Why are there much more prolate nuclei than oblate ones?

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- Macroscopic (Coulomb) or collective effects (W. Zickendraht, 1985) 
  are not strong enough.
- Shell effect of anisotropic harmonic oscillator (Castel et al., 1990) 
  is rather neutral.
- Woods-Saxon radial profile (H. Frisk, 1990)
- unique-parity high-J intruder due to spin-orbit potential (N.T. et al., 1996)

We study the ratio of prolate nuclei among well deformed nuclei, $R_p$, as a function of the strengths of $ls$ and $l^2$ potentials of the Nilsson model.

$$U(r) = \frac{1}{2} \left( \omega_{\perp}^2 z^2 + \omega_{\parallel}^2 y^2 + \omega_{\parallel}^2 z^2 \right) + 2\hbar \omega_{\perp} r^2 \sqrt{\frac{4\pi}{9}} \epsilon_4 Y_{40}(\hat{r})$$
+ $f_\perp 2\kappa \hbar \omega_{\parallel,1} \cdot s - f_\parallel \kappa \mu \hbar \omega_{0} \left( i_\perp^2 - (i_\perp^2)_N \right)$

- volume conservation: $\omega_{\parallel}^2 \omega_{\perp} = \text{constant} \rightarrow \omega_{\perp}(\epsilon_2), \omega_{\parallel}(\epsilon_2)$
- $\epsilon_4$ optimized for each $\epsilon_2$
- standard $\kappa$ and $\mu$ of Bengtsson and Ragnarsson (1985)
- pairing force such that average pairing gap $\tilde{\Delta} = 13/\sqrt{A}$ MeV
- Strutinsky method
- 1834 even even nuclei with $8 \leq Z \leq 126$ and $8 \leq N \leq 184$ between drip lines for each of $17 \times 17$ sets of $(f_{\parallel}, f_{\perp})$
Summary of the results

1. Standard $l$ - s and $l^2 \Rightarrow R_p = 0.86$.

2. Changing $l$ - s strength $\Rightarrow$ Strong interference:

\[
\begin{array}{c|cccc}
  f_{ls} & -1 & -0.5 & 0 & 0.5 & 1 \\
  R_p & 0.81 & 0.44 & 0.78 & 0.45 & 0.86 \\
\end{array}
\]

3. H. Frisk's idea is confirmed.

($f_{ls} = 0$ line)

4. Harmonic oscillator has a weak prolate preference

($R_p = 0.55$ at $f_{ll} = f_{ls} = 0$)

5. $Y_40$ enhances prolate dominance by 0.03-0.05

6. Pairing weakens prolate dominance slightly

Discussion

Prolate dominance observed in real nuclei may be a result of an accidental combination of the strengths of the two potentials.

Frisk's idea applies in situations where there is

- spin decoupling at $(f_{ll}, f_{ls}) = (1, 0)$
- pseudo spin decoupling at $(f_{ll}, f_{ls}) = (1, 1)$
- any kind of spin decoupling at $(f_{ll}, f_{ls}) = (1, -1)$?

There has been opinions (intuitions) that

the pseudo spin symmetry must have a fundamental origin,


The prolate dominance may also be the same.