Prolate – Oblate Shape Transition in the Proxy - SU(3) Model

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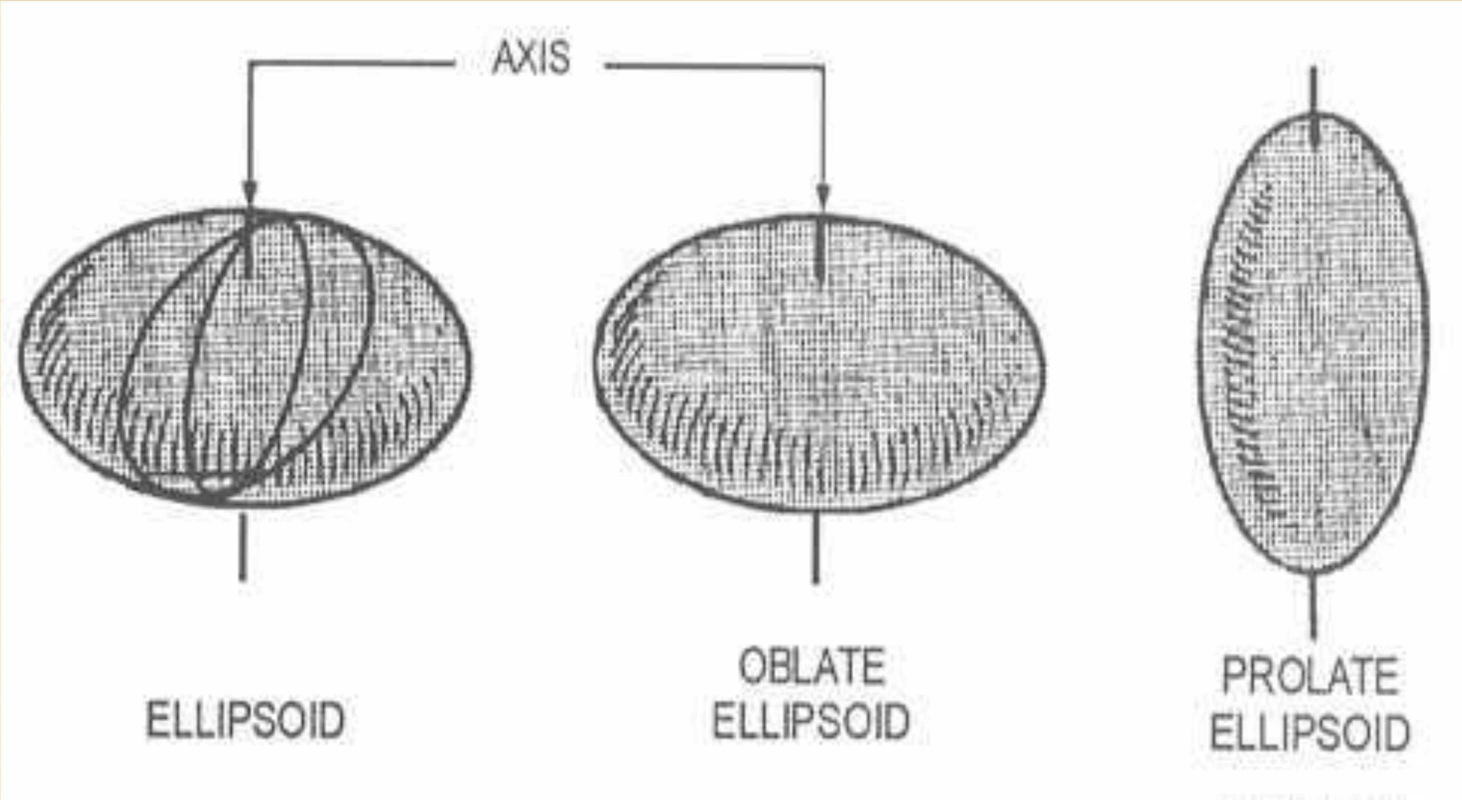


Prolate – Oblate Shape Phase Transition

The Phenomenon Into The Years

- 1978 : $^{192}\mathrm{Os}$ R. F. Casten et al, PLB76
- 2003 : $\mathrm{Hf} - \mathrm{Hg}$ J. Jolie, A. Linnemann, PRC68
- 2007 : $^{190}\mathrm{W}$ Yang Sun et al, PLB659
- 2011 : Yb, Hf, W, Os and Pt Nomura et al, PRC84

Prolate-Oblate Phase Transition In The Hf-Hg region

N	108	108	110	112	112	114	**116**	116	118	118	120
Nucleus	^{180}Hf	^{182}W	^{184}W	^{186}W	^{188}Os	^{190}Os	^{192}Os	^{194}Pt	^{196}Pt	^{198}Hg	^{200}Hg
(λ,μ)	(40,20)	(34,24)	(34,20)	(36,12)	(32,12)	(22,22)	**(14,28)**	(12,24)	(6,26)	(6,18)	(2,16)
$R_{4/2}$	3.307	3.291	3.274	3.242	3.083	2.934	**2.820**	2.470	2.465	2.546	2.574

prolate

oblate

$\lambda<\mu$

* J. JOLIE AND A. LINNEMANN, Phys. Rev. C 68, 031301 (R) (2003)

Prolate to Oblate shape phase transition in Os

N	96	98	100	102	104	106	108	110	112	114	**116**	118
Nucleus	^{172}Os	^{174}Os	^{176}Os	^{178}Os	^{180}Os	^{182}Os	^{184}Os	^{186}Os	^{188}Os	^{190}Os	^{192}Os	^{194}Os
(λ,μ)	(36,18)	(36,20)	(38,18)	(42,12)	(36,20)	(32,24)	(30,24)	(30,20)	(32,12)	(22,22)	**(14,28)**	(8,30)
$R_{4/2}$	2.661	2.740	2.925	3.016	3.091	3.154	3.204	3.165	3.083	2.934	**2.820**	2.753

prolate

oblate

$\lambda<\mu$

Prolate to Oblate shape phase transition in W

N	94	96	98	100	102	104	106	108	110	112	114	**116**	118
Nucleus	^{168}W	^{170}W	^{172}W	^{174}W	^{176}W	^{178}W	^{180}W	^{182}W	^{184}W	^{186}W	^{188}W	^{190}W	^{192}W
(λ,μ)	(42,12)	(40,18)	(40,20)	(42,18)	(46,12)	(40,20)	(36,24)	(34,24)	(34,20)	(36,12)	(26,22)	**(18,28)**	(12,30)
$R_{4/2}$	2.815	2.953	3.067	3.172	3.209	3.241	3.262	3.291	3.274	3.242	3.091	**2.725**	-

prolate

oblate

$\lambda<\mu$

Prolate to Oblate shape phase transition in Pt (not SU(3)!)

N	106	108	110	112	114	**116**	118	120	122
Nucleus	^{184}Pt	^{186}Pt	^{188}Pt	^{190}Pt	^{192}Pt	^{194}Pt	^{196}Pt	^{198}Pt	^{200}Pt
(λ,μ)	(30,18)	(28,20)	(28,16)	(30,8)	(20,18)	**(12,24)**	(6,26)	(2,24)	(0,18)
$R_{4/2}$	2.675	2.559	2.525	2.492	2.479	**2.470**	2.465	2.419	2.358

prolate

oblate

$\lambda<\mu$

The Proxy - SU(3) scheme model

TABLE II: Most leading SU(3) irreps [34, 35] for nuclei with protons in the 50-82 shell and neutrons in the 82-126 shell. Boldface numbers indicate nuclei with $R_{4/2} = E(4_1^+)/E(2_1^+) \geq 2.8$, while * denotes nuclei with $2.8 > R_{4/2} \geq 2.5$, and ** labels a few nuclei with $R_{4/2}$ ratios slightly below 2.5, shown for comparison, while no irreps are shown for any other nuclei with $R_{4/2} < 2.5$. For the rest of the nuclei shown (using normal fonts and without any special signs attached) the $R_{4/2}$ ratios are still unknown [40]. Oblate irreps are underlined.

			Ba	Ce	Nd	Sm	Gd	Dy	Er	Yb	Hf	W	Os	Pt
		Z	56	58	60	62	64	66	68	70	72	74	76	78
		Z_{val}	6	8	10	12	14	16	18	20	22	24	26	28
N	N_{val}	irrep	(18,0)	(18,4)	(20,4)	(24,0)	(20,6)	(18,8)	(18,6)	(20,0)	(12,8)	(6,12)	(2,12)	(0,8)
88	6	(24,0)	(42,0)*	(42,4)*	(44,4)*									
90	8	(26,4)	**(44,4)**	**(44,8)**	**(46,8)**	**(50,4)**	**(46,10)**	**(44,12)**	(44,10)*	(46,4)*	(38,12)*			
92	10	(30,4)	**(48,4)**	**(48,8)**	**(50,8)**	**(54,4)**	**(50,10)**	**(48,12)**	**(48,10)**	**(50,4)**	(42,12)*			
94	12	(36,0)	(54,0)	**(54,4)**	**(56,4)**	**(60,0)**	**(56,6)**	**(54,8)**	**(54,6)**	**(56,0)**	**(48,8)**	**(42,12)**	(38,12)*	
96	14	(34,6)	(52,6)	(52,10)	**(54,10)**	**(58,6)**	**(54,12)**	**(52,14)**	**(52,12)**	**(54,6)**	**(46,14)**	**(40,18)**	(36,18)*	
98	16	(34,8)	(52,8)	(52,12)	(54,12)	**(58,8)**	**(54,14)**	**(52,16)**	**(52,14)**	**(54,8)**	**(46,16)**	**(40,20)**	(36,20)*	
100	18	(36,6)	(54,6)	(54,10)	(56,10)	(60,6)	**(56,12)**	**(54,14)**	**(54,12)**	**(56,6)**	**(48,14)**	**(42,18)**	**(38,18)**	(36,14)*
102	20	(40,0)	(58,0)	(58,4)	(60,4)	(64,0)	**(60,6)**	**(58,8)**	**(58,6)**	**(60,0)**	**(52,8)**	**(46,12)**	**(42,12)**	(40,8)*
104	22	(34,8)	(52,8)	(52,12)	(54,12)	(58,8)	(54,14)	**(52,16)**	**(52,14)**	**(54,8)**	**(46,16)**	**(40,20)**	**(36,20)**	(34,16)*
106	24	(30,12)	(48,12)	(48,16)	(50,16)	(54,12)	(50,18)	(48,20)	**(48,18)**	**(50,12)**	**(42,20)**	**(36,24)**	**(32,24)**	(30,20)*
108	26	(28,12)	(46,12)	(46,16)	(48,16)	(52,12)	(48,18)	(46,20)	(46,18)	**(48,12)**	**(40,20)**	**(34,24)**	**(30,24)**	(28,20)*
110	28	(28,8)	(46,8)	(46,12)	(48,12)	(52,8)	(48,14)	(46,16)	(46,14)	(48,8)	**(40,16)**	**(34,20)**	**(30,20)**	(28,16)*
112	30	(30,0)	(48,0)	(48,4)	(50,4)	(54,0)	(50,6)	(48,8)	(48,6)	(50,0)	**(42,8)**	**(36,12)**	**(32,12)**	(30,8)**
114	32	(20,10)	(38,10)	(38,14)	(40,14)	(44,10)	(40,16)	(38,18)	(38,16)	(40,10)	(32,18)	**(26,22)**	**(22,22)**	(20,18)**
116	34	(12,16)	(30,6)	(30,10)	(32,10)	(36,6)	(32,12)	(30,14)	(30,12)	(32,6)	(24,14)	(18, 28)*	**(14, 28)**	(12, 24)**
118	36	(6,18)	(24,18)	(24,22)	(26,22)	(30,18)	(26,24)	(24,16)	(24,24)	(26,18)	(18, 26)	(12, 30)	(8, 30)*	(6, 26)**
120	38	(2,16)	(20,16)	(20,20)	(22,20)	(26,16)	(22,22)	(20, 24)	(20, 22)	(22,16)	(14, 24)	(8, 28)	(4, 28)*	(2, 24)**

TABLE III: Same as Table II, but for the most leading SU(3) irreps [34, 35] for nuclei with protons in the 50-82 shell and neutrons in the 50-82 shell.

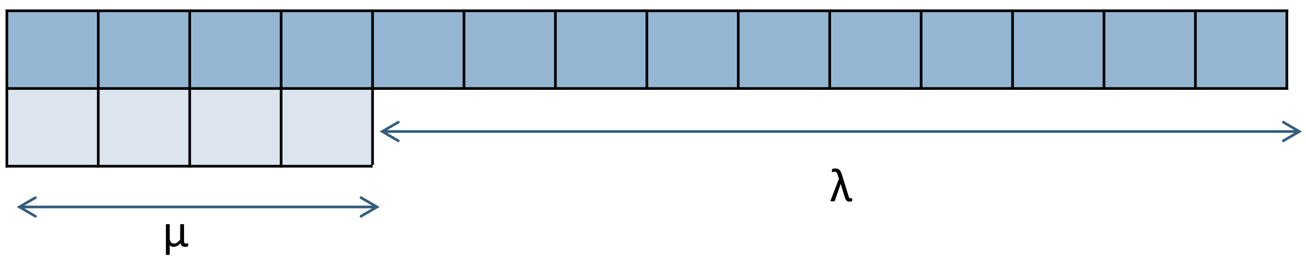
			Ba	Ce	Nd	Sm	Gd	Dy	Er	Yb	Hf	W	Os	Pt
		Z	56	58	60	62	64	66	68	70	72	74	76	78
		Z_{val}	6	8	10	12	14	16	18	20	22	24	26	28
N	N_{val}	irrep	(18,0)	(18,4)	(20,4)	(24,0)	(20,6)	(18,8)	(18,6)	(20,0)	(12,8)	(6,12)	(2,12)	(0,8)
56	6	(18,0)	(36,0)	(36,4)	(38,4)	(42,0)	(38,6)	(36,8)	(36,6)	(38,0)	(30,8)	(24,12)	(20,12)	(18,8)
58	8	(18,4)	(36,4)	(36,8)	(38,8)	(42,4)	(38,10)	(36,12)	(36,10)	(38,4)	(30,12)	(24,16)	(20,16)	(18,12)
60	10	(20,4)	(28,4)	(38,8)	(40,8)	(44,4)	(40,10)	(38,12)	(38,10)	(40,4)	(32,12)	(26,16)	(22,16)	(20,12)
62	12	(24,0)	**(42,0)**	(42,4)	(44,4)	(48,0)	(44,6)	(42,8)	(42,6)	(44,0)	(36,8)	(30,12)	(26,12)	(24,8)
64	14	(20,6)	**(38,6)**	**(38,10)**	(40,10)	(44,6)	(40,12)	(38,14)	(38,12)	(40,6)	(32,14)	(26,18)	(22,18)	(20,14)
66	16	(18,8)	**(36,8)**	**(36,12)**	(38,12)	(32,8)	(38,14)	(36,16)	(36,14)	(38,8)	(30,16)	(24,20)	(20,20)	(18,16)
68	18	(18,6)	**(36,6)**	**(36,10)**	**(38,10)**	(42,6)	(38,12)	(36,14)	(36,12)	(38,6)	(30,14)	(24,18)	(20,18)	(18,14)
70	20	(20,0)	(38,0)*	**(38,4)**	**(40,4)**	**(44,0)**	(40,6)	(38,8)	(38,6)	(40,0)	(32,8)	(26,12)	(22,12)	(20,8)
72	22	(12,8)	(30,8)*	(30,12)*	**(32,12)**	**(36,8)**	(32,14)	(30,16)	(30,14)	(32,8)	(24,16)	(18, 20)	(14, 20)	(12, 16)
74	24	(6,12)	(24,12)*	(24,16)*	(26,16)*	(30,12)*	(26,18)*	**(24,20)**	(24,18)	(26,12)	(18, 20)	(12, 24)	(8, 24)	(6, 20)
76	26	(2,12)		(20,16)*	(22,16)*	(26,12)*	(22,18)*	(20,20)*	(20,18)	(22,12)	(14, 20)	(8, 24)	(4, 24)	(2, 20)
78	28	(0,8)							(18,14)	(20,8)	(12, 16)	(6, 20)	(2, 20)	(0, 16)

Young Diagram

$$\gamma = \arctan\left(\frac{\sqrt{3}(\mu+1)}{2\lambda+\mu+3}\right)$$

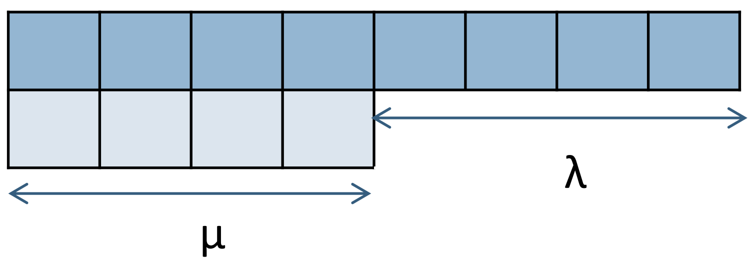
Prolate

For λ>>μ, γ≈0



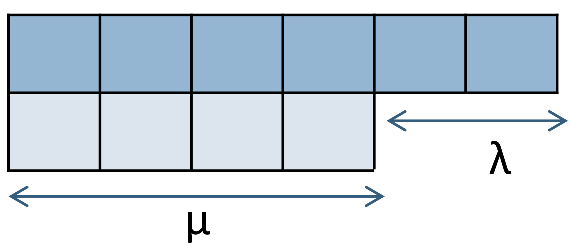
Phase Transition

For λ=μ, $\gamma = 30^{o}$



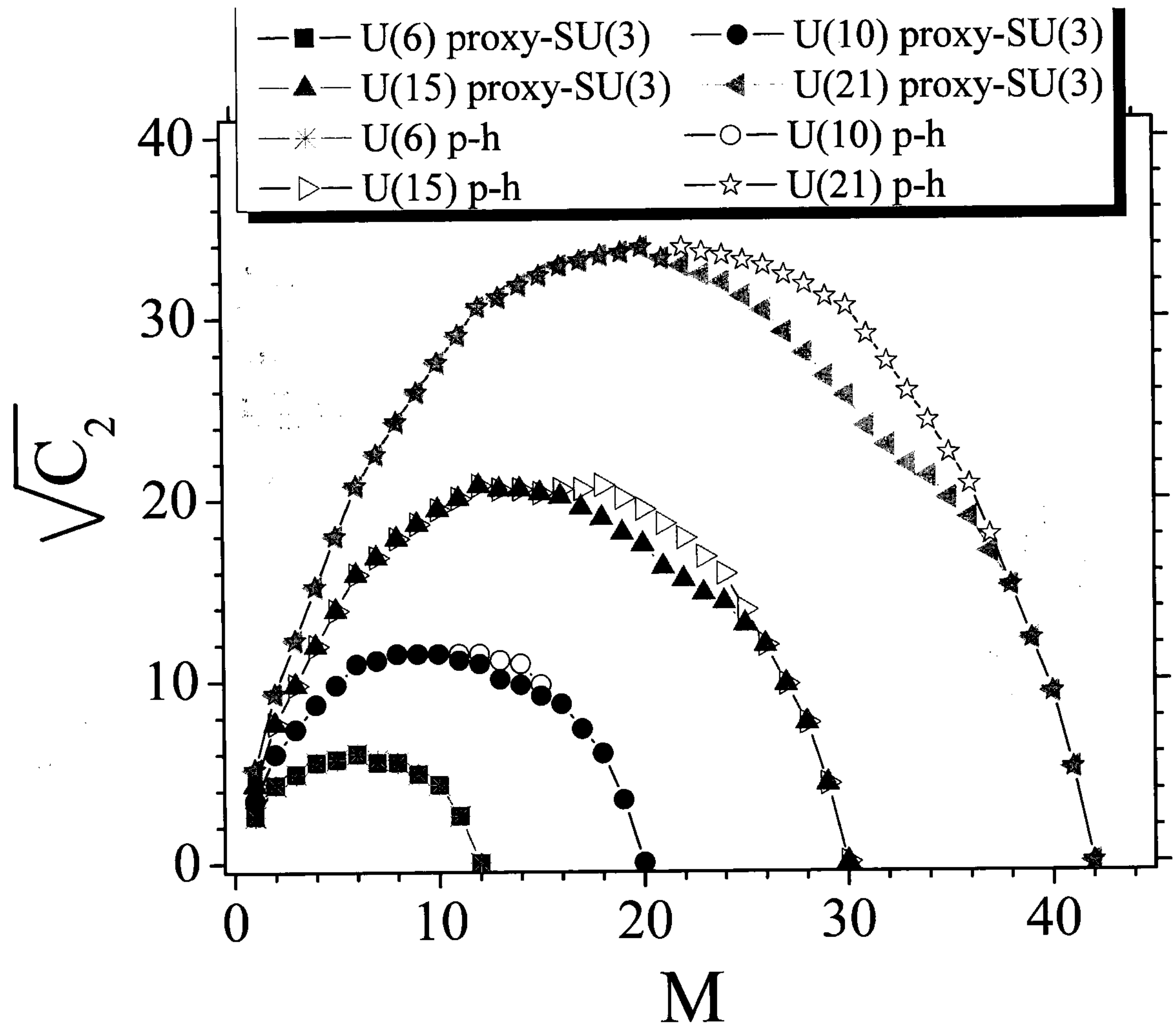
Oblate

For λ<<μ, $\gamma \approx 60^{o}$

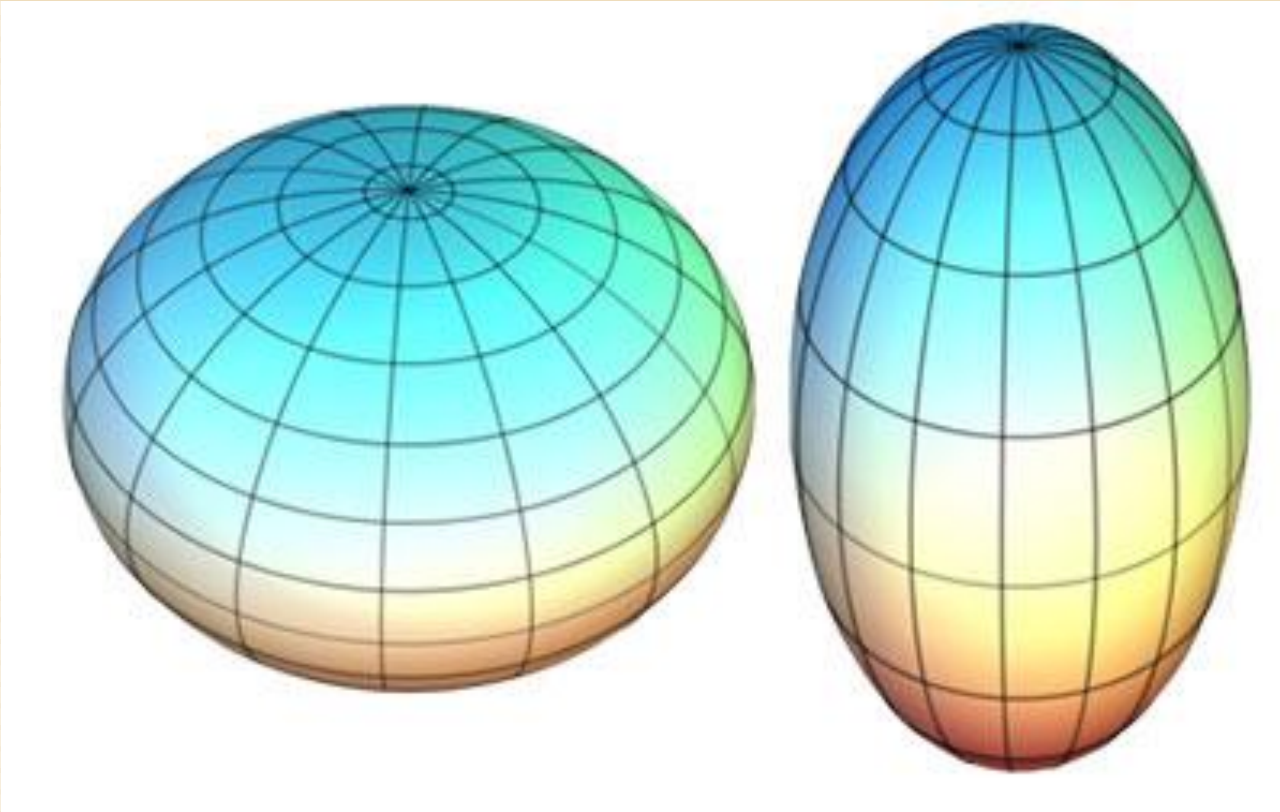


Destruction of particle-hole symmetry

N	irrep	8-20 sd U(6) hw	8-20 sd U(6) C	28-50 pf U(10) hw	28-50 pf U(10) C
0		(0,0)	(0,0)	(0,0)	(0,0)
1	[1]	(2,0)	(2,0)	(3,0)	(3,0)
2	[2]	(4,0)	(4,0)	(6,0)	(6,0)
3	[21]	(4,1)	(4,1)	(7,1)	(7,1)
4	[2^2]	(4,2)	(4,2)	(8,2)	(8,2)
5	[$2^2$1]	(5,1)	(5,1)	(10,1)	(10,1)
6	[2^3]	(6,0)	(0,6)	(12,0)	(12,0)
7	[$2^3$1]	**(4,2)**	(1,5)	(11,2)	(11,2)
8	[2^4]	(2,4)	(2,4)	(10,4)	(10,4)
9	[$2^4$1]	(1,4)	(1,4)	(10,4)	(10,4)
10	[2^5]	(0,4)	(0,4)	(10,4)	(4,10)
11	[$2^5$1]	(0,2)	(0,2)	**(11,2)**	(4,10)
12	[2^6]	(0,0)	(0,0)	**(12,0)**	(4,10)
13	[$2^6$1]			**(9,3)**	(2,11)
14	[2^7]			**(6,6)**	(0,12)
15	[$2^7$1]			**(4,7)**	(1,10)
16	[2^8]			(2,8)	(2,8)
17	[$2^8$1]			(1,7)	(1,7)
18	[2^9]			(0,6)	(0,6)
19	[$2^9$1]			(0,3)	(0,3)
20	[2^{10}]			(0,0)	(0,0)



U(6) proxy-SU(3)
U(10) proxy-SU(3)
U(15) proxy-SU(3)
U(21) proxy-SU(3)
U(6) p-h
U(10) p-h
U(15) p-h
U(21) p-h
40
30
20
10
0
$\sqrt{C_2}$
0
10
20
30
40
M



Conclusions

THE PROXY SU(3) SCHEME

- The dominance of prolate over oblate deformation is obtained without any free parameters.
- The occurrence of the prolate-oblate transition at $N \approx 116$ comes out correctly in the W and Os chains of isotopes, while predictions are made for $Z<74$.
- Predictions are made concerning the prolate-oblate transition in the region of the (yet unknown) neutron-deficient rare earths around $N \approx 72$.

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HAVE A NICE SUMMER!!!

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