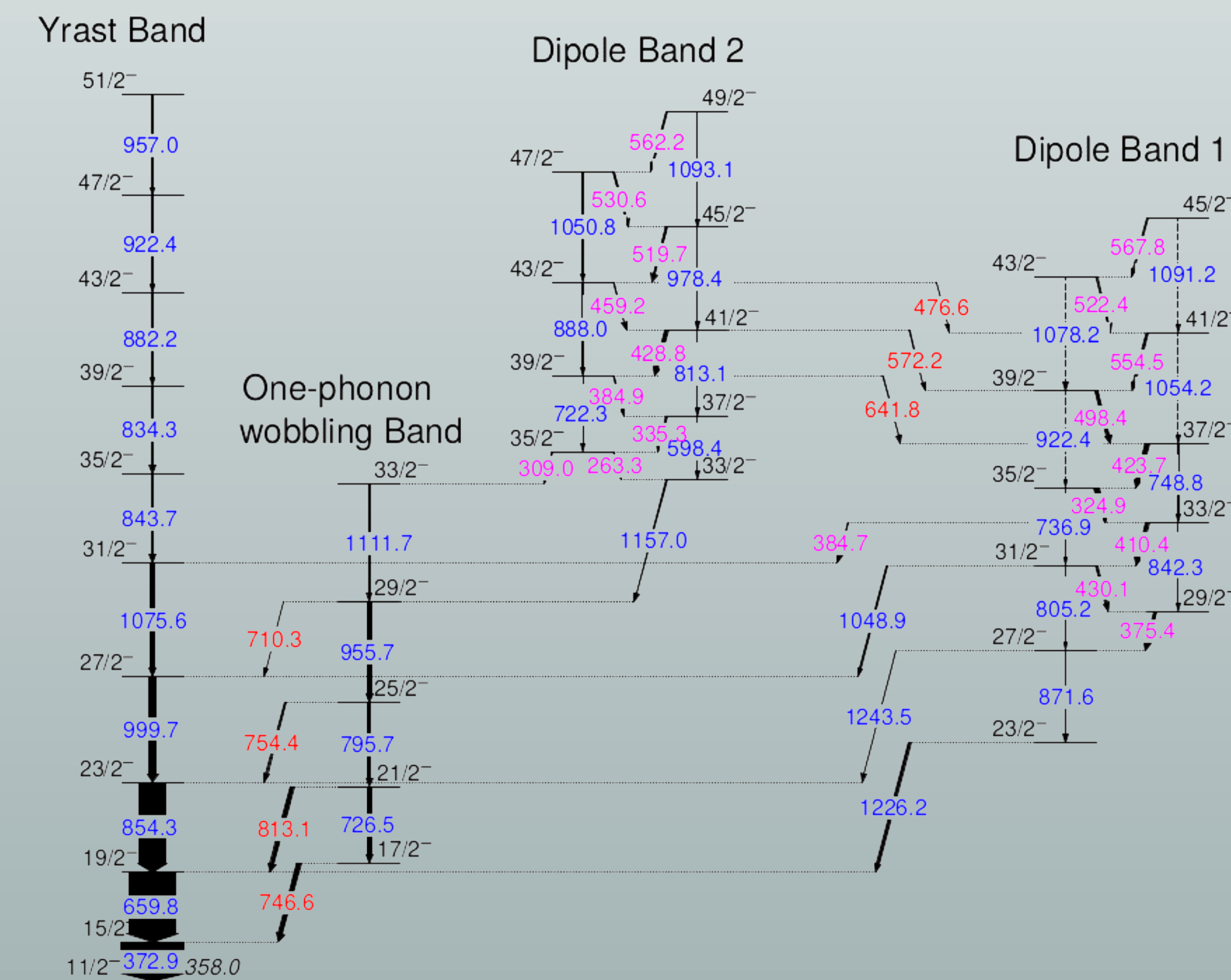

Fig. 4. Partial negative parity level scheme for ^{135}Pr. The colors blue, magenta and red indicate pure E2, pure M1 and mixed M1+E2 transitions respectively.

Results

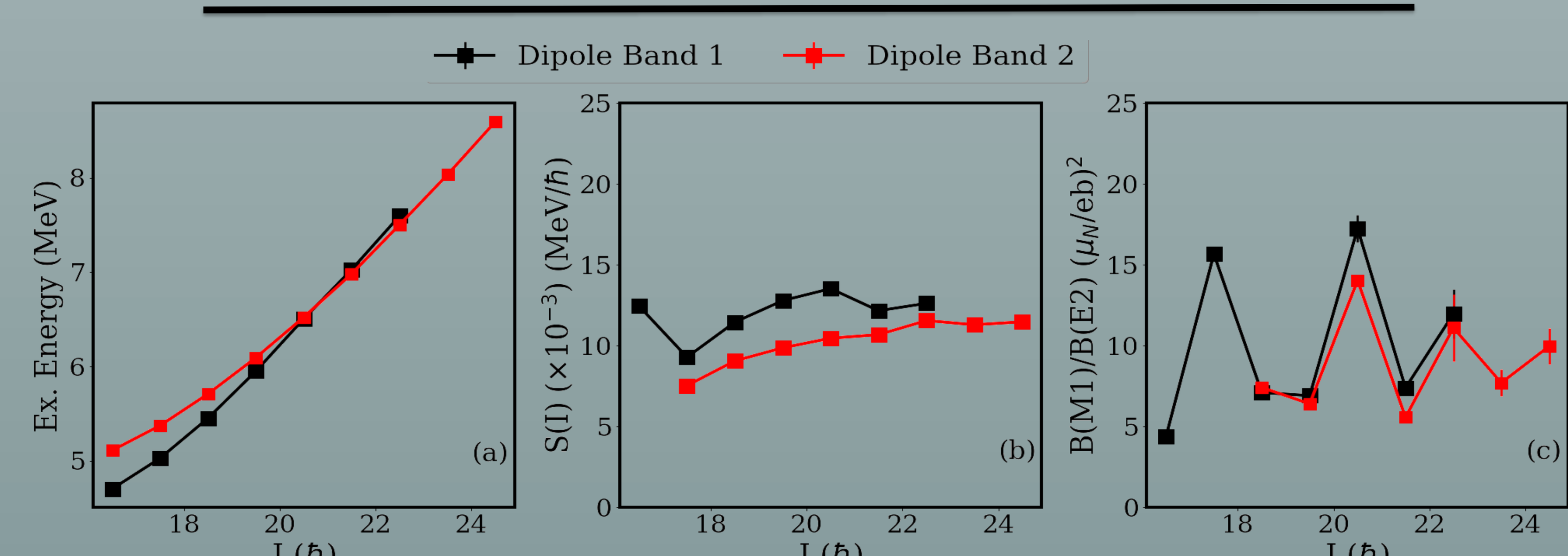

Fig. 5. (a) Excitation energies, (b) Staggering parameter and (c) Reduced transition probability ratios for Dipole Bands 1 and 2.

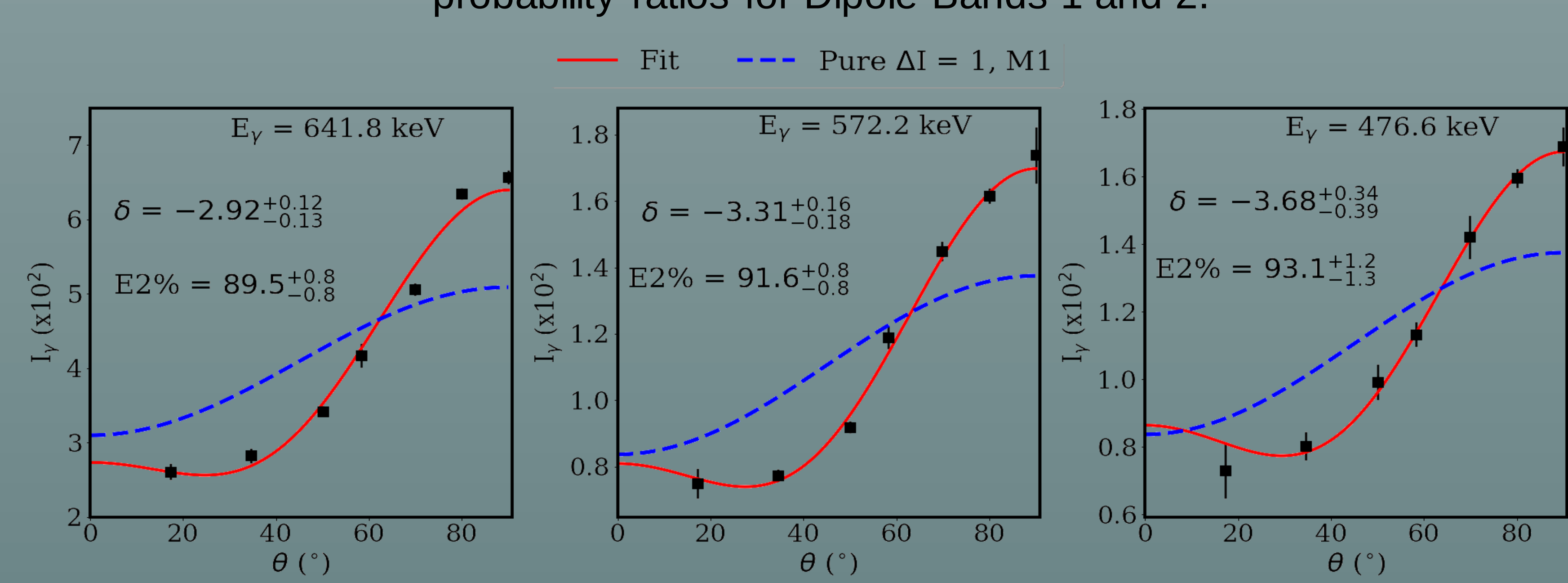

Fig. 6. Angular distribution plots for Dipole Band 2 → Dipole Band 1 transitions.

Interpretation

Transverse wobbling:

- Odd $(\pi h_{11/2})^1$ aligns with the short (s) axis of the triaxial rotor.

Chiral wobbling:

- Two additional $(\nu h_{11/2})^{-2}$ align with the long (l) axis.
- Net angular momentum generated in the s-l plane.
- Collective *R* precesses along this axis.
- Collective excitation of the wobbling type.

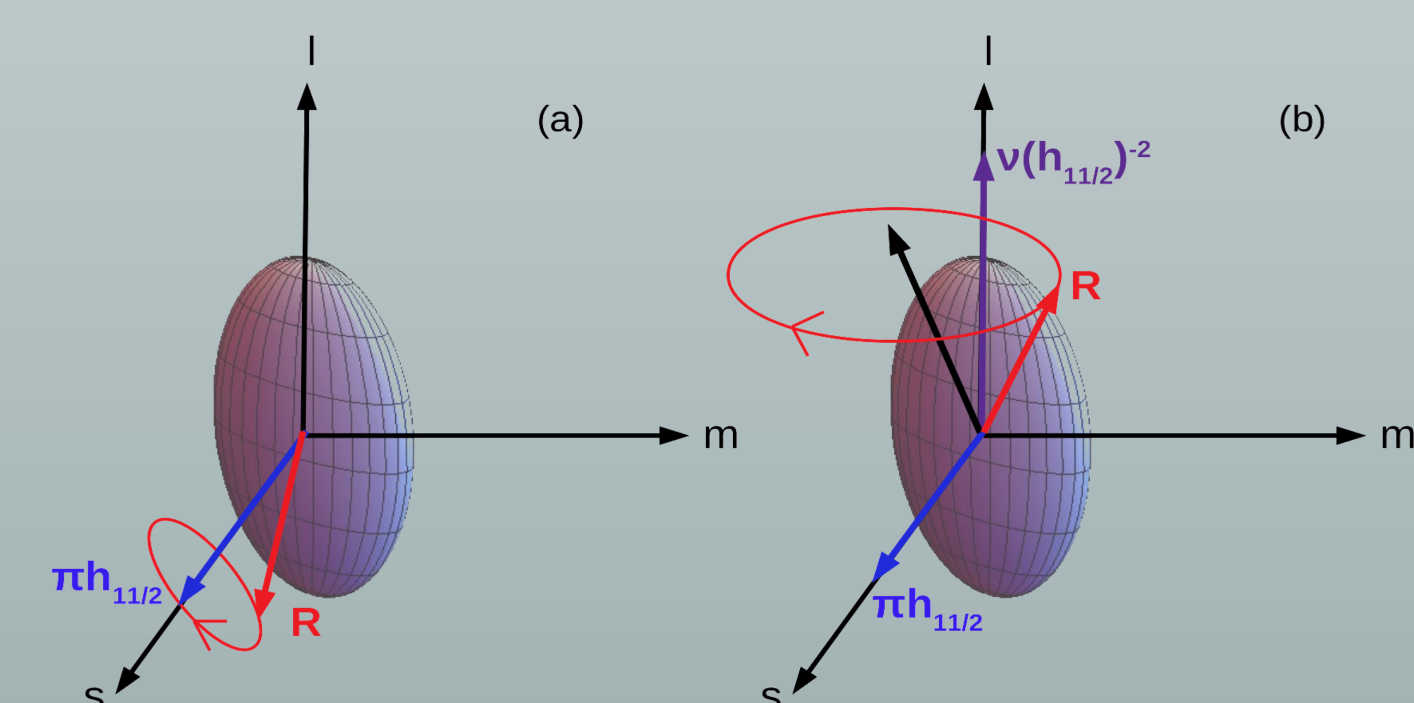

Fig. 4. Schematic of (a) Transverse wobbling and (b) Chiral wobbling in ^{135}Pr.

The simultaneous observation of wobbling and chirality in a triaxial nucleus has never been done before.

Conclusion and Future Work

- ^{135}Pr is the first possible case of Chiral wobbling.
- High statistics angular distribution measurements performed.
- Analysis ongoing to extend Dipole bands 1 and 2 and find more connecting transitions.
- Calculations in the framework of the Particle Rotor Model (PRM) being done to affirm experimental observations.

References

[1] S. Frauendorf, F. Dönau, Phys. Rev. C 89 (2014) 014322.

[2] S. Frauendorf and J. Meng, Nucl. Phys. A617, 131 (1997)

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