UNIVERSITY OF NOTRE DAME

I S N A P

Wobbling motion in A$\sim$190 region

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Fifth Joint Meeting of the DNP of the APS and the JPS

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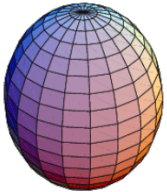
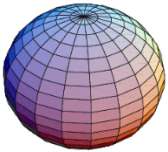
University of Notre Dame

Nuclear Shapes

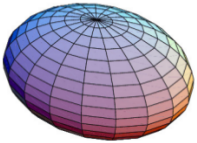
Prolate

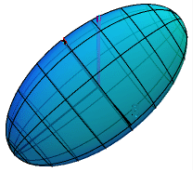


Spherical



Oblate



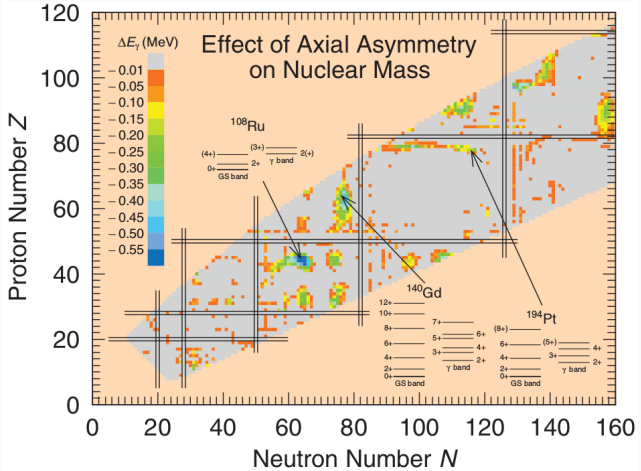


Triaxial Nucleus

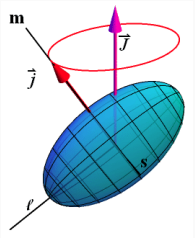
Triaxial Region

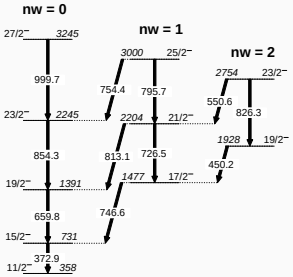
Triaxiality - A rare phenomenon!

P. Möller et. al. PRL 97, 162502 (2006)



Wobbling - Unique fingerprint of Triaxiality



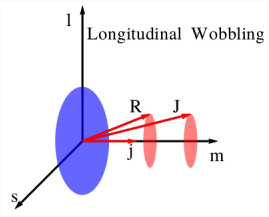


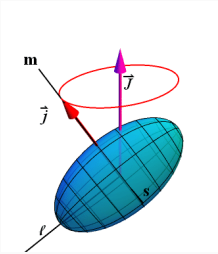
- Analog of the spinning motion of an asymmetric top.
- Oscillation of a principal axis about the space fixed $\vec{J}$.

Standard fingerprints for Wobbling bands:

- Rotational bands corresponding to n_w = 0, 1, 2, ...
- Transitions from $n_{w+1} \rightarrow n_w$ (Δn_w = +1)
- Interband Transitions are ΔI = 1, E2

Wobbling in odd-A nuclei - Types of Wobbling(1/2)





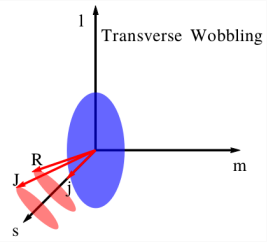
- Odd-particle aligned with axis with max. MOI (m-axis).
- $\mathcal{J}_3 > \mathcal{J}_2$ and $\mathcal{J}_3 > \mathcal{J}_1$
- Longitudinal wobbling: $\mathcal{J}_3 = \mathcal{J}_m$

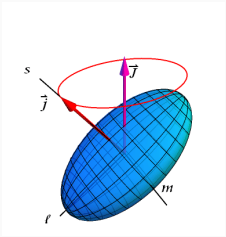
Wobbling energy, $\hbar\omega_w = \frac{j}{\mathcal{J}_3}\left[\left(1+\frac{J}{j}\left(\frac{\mathcal{J}_3}{\mathcal{J}_1}-1\right)\right)\left(1+\frac{J}{j}\left(\frac{\mathcal{J}_3}{\mathcal{J}_2}-1\right)\right)\right]^{1/2}$

$\Longrightarrow$ E_{wobb} increases with J.

S.Frauendorf and F.Dönau, Phys. Rev. C 89, 014322 (2014)

Wobbling in odd-A nuclei - Types of Wobbling(2/2)





- Odd-particle aligned perpendicular to axis with max. MOI (s- or l-axis).
- $\mathcal{J}_3 < \mathcal{J}_2$ and $\mathcal{J}_3 > \mathcal{J}_1$
- Transverse wobbling: $\mathcal{J}_3 = \mathcal{J}_s$

Wobbling energy, $\hbar\omega_w = \frac{j}{\mathcal{J}_3}\left[\left(1+\frac{J}{j}\left(\frac{\mathcal{J}_3}{\mathcal{J}_1}-1\right)\right)\left(1+\frac{J}{j}\left(\frac{\mathcal{J}_3}{\mathcal{J}_2}-1\right)\right)\right]^{1/2}$

$\Longrightarrow$ E_{wobb} decreases with J.

S.Frauendorf and F.Dönau, Phys. Rev. C 89, 014322 (2014)

More on wobbling...

- ^{163}Lu - first observation of wobbling in 2001.
- For long, wobbling known in only 5 nuclei: ^{161}Lu, ^{163}Lu, ^{165}Lu, ^{167}Lu and ^{167}Ta.

  Eur. Phys. J. A 24 (2005), PRL 86(2001), PLB 552 (2003), PLB 553 (2003), PRC 80 (2009)
- All in A$\sim$160 region.

- Breakthrough observation in 2015 - Wobbling found in ^{135}Pr.

  J. T. Matta et. al., PRL 114 (2015)
- Followed by reporting of wobbling bands in ^{133}La.

  S. Biswas, et al., arxiv: nucl-ex 1608 (2016) 07840v1.

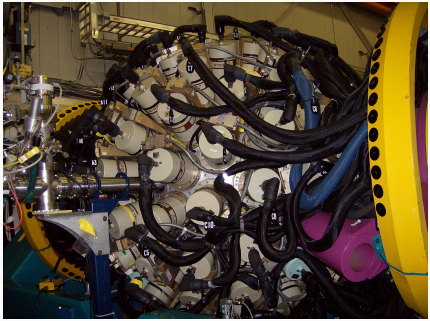
Are there other regions of nuclear chart where wobbling bands may be observed?

Exploring in A$\sim$190 region

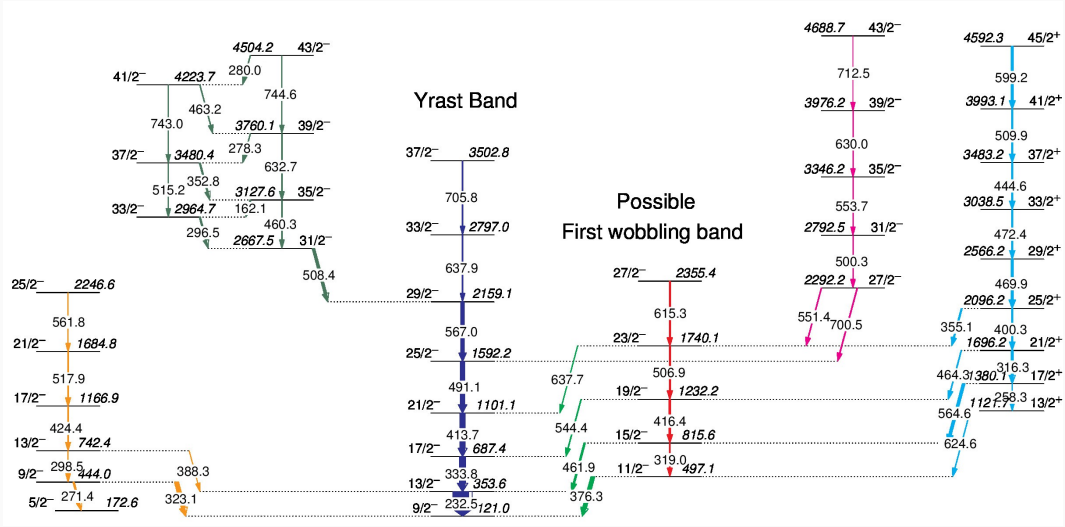
- Significant triaxiality suggested for nuclei at low spins in this mass region.
  (T. Nikšic, et. al. Part. Nucl. Phys. 66 (2011))
- Clear evidence for triaxiality provided by observation of chiral band pairs in ^{188}Ir, ^{194}Tl and ^{198}Tl.
- Our choice - ^{187}Au
  - The nucleus ^{186}Pt known to exhibit triaxial behavior.
  - Wobbling observed so far only in odd-Z nuclei.
  - The $\pi h_{9/2}$ orbital expected to lead to stabilization of triaxial shapes in this region.

Experiment

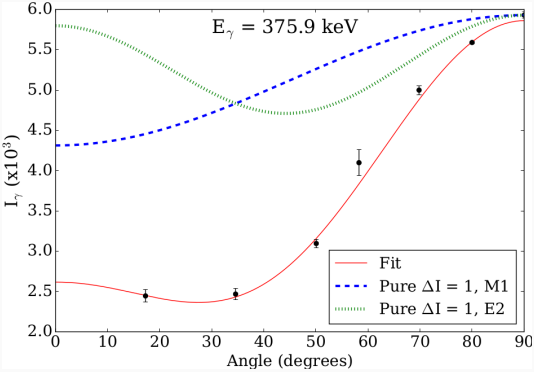
- Experiment performed using Gammasphere array at the Argonne National Laboratory.
- Reaction: ^{174}Yb(^{19}F,6n)^{187}Au at 115 MeV.
- 73 Compton suppressed Ge detectors used.
- No. of three and higher-fold γ-ray coincidence events collected - 6×10^{10}.



Partial Level Scheme of ^{187}Au



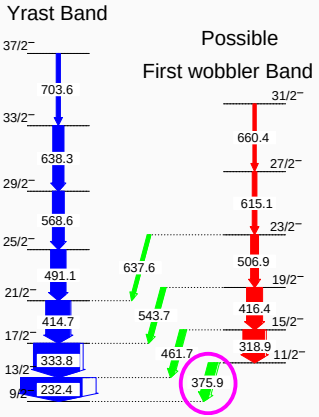
Angular Distributions (1/4)



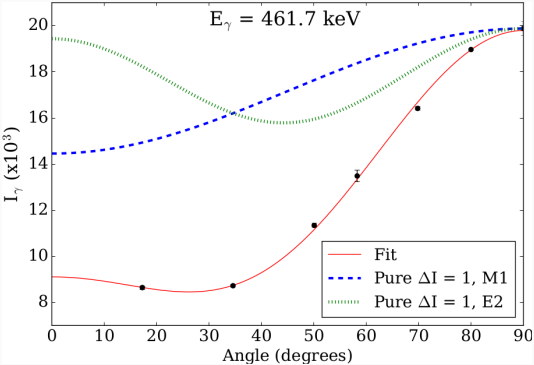
δ = **-2.62**$^{+0.09}_{-0.11}$

E2% = 87.28$^{+0.93}_{-0.76}$

E$_\gamma$ = 375.9 keV



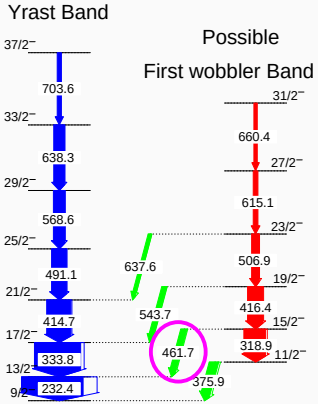
Angular Distributions (2/4)



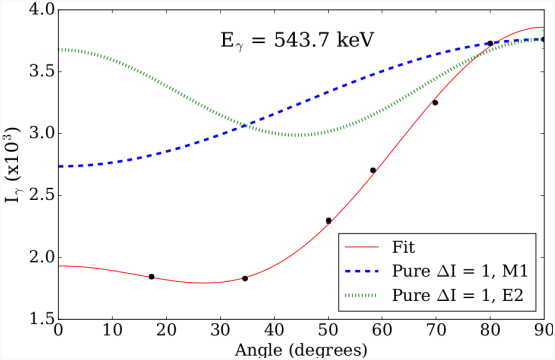
δ = **-2.97**$^{+0.04}_{-0.04}$

E2% = 89.82$^{+0.25}_{-0.25}$

E$_\gamma$ = 461.7 keV



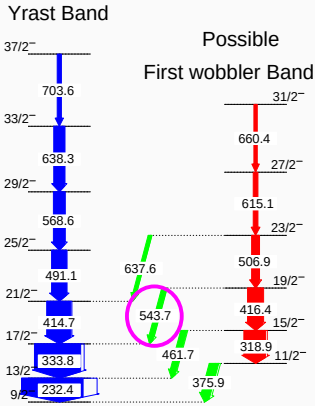
Angular Distributions (3/4)



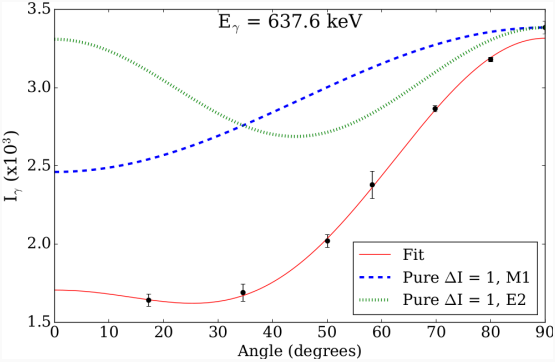
δ = **-3.45**$^{+0.05}_{-0.06}$

E2% = 92.25$^{+0.25}_{-0.21}$

E$_\gamma$ = 543.7 keV



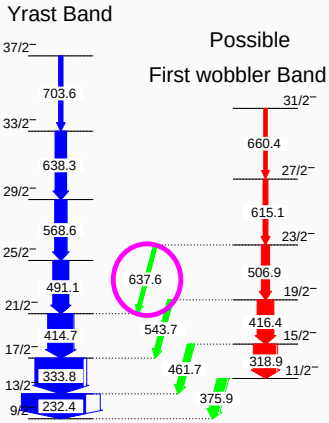
Angular Distributions (4/4)



δ = **-3.82**$^{+0.17}_{-0.19}$

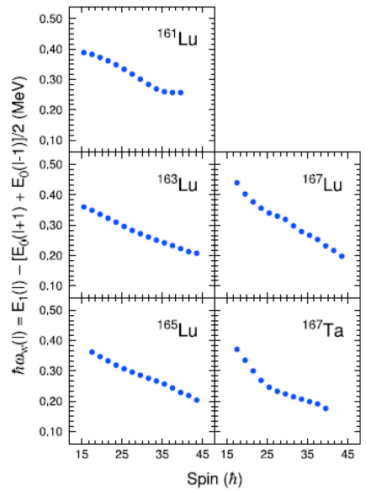
E2% = 93.59$^{+0.60}_{-0.53}$

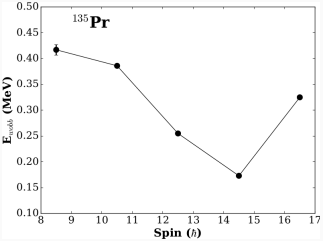
E$_\gamma$ = 637.6 keV



Wobbling Energy (1/3)

Wobbling energy (E_{wobb})- energy associated with wobbling excitations.





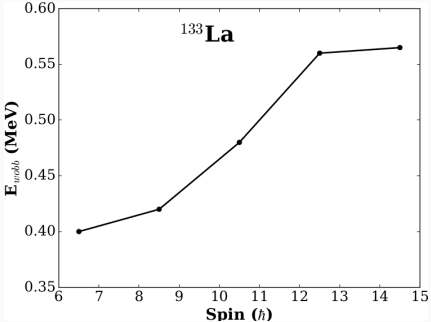
Transverse Wobbling

Odd particle aligns ⊥ to axis with maximum M.O.I

S. Frauendorf, F. Dönau, Phys. Rev. C 89 (2014)

Wobbling Energy (2/3)

Wobbling energy (E_{wobb})- energy associated with wobbling excitations.

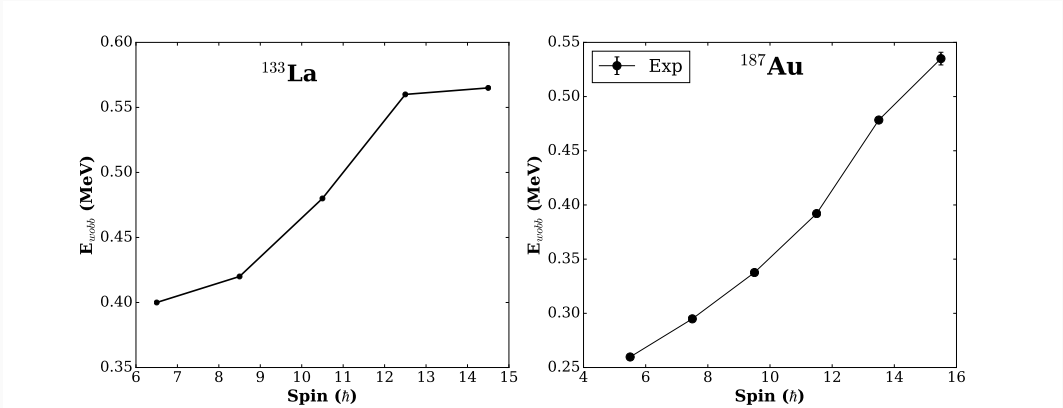


First case of Longitudinal Wobbling

Odd particle aligns parallel to axis with maximum M.O.I

Wobbling Energy (3/3)

Wobbling energy (E_{wobb})- energy associated with wobbling excitations.



^{187}Au - Only the second case of Longitudinal Wobbling!

Conclusion and Future Work

- Wobbling motion has been investigated in the A$\sim$190 region.
- ^{187}Au - clear observation of wobbling bands.
- ^{187}Au - only the second case of *Longitudinal wobbling*.
- Calculations in the framework of the Particle Rotor Model (PRM) being done to affirm experimental observations.

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