

New Data on Wobbling Motion for $A \approx 130$ Mass Region

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Outline

- 1 Nuclear Triaxiality
- 2 Wobbling Motion in Nuclei
- 3 Current status of nuclear "wobblers"

Nuclear Deformation

Nuclear shapes

Most generally described in terms of the **nuclear radius**:

$$R(\theta, \varphi) = R_0 \left(1 + \sum_{\lambda=0}^{\infty} \sum_{\mu=-\lambda}^{\lambda} \alpha_{\lambda\mu} Y_{\lambda}^{\mu}(\theta, \varphi) \right)$$

Quadrupole deformations $\lambda = 2$

- Most relevant modes are the **quadrupole vibrations** $\lambda = 2 \implies$ *Play a crucial role in the rotational spectra of nuclei*:
- $\alpha_{2\mu}$ reduced to only two *deformation parameters*: β_2 (**eccentricity**) and γ (**triaxiality**) (*Bohr and Mottelson, 1969*).

Axial shapes

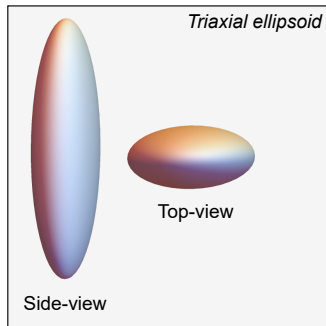
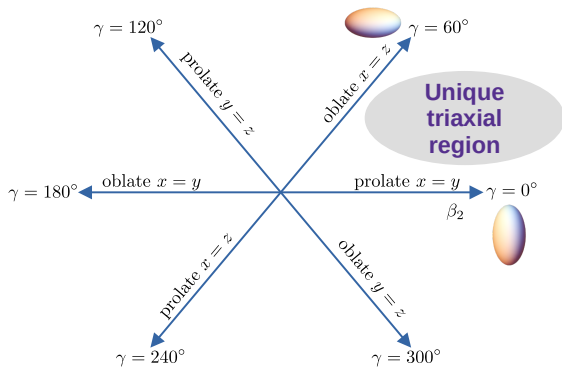
- Most of the nuclei are either **spherical** or **axially symmetric** in their ground-state.
- Nuclear moments of inertia $\mathcal{I}_{1,2,3}$: only two are equal.



Figure: **spherical:** $\beta_2 = 0$ **prolate:** $\beta_2 > 0$ **oblate:** $\beta_2 < 0$. ($\gamma = 0^\circ$).

Non-axial shapes

- The triaxiality parameter $\gamma \neq 0^\circ$: departure from axial symmetry.
- Moments of inertia: $\mathcal{I}_1 \neq \mathcal{I}_2 \neq \mathcal{I}_3$.

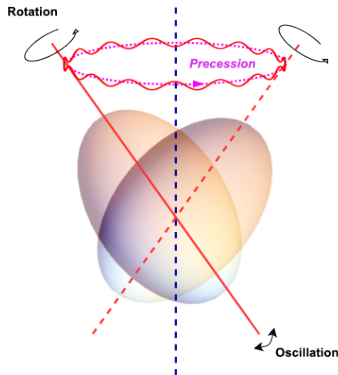


Wobbling Motion

$$\gamma \neq 0^\circ$$

MOI anisotropy

main rotation around \mathcal{I}_{\max} is
disturbed by the other two axes



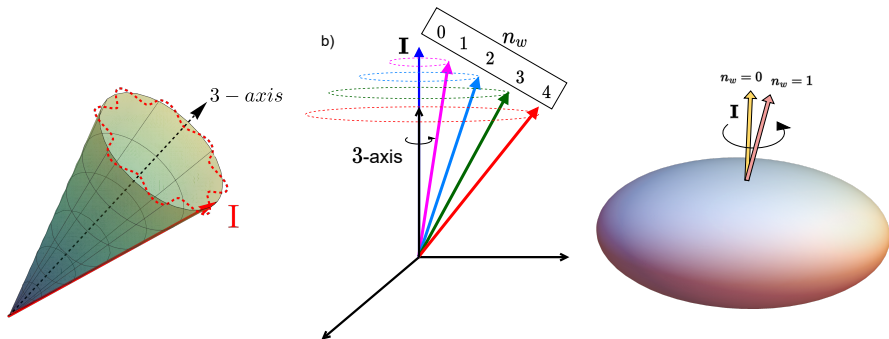
Wobbling Effect

- The **total angular momentum** of the nucleus **precesses** and **oscillates** around \mathcal{I}_{\max} .

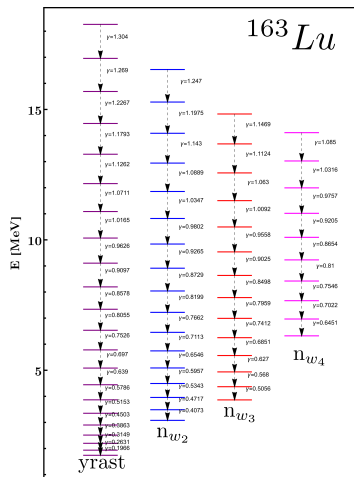
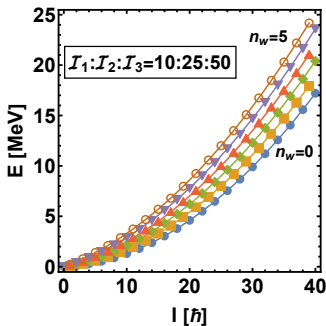
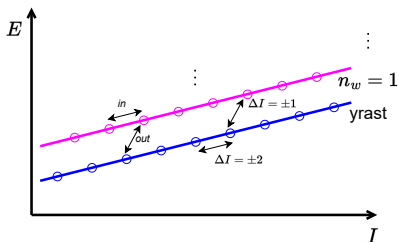
Wobbling Motion

Harmonic oscillation

- Precession of \mathbf{I} is affected by **rotational frequency** and/or **tilting**
- Tilting only by "specific" amount \rightarrow **harmonic character** \rightarrow **wobbling phonon**: $n_w = 0, 1, 2, \dots$



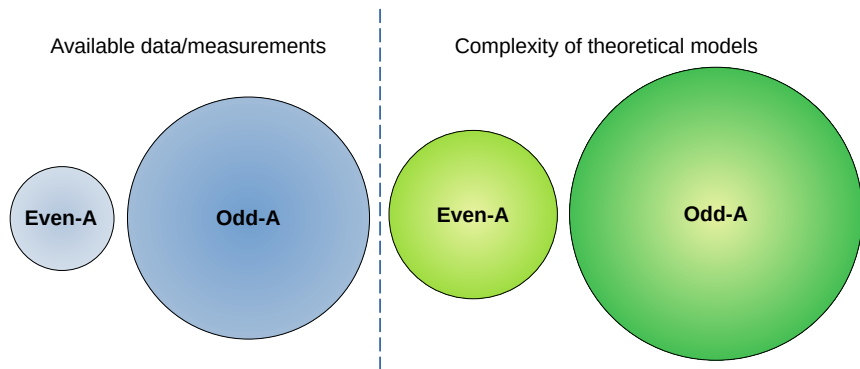
Wobbling Motion II



R. Poenaru, 2023.

Even-A vs. Odd-A Picture

- Predicted for even- A nuclei more than 50 years ago.
- First experimental evidence: ^{163}Lu (*Ødegård, 2001*).
- Current mass-regions for wobblers: $A \approx [130, 160, 180]$.



$$A \approx 100$$

Excitation energies vs. Wobbling Energies:

$$E_{\text{wob}}(I_{\text{even}}) = E_{I,n} - E_{I,0} ,$$

$$E_{\text{wob}}(I_{\text{odd}}) = E_{I,n} - \frac{1}{2} (E_{I-1,0} + E_{I+1,0})$$

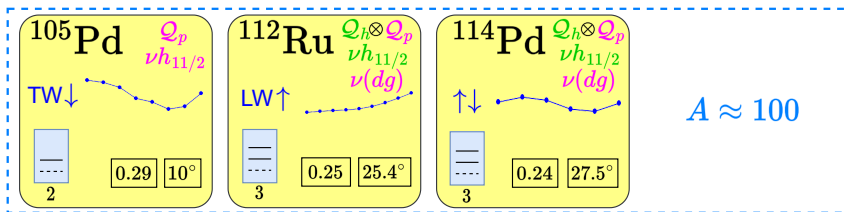


Figure: Experimentally confirmed wobblers, R Poenaru, 2023.

$$A \approx 130$$

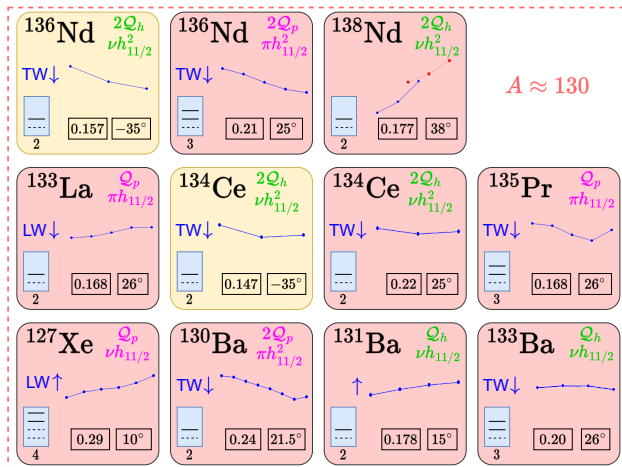


Figure: Experimentally confirmed wobblers, R Poenaru, 2023.

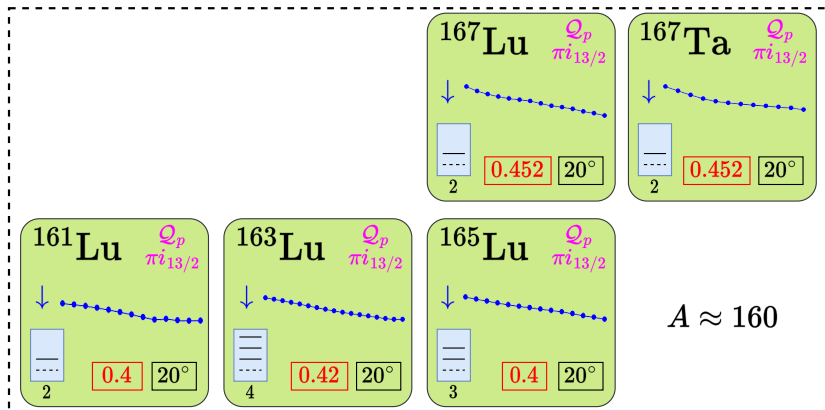
$A \approx 160$


Figure: Experimentally confirmed wobblers, R Poenaru, 2023.

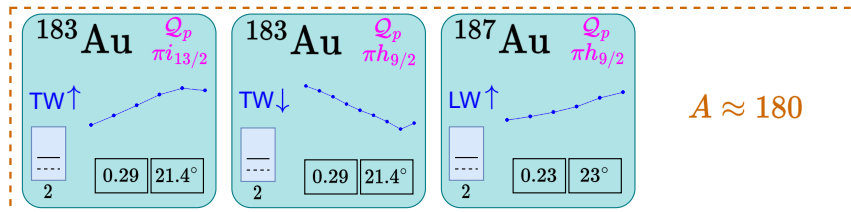
$A \approx 180$ 

Figure: Experimentally confirmed wobblers, R Poenaru, 2023.

Wobbling Motion in ^{135}Pr

Thank you for your attention!