

Proton-neutron pairs in heavy deformed nuclei

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How do regular and simple patterns emerge
in the structure of complex nuclei?

(NuPECC Long Range Plan 2010)

new coupling scheme

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**Emergent collectivity in nuclei and
enhanced proton-neutron interactions**

D. Bonatsos, S. Karampagia (Demokritos)

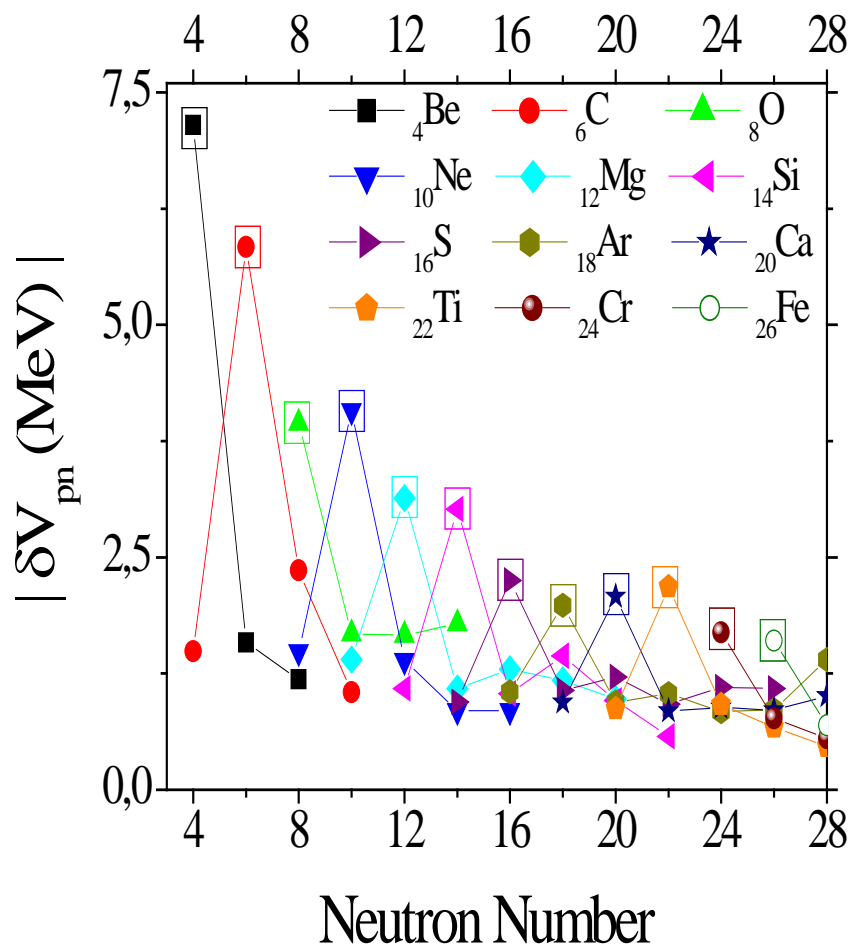
R. B. Cakirli, L. Amon Susam (Istanbul)

R. F. Casten (Yale)

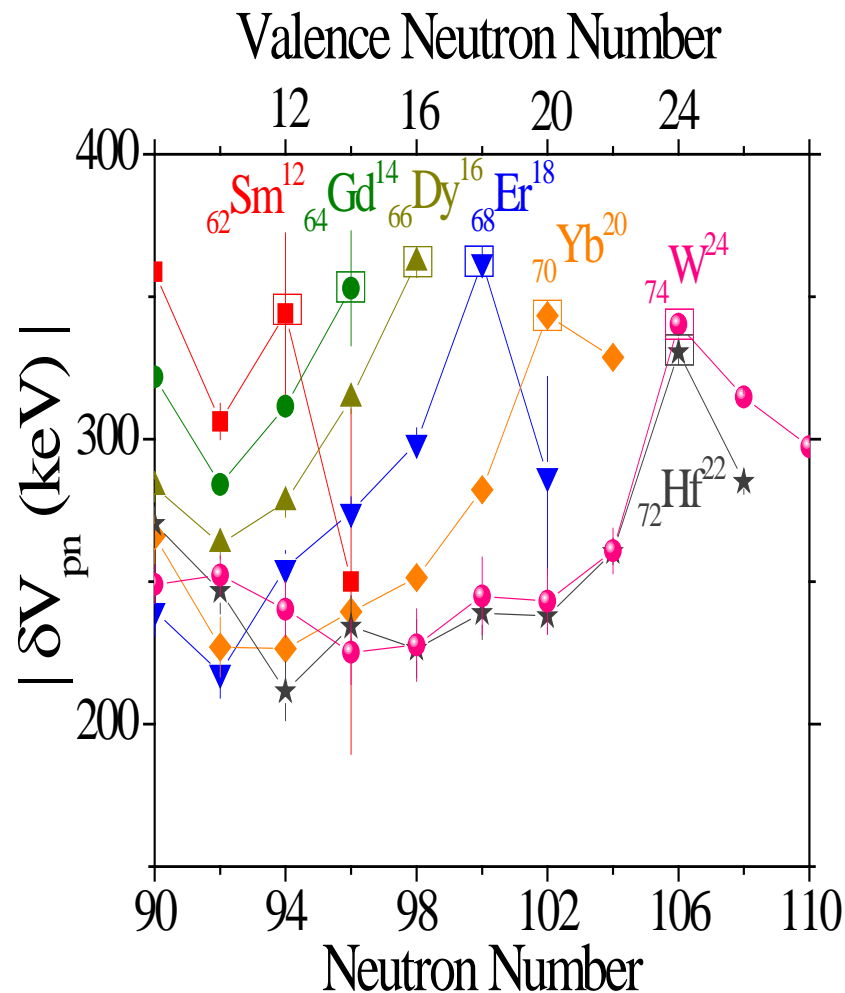
K. Blaum (MPI Heidelberg)

$$\delta V_{pn}(Z,N) = (B(Z,N) - B(Z,N-2) - B(Z-2,N) + B(Z-2,N-2)) / 4$$

light nuclei
spikes at N=Z



heavy nuclei
spikes at Nval=Zval

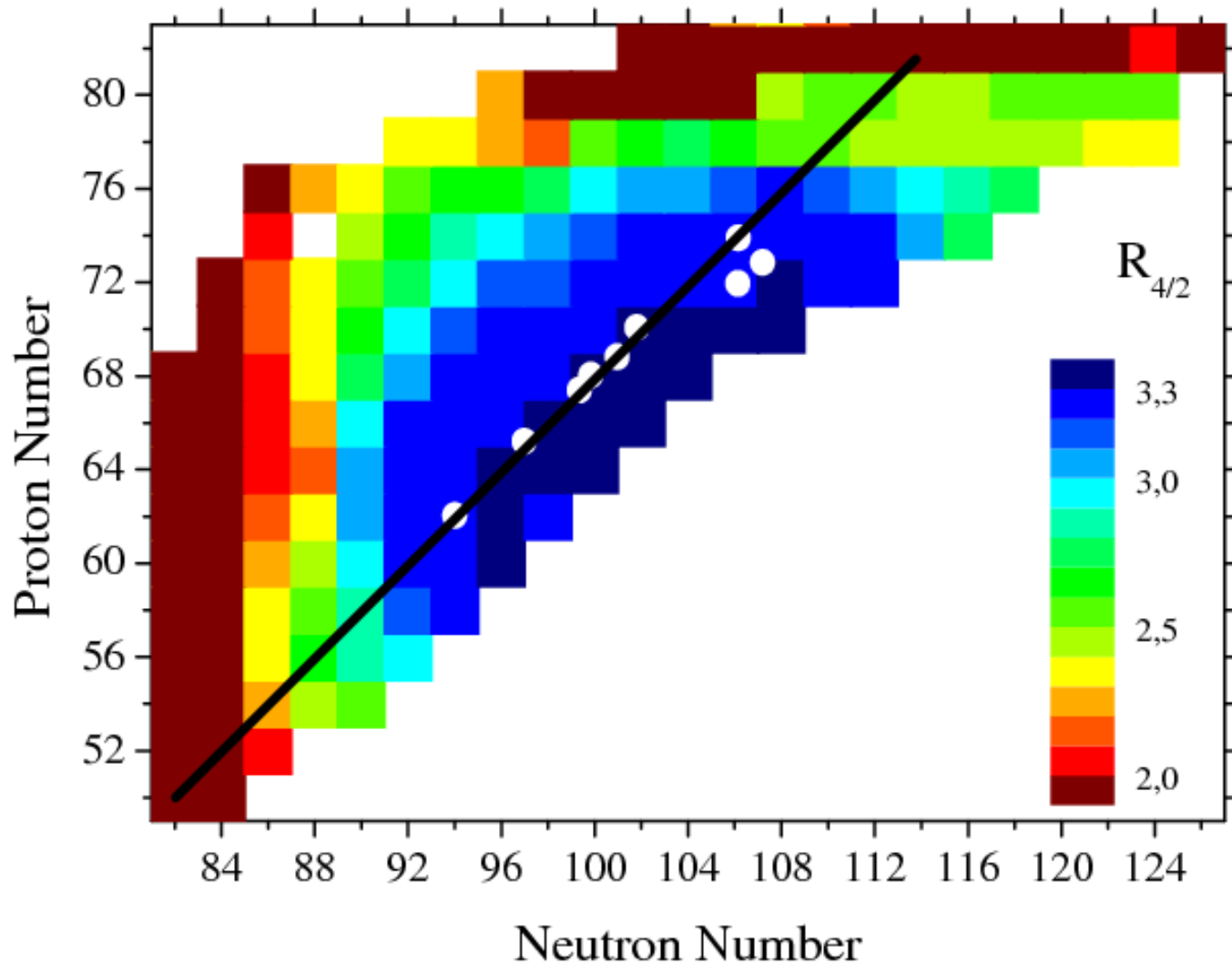


- Light nuclei
SU(4) Wigner supermultiplet
(T=1, S=0) and (T=0, S=1) pairs
- Heavy nuclei
Nilsson 0[110] pairs
 $\Delta K [\Delta N \Delta n_z \Delta \Lambda]$

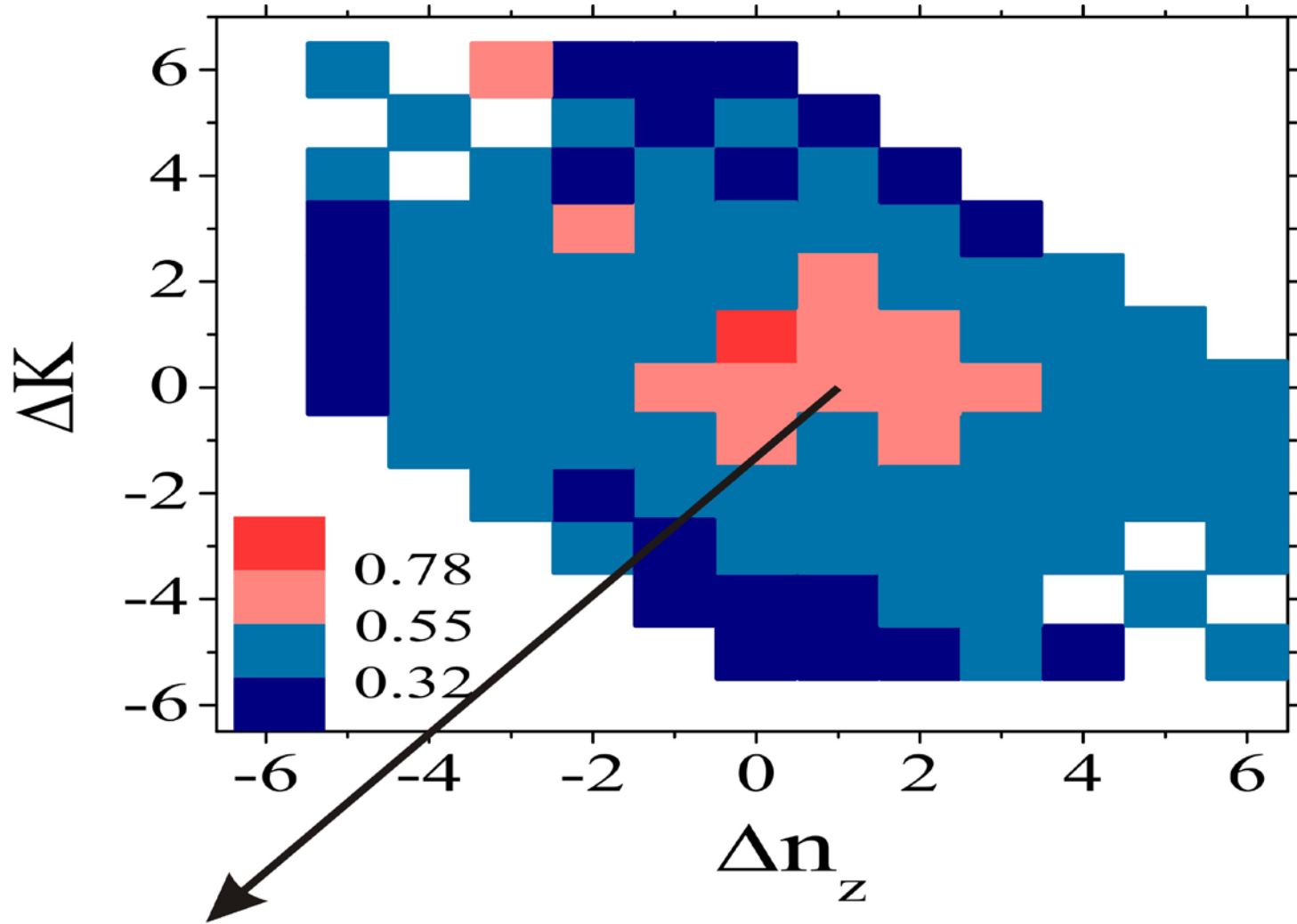
δV_{pn} peaks

	Z	N	last protons	last neutrons
168Er	68	100	7/2[523]	7/2[633]
172Yb	70	102	1/2[411]	1/2[521]
178Hf	72	106	7/2[404]	7/2[514]
180W	74	106	7/2[404]	7/2[514]
			K[N Nz Λ]	S=1

$$R_{4/2} = E(4)/E(2)$$

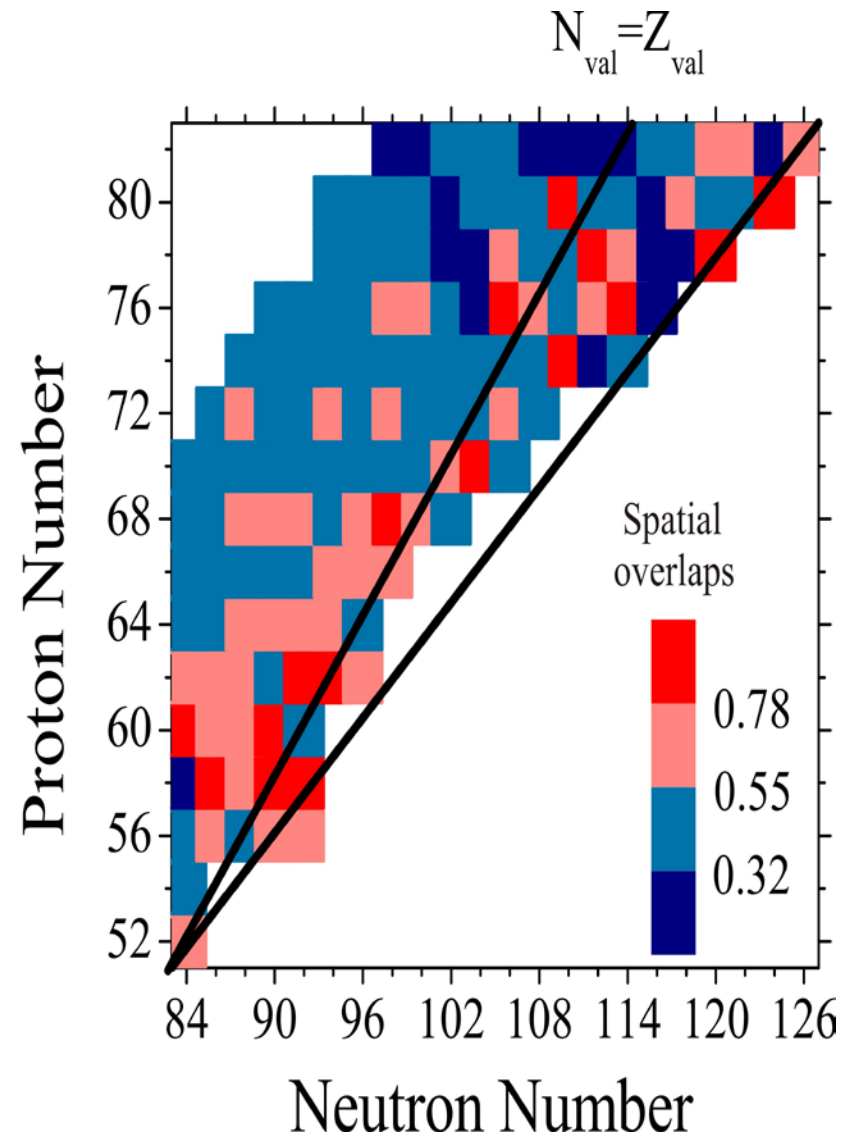
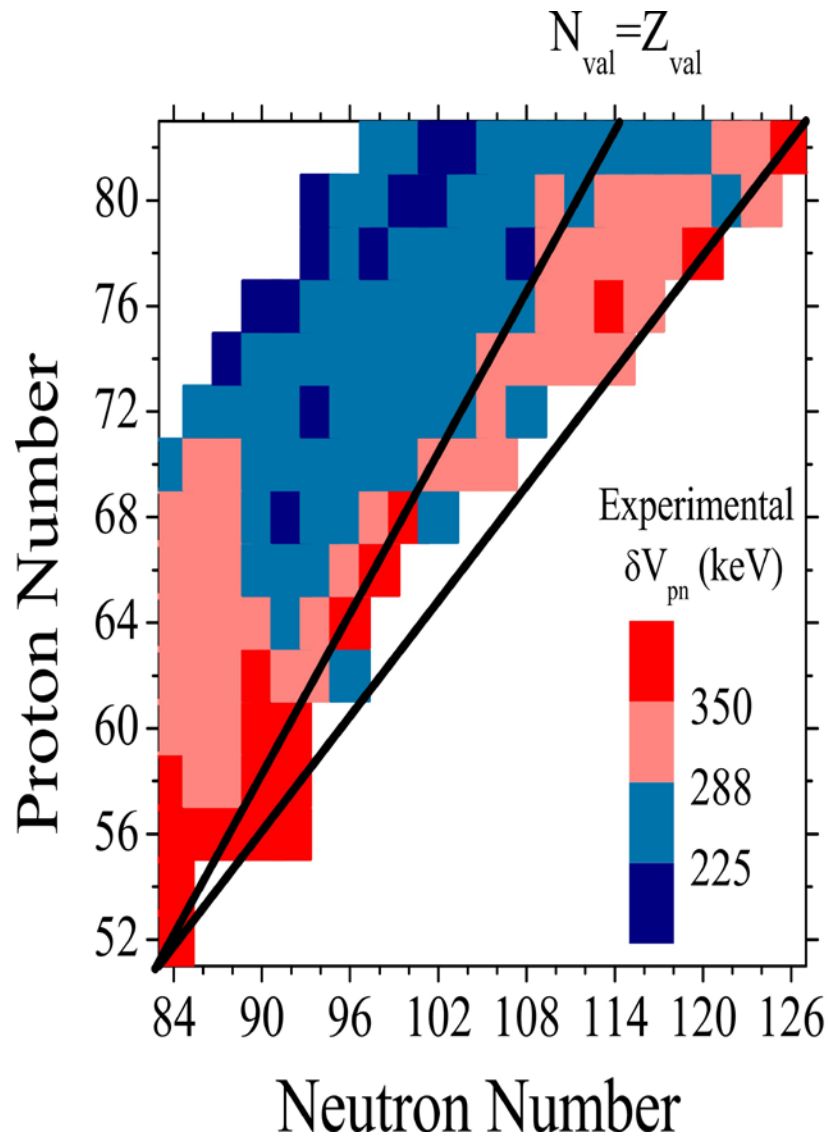


Nilsson model overlaps

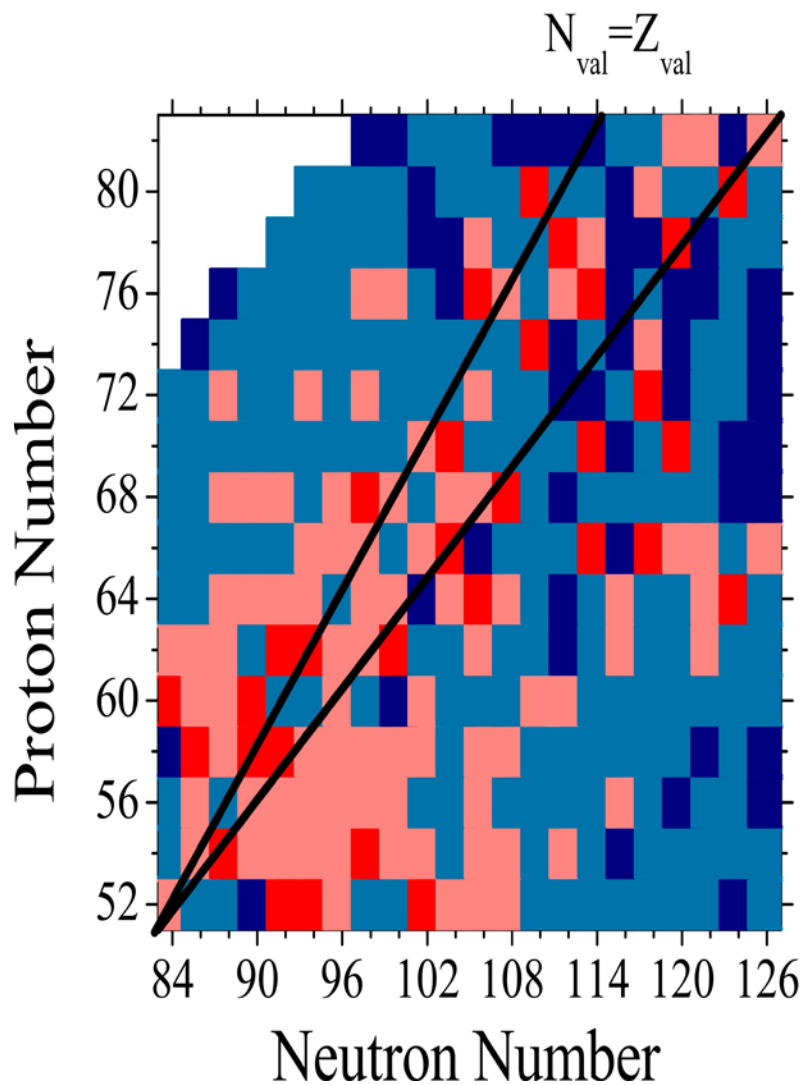


$\Delta K[\Delta N \ \Delta n_z \ \Delta \Lambda] = 0[110]$ pairs

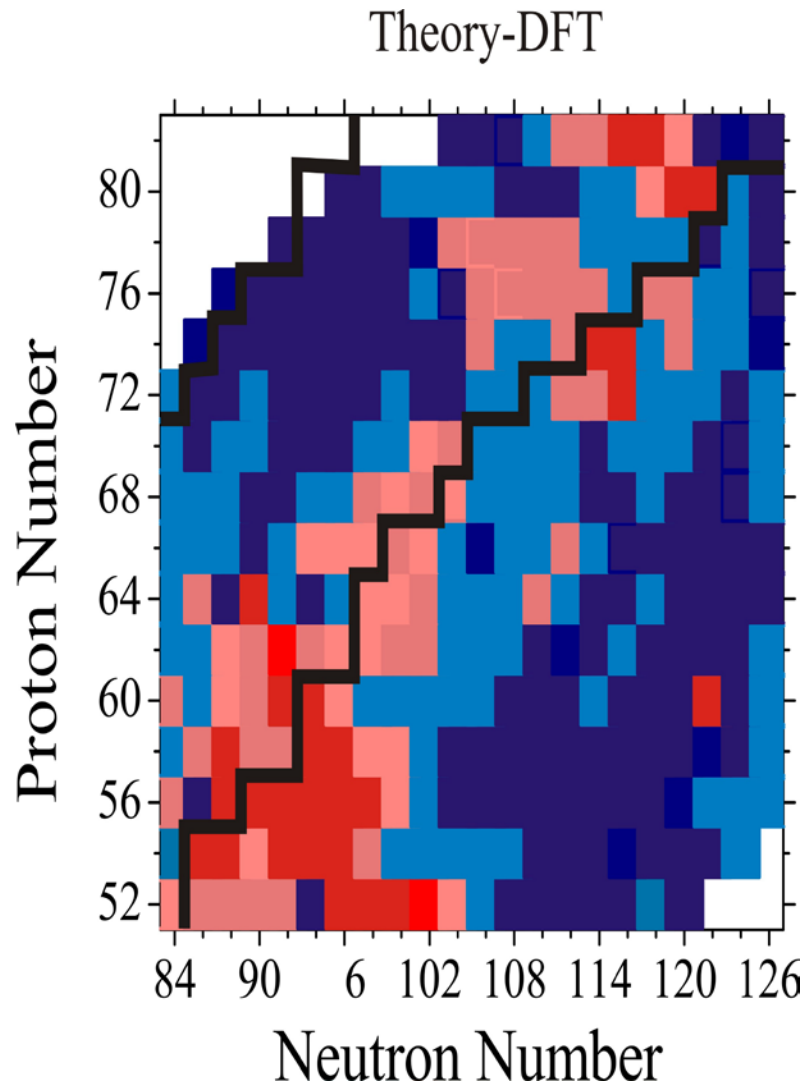
Nilsson model overlaps



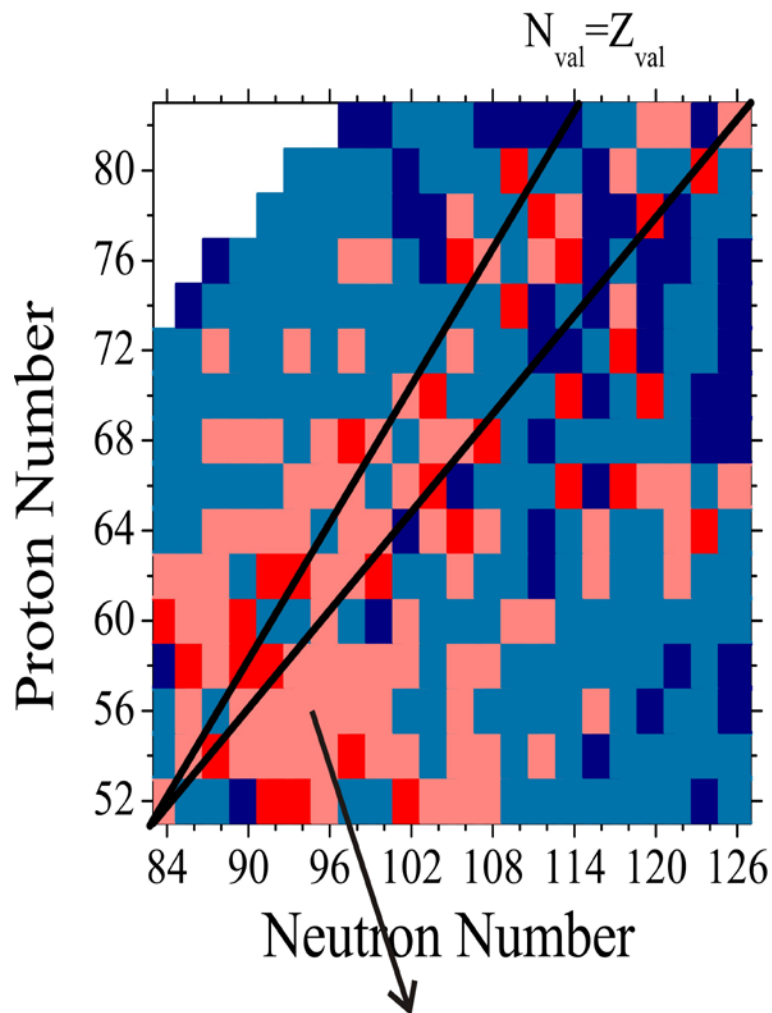
Nilsson



DFT

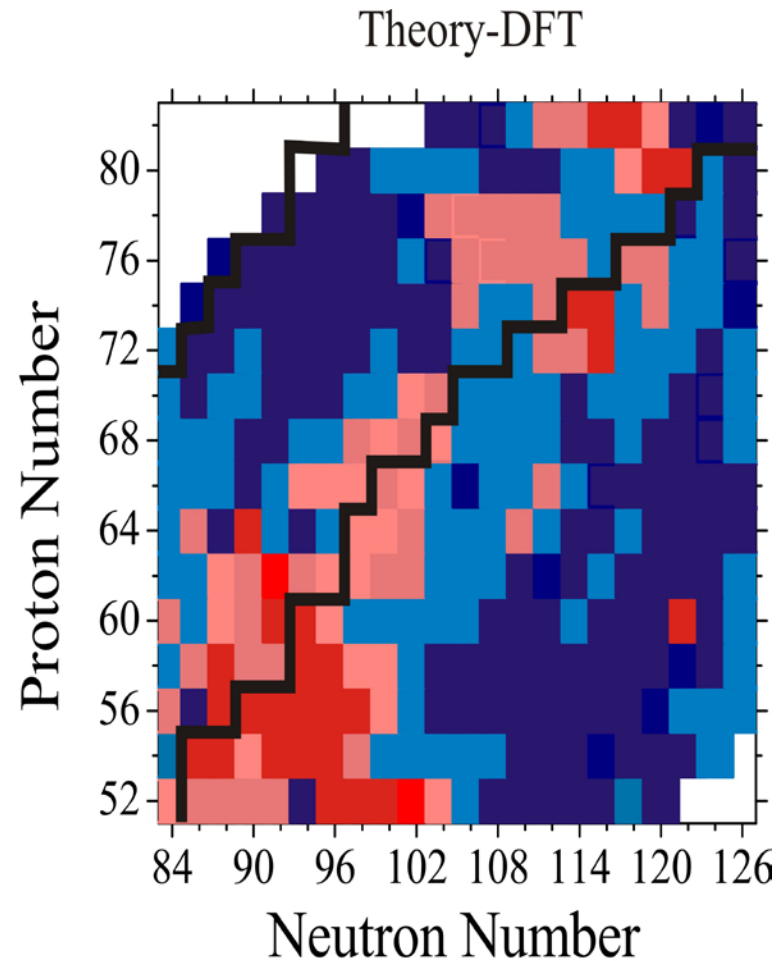


Nilsson

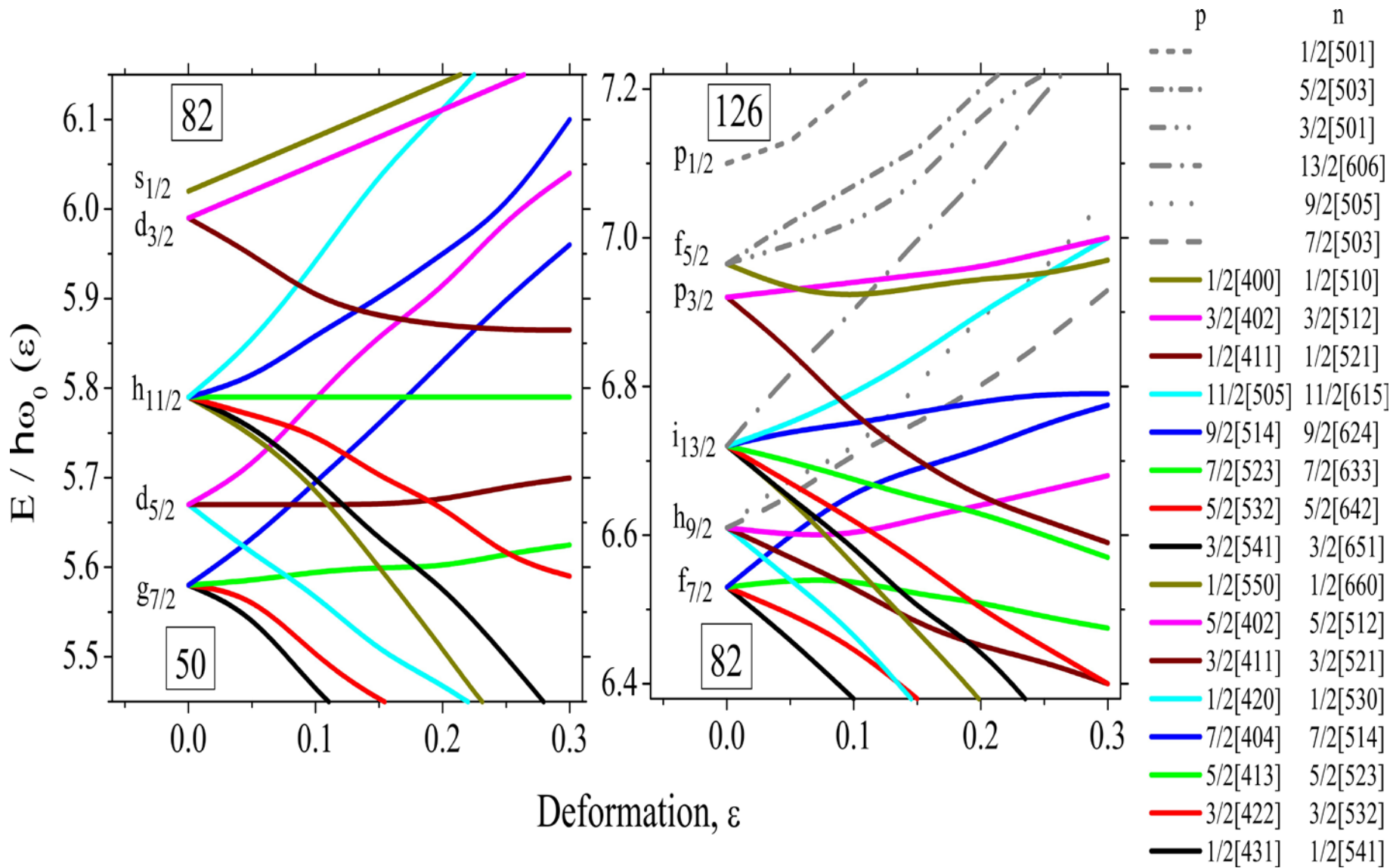


S=0 (antiparallel spin projection)

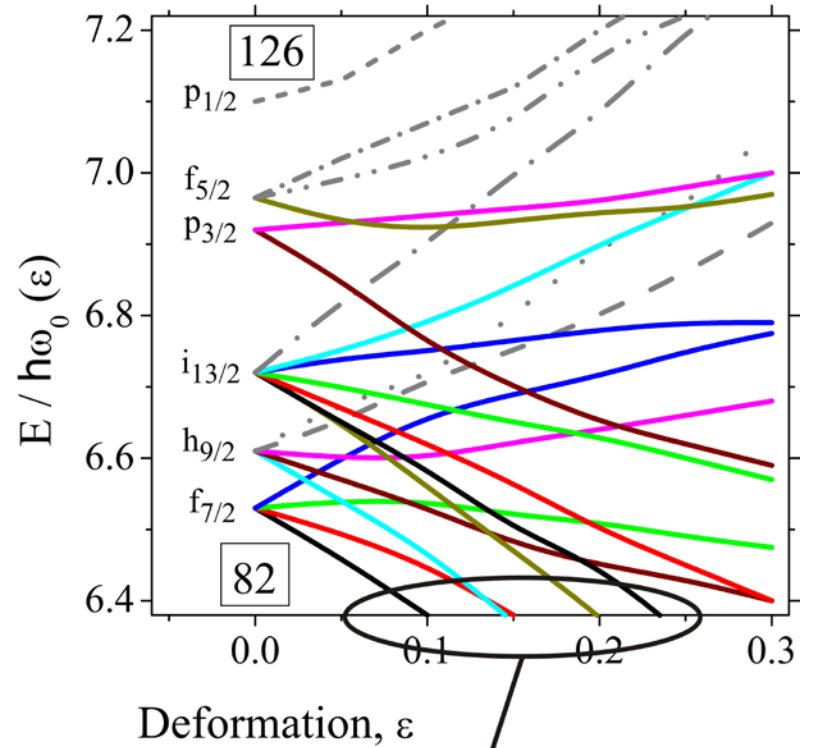
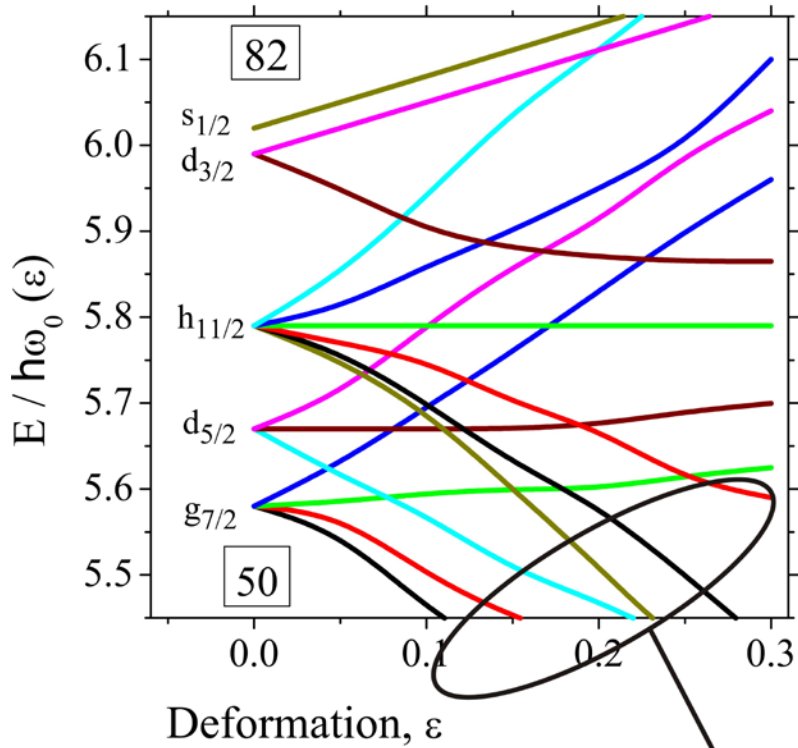
DFT



Nilsson level scheme



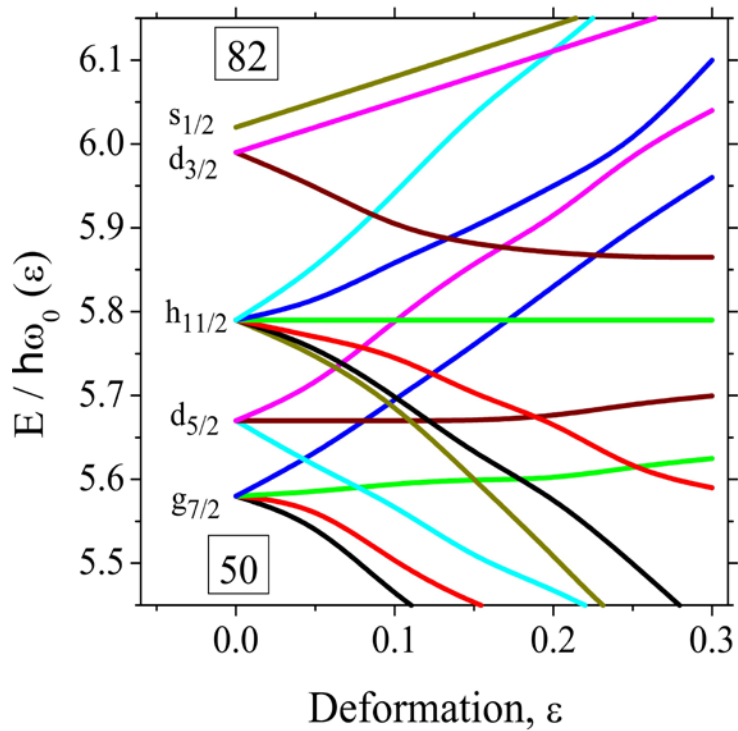
^{154}Sm : 12 valence protons
10 valence neutrons



12 valence protons
sit in the (24,0) irrep of U(15)

10 valence neutrons
sit in the (30,4) irrep of U(21)

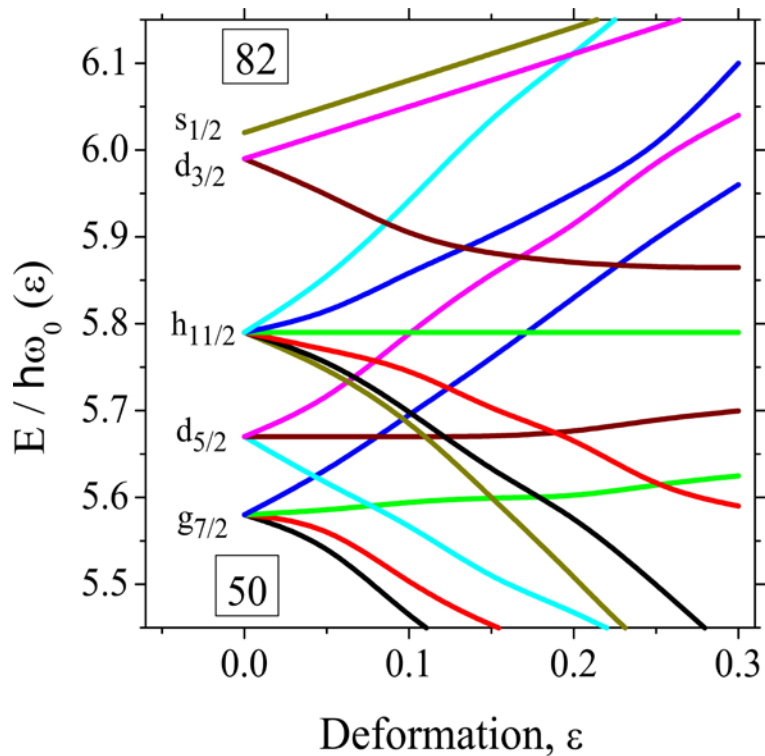
(54,4) irrep for all valence nucleons



0[110] partners

left out

50-82	50-82	sdg	sdg
3s1/2	1/2[411]	3s1/2	1/2[411]
2d3/2	1/2[400]	2d3/2	1/2[400]
	3/2[402]		3/2[402]
2d5/2	1/2[431]	2d5/2	1/2[431]
	3/2[422]		3/2[422]
	5/2[413]		5/2[413]
1g7/2	1/2[420]	1g7/2	1/2[420]
	3/2[411]		3/2[411]
	5/2[402]		5/2[402]
	7/2[404]		7/2[404]
1h11/2	1/2[550]	1g9/2	1/2[440]
	3/2[541]		3/2[431]
	5/2[532]		5/2[422]
	7/2[523]		7/2[413]
	9/2[514]		9/2[404]
	11/2[505]		



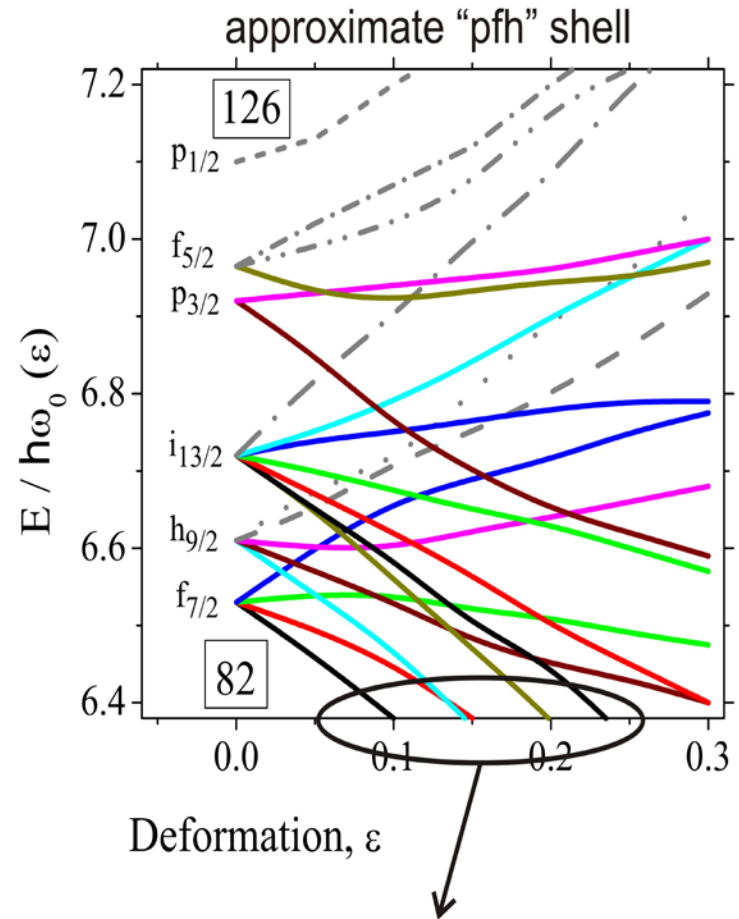
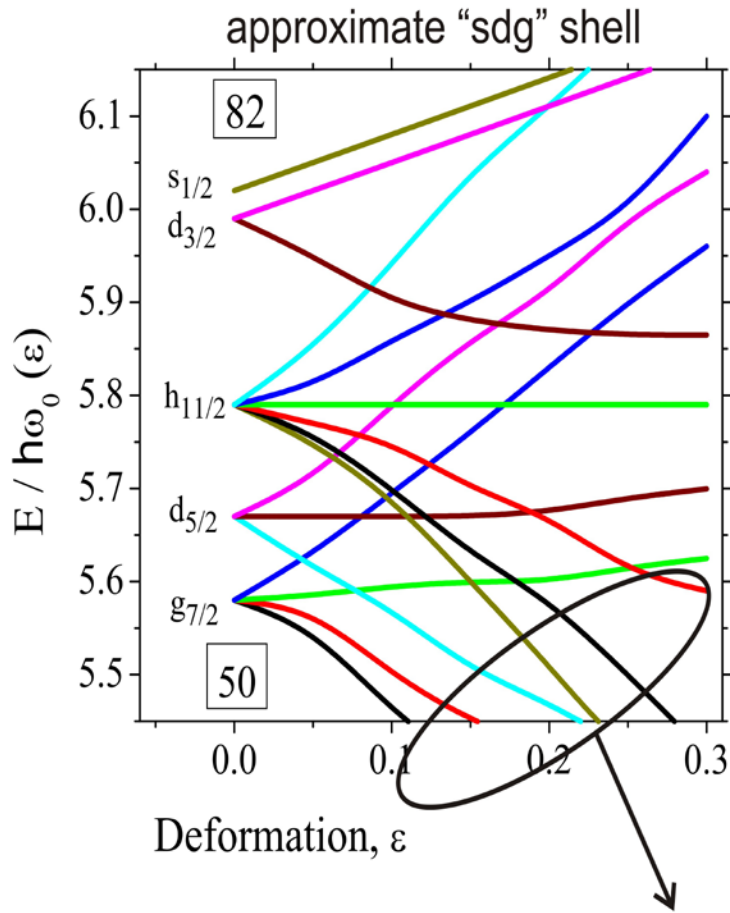
0[110] counterparts
 parity changes
 N changes by 1
 nz changes by 1
 K, Λ, Σ same

left out

50-82 shell mapped onto an
 sdg shell with $U(15) \supset SU(3)$

50-82	50-82	sdg	sdg
3s1/2	1/2[411]	3s1/2	1/2[411]
2d3/2	1/2[400]	2d3/2	1/2[400]
	3/2[402]		3/2[402]
2d5/2	1/2[431]	2d5/2	1/2[431]
	3/2[422]		3/2[422]
	5/2[413]		5/2[413]
1g7/2	1/2[420]	1g7/2	1/2[420]
	3/2[411]		3/2[411]
	5/2[402]		5/2[402]
	7/2[404]		7/2[404]
1h11/2	1/2[550]	1g9/2	1/2[440]
	3/2[541]		3/2[431]
	5/2[532]		5/2[422]
	7/2[523]		7/2[413]
	9/2[514]		9/2[404]
	11/2[505]		

^{154}Sm : 12 valence protons
10 valence neutrons



12 valence protons in the [222222] irrep of U(15)

(24,0) most leading SU(3) irrep of U(15)

SU(3) irreps labelled (λ, μ)

× 10 valence neutrons in the [22222] irrep of U(21) >

× (30,4) most leading SU(3) irrep of U(21) >

(54,4) irrep for all valence nucleons

- New coupling scheme
for symmetry based calculations
- Different kinds of pairing
[($T=1$, $S=0$), ($S=1$, $T=0$)]
favored at different regions
of the nuclear chart

Reductions $U(N) \supset SU(3)$

$N=10, 15, 21, 28$

N. Minkov (INRNE, Sofia)

I. E. Assimakis (NTUA)

Hamiltonian

non-diagonal third, fourth order terms

conserving $SU(3)$

breaking β, γ degeneracy