Evaluation of the Wobbling Motion in Even-Even Nuclei Within a Simple Rotor Model

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Nuclear Deformation

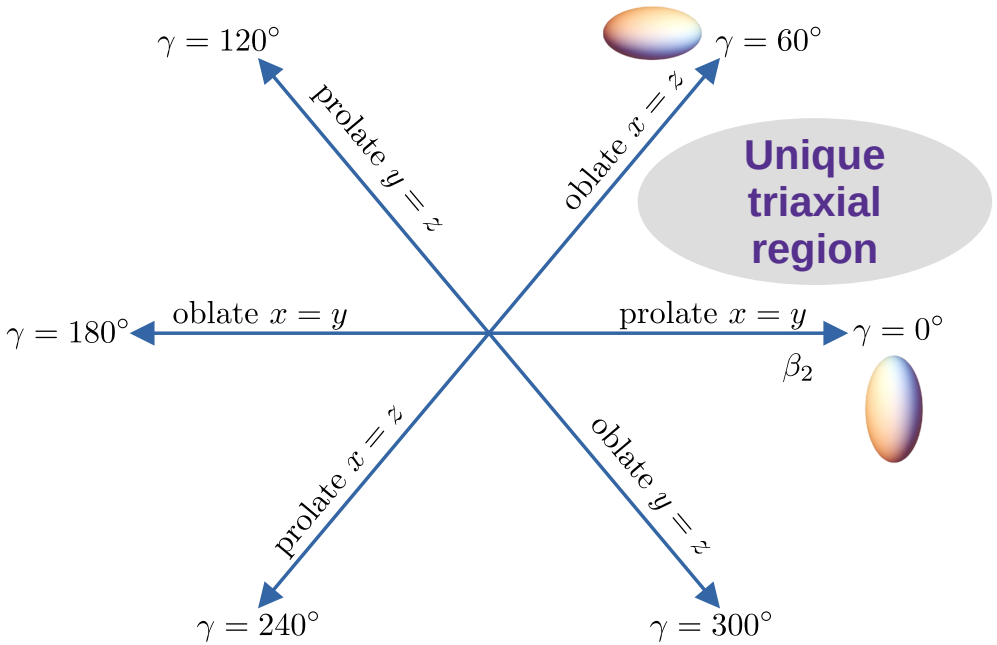
- Most of the nuclei are either *spherical* or *axially symmetric* in their ground-state.
- Deformation parameter β (*Bohr, 1969*): preserves axial symmetry

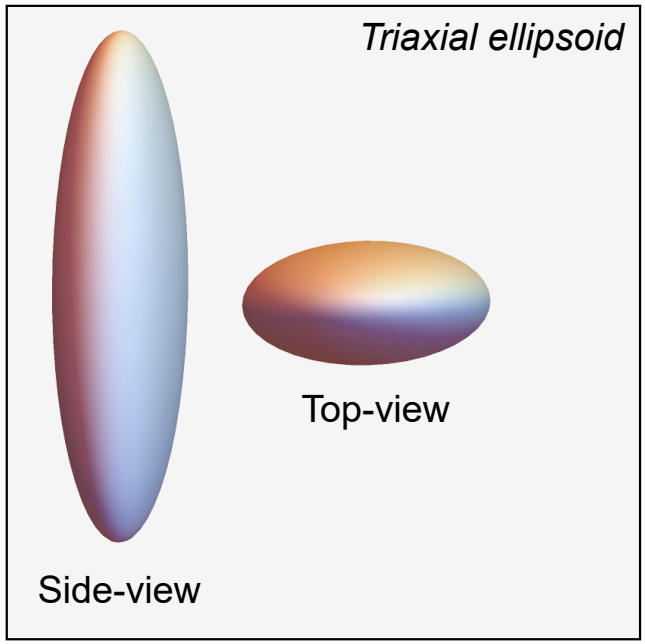
Figure 1: **spherical:** $\beta = 0$ **prolate:** $\beta > 0$ **oblate:** $\beta < 0$

Nuclear Triaxiality

Non-axial shapes

- Deviations from symmetric shapes can occur across the chart of nuclides $\rightarrow$ **triaxial nuclei**.
- The triaxiality parameter γ (*Bohr, 1969*): departure from axial symmetry





Fingerprints for Triaxiality

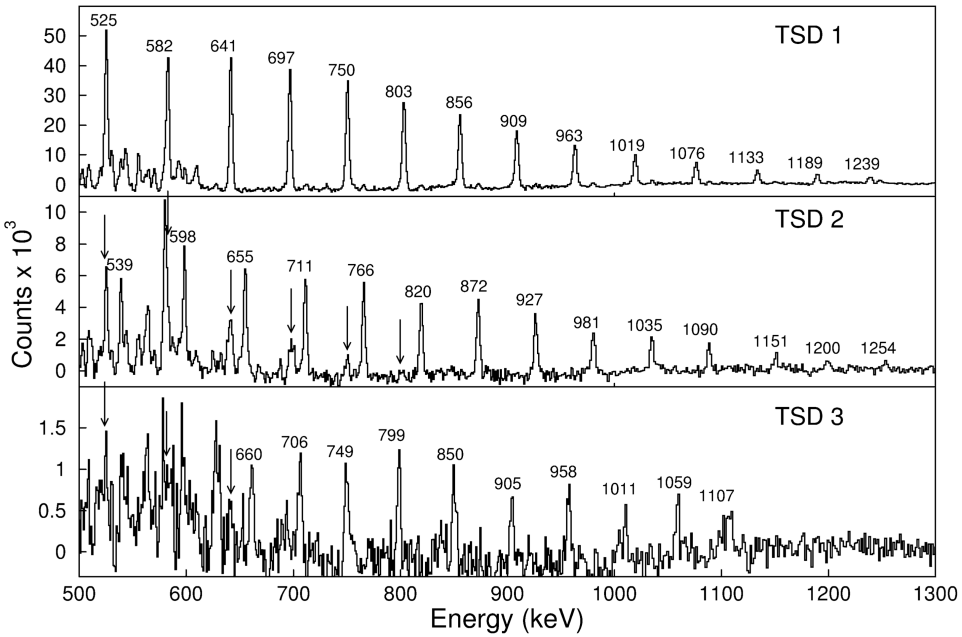
- Stable triaxial nuclei represent a real challenge for experimentalists and theoreticians
- Clear signatures for confirming stable triaxiality in nuclei
  1. Chiral symmetry breaking (*Frauendorf, 1997*)
  2. **Wobbling motion** (*Bohr & Mottelson, 1975*)

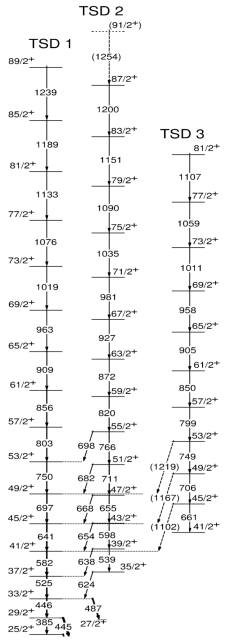
Wobbling Motion (WM)

- Unique to non-axial nuclei
- Predicted 50 years ago for even-A nuclei (i.e., the simple wobbler)
- First experimental evidence for ^{163}Lu (*Ødegård*, 2001)
- Currently confirmed wobblers $A \approx [100, 130, 160, 180]$.

Triaxial Rotor Energy

- Rigid body rotational energy: $E_{\text{rot}} \propto \frac{\hbar^2}{2\mathcal{J}_{\text{max}}} I(I+1)$
- A triaxial nucleus can rotate about any of the three axes $\rightarrow$ *rich energy specra spectra*
- MOI anisotropy $\rightarrow$ the *main rotation* around $\mathcal{J}_{\text{max}}$ is disturbed by the other two axes $\rightarrow$ **resulting motion of the rotating nucleus has an oscillating behavior**

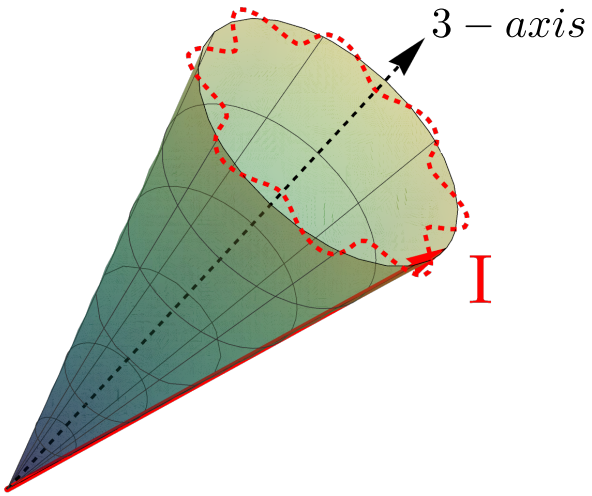


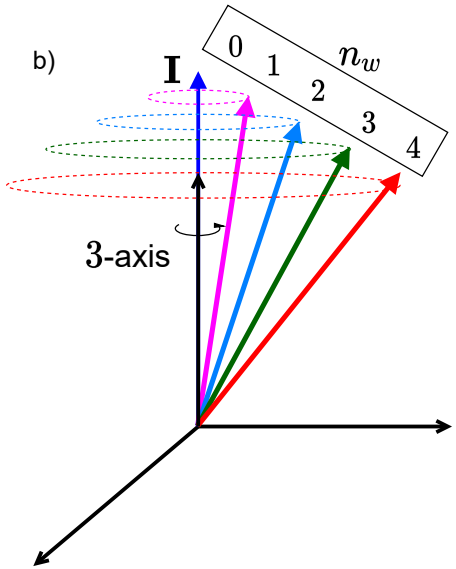


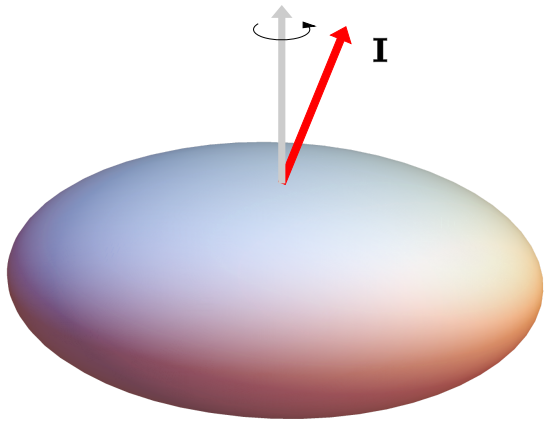
Figures from Schönwaßer et al., 2001

Wobbling Motion

- Oscillatory character of **I** $\rightarrow$ **I** *disaligned* w.r.t. body-fixed axes
- The a.m. **precesses** and **wobbles** around the axis with $\mathcal{J}_{\max}$
- The precession of **I** can increase by **tilting**
- Tilting by an energy quanta $\sim$ *vibrational character* $\rightarrow$ **wobbling phonon** $n_w = 0, 1, 2...$





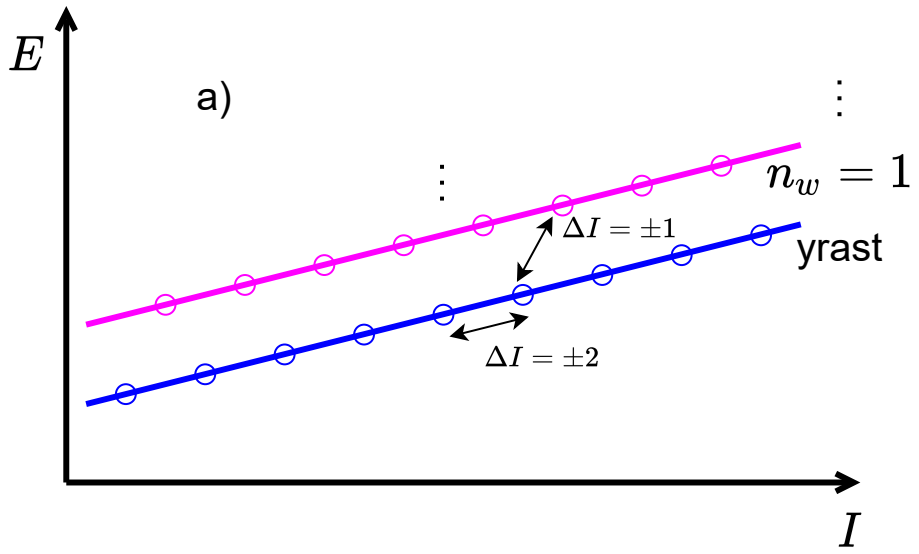


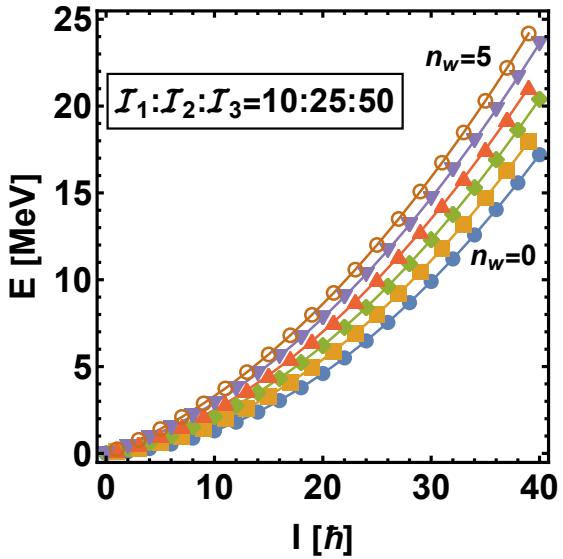
Wobbling Spectrum

Even-A Nuclei

- Employing the Harmonic Approximation *(Bohr, 1969)*
- $\hat{H}$ composed of a *rotational* part and *harmonic oscillation* (i.e., wobbling) part:

$$\hat{H} = \frac{\hbar^2}{2\mathcal{J}_{\max}} I(I+1) + \hbar\omega_{\text{wob}} \left(n_w + \frac{1}{2} \right) , n_w = 0, 1, 2, \ldots \qquad (1)$$





- New experimental measurements show *potential* wobbling candidates in the $A \approx 130$ region
- Three even-A are studied with the *simple wobbler* formalism
  1. ^{130}Ba
  2. ^{134}Ce
  3. ^{136}Nd
- Study the excited spectra: *theoretical model checks the data?*

New Results for A=130

Recent findings for even-even nuclei

- Two wobbling bands have been identified experimentally in ^{130}**Ba** (*Petrache et al., 2019*)
- DFT+PRM description of the wobbling motion described the excited spectra (*Chen et al., 2019*)
- Stable triaxiality for $\beta = 0.24$ and $\gamma = 21.5°$

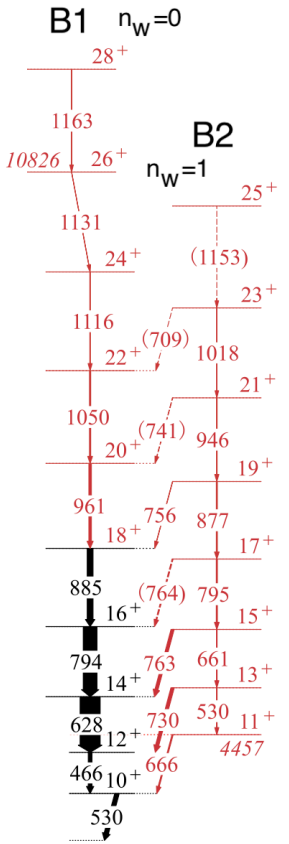


Figure from Petrache et al., 2019