Shell model treatment of neutron-rich nuclei near ^{78}Ni

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- Recent experimental progress and forthcoming experiments: new regions of neutron rich nuclei
- New magic numbers at extreme N/Z ratio
- astrophysical processes
- isomerism in nuclei around ^{78}Ni

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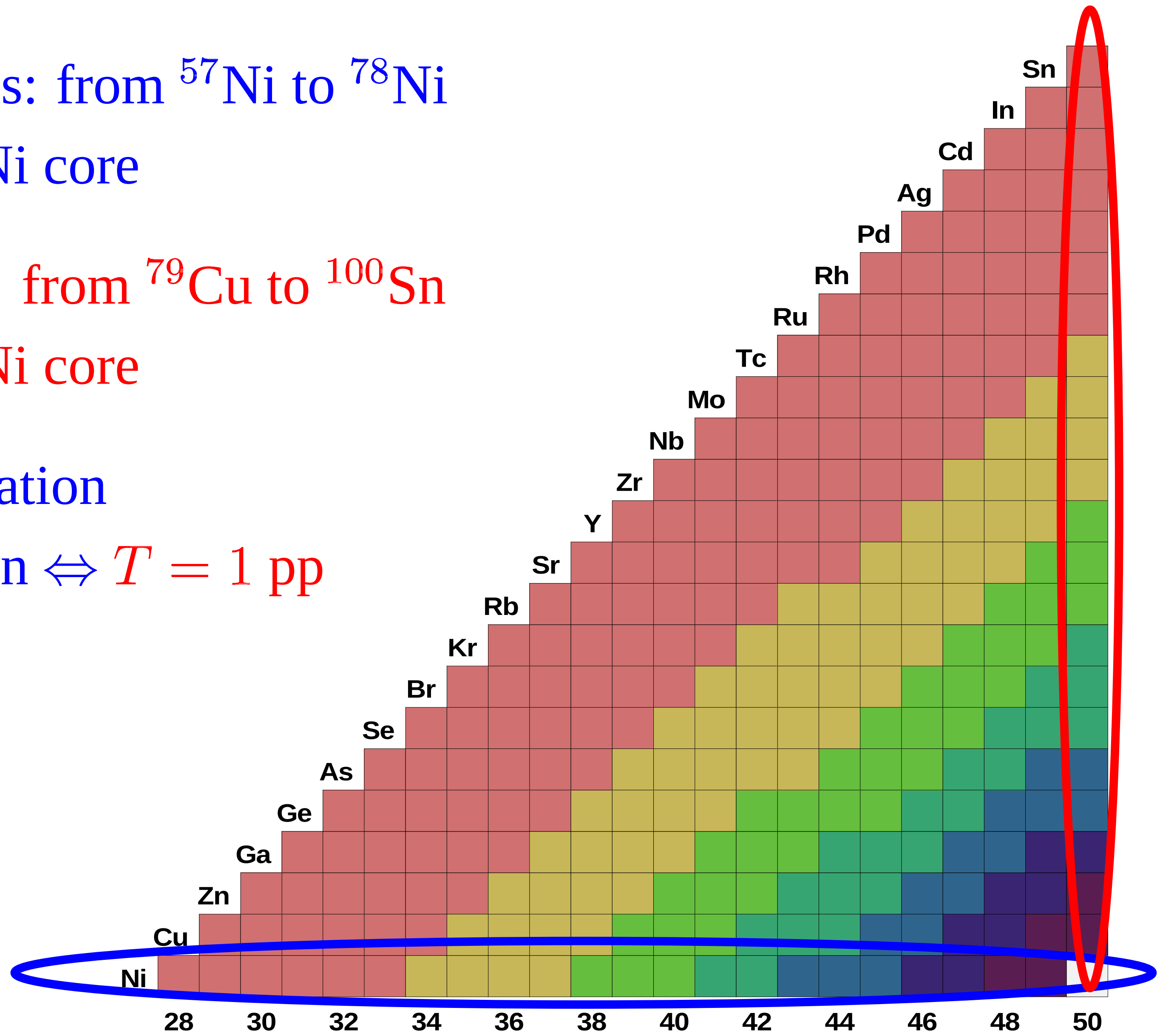
Supported by the NSF Grant PHY-0244453

Unique $T = 1$ interaction ?

Neutrons: from ^{57}Ni to ^{78}Ni
with ^{56}Ni core

Protons: from ^{79}Cu to ^{100}Sn
with ^{78}Ni core

Interpolation
$T = 1$ nn $\Leftrightarrow$ $T = 1$ pp



Determination of the effective SM interaction

$$E_\alpha^{\mathrm{th}} = \sum_i \epsilon_i \cdot \mathrm{n}_i + \sum_{ij,km} \langle ij|V|km\rangle_J \cdot D^J_{ij,km}$$

χ^2−minimization $$\chi^2 = \frac{1}{N}\sum_{\alpha,k}\left[E_\alpha^{th}(k) - E_\alpha^{exp}(k)\right]^2$$

Parameters:

4 s.p.e. ϵ_i: $p_{3/2}$, $p_{1/2}$, $f_{5/2}$ and $g_{9/2}$

65 T.B.M.E. : $\langle ij|V|km\rangle_J$

Initial interaction: G-matrix

Linear Combination Method: 20 most important linear combinations of interaction parameters;

Convergence of energies after 6 iterations

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Results

Neutrons: Z=28; ^{61}Ni – ^{78}Ni; 106 states ; χ^2=0.241 MeV

$p_{3/2}$=-9.988 MeV	$\langle g_{9/2}^2, J=0\rangle$ = -1.372 MeV
$p_{1/2}$= - 8.361 MeV	$\langle g_{9/2}^2, J=2\rangle$ = -0.999 MeV
$f_{5/2}$= - 9.153 MeV	$\langle g_{9/2}^2, J=4\rangle$ = - 0.329 MeV
$g_{9/2}$= - 5.255 MeV	$\langle g_{9/2}^2, J=6\rangle$ = 0.189 MeV
	$\langle g_{9/2}^2, J=8\rangle$ = 0.325 MeV

Protons: N=50; ^{79}Cu – ^{100}Sn; 132 states; χ^2=0.124 MeV

$p_{3/2}$= - 13.437 MeV	$\langle g_{9/2}^2, J=0\rangle$ = - 1.146 MeV
$p_{1/2}$= - 12.044 MeV	$\langle g_{9/2}^2, J=2\rangle$ = - 0.419 MeV
$f_{5/2}$= -14.938 MeV	$\langle g_{9/2}^2, J=4\rangle$ = 0.219 MeV
$g_{9/2}$= -8.905 MeV	$\langle g_{9/2}^2, J=6\rangle$ = 0.442 MeV
	$\langle g_{9/2}^2, J=8\rangle$ = 0.629 MeV

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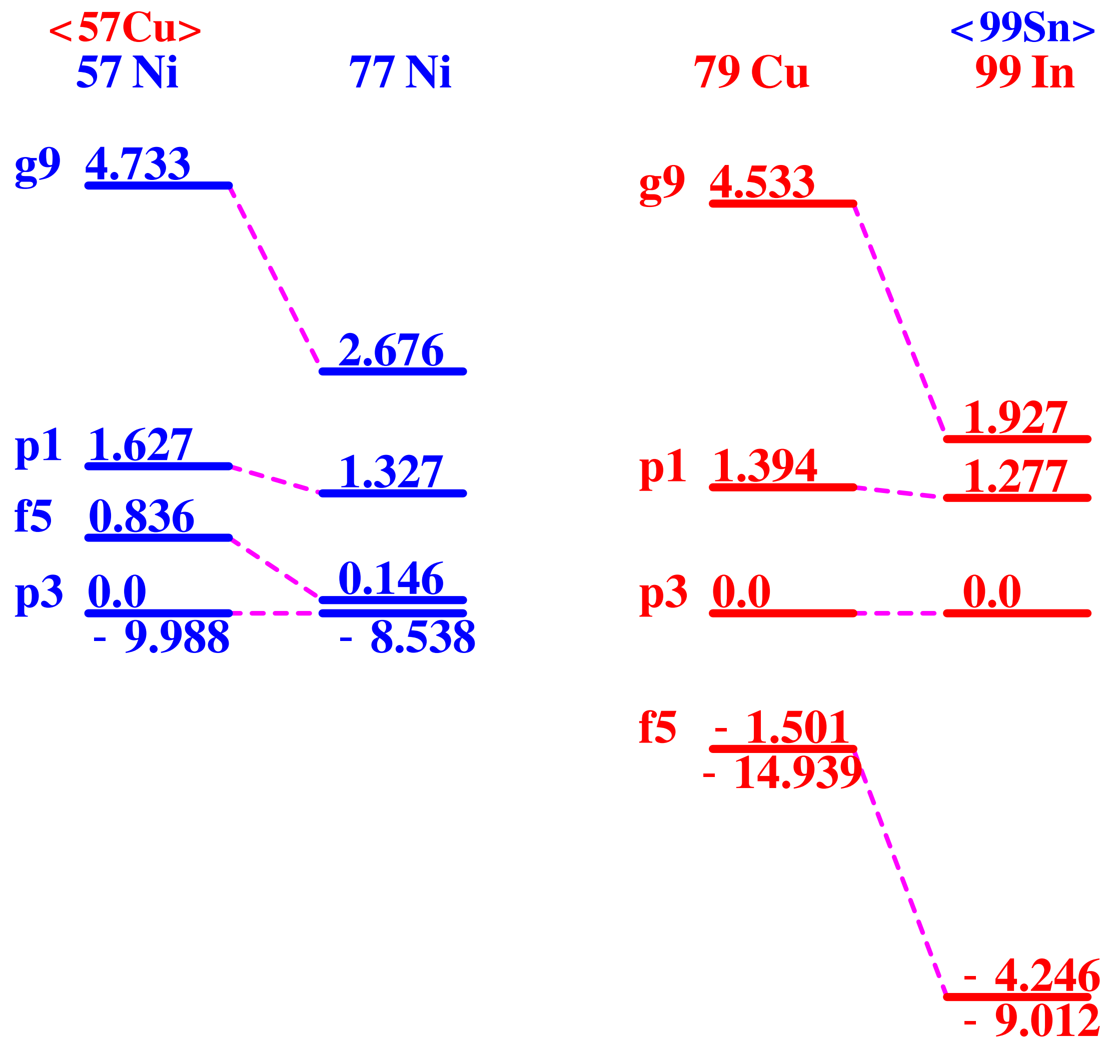
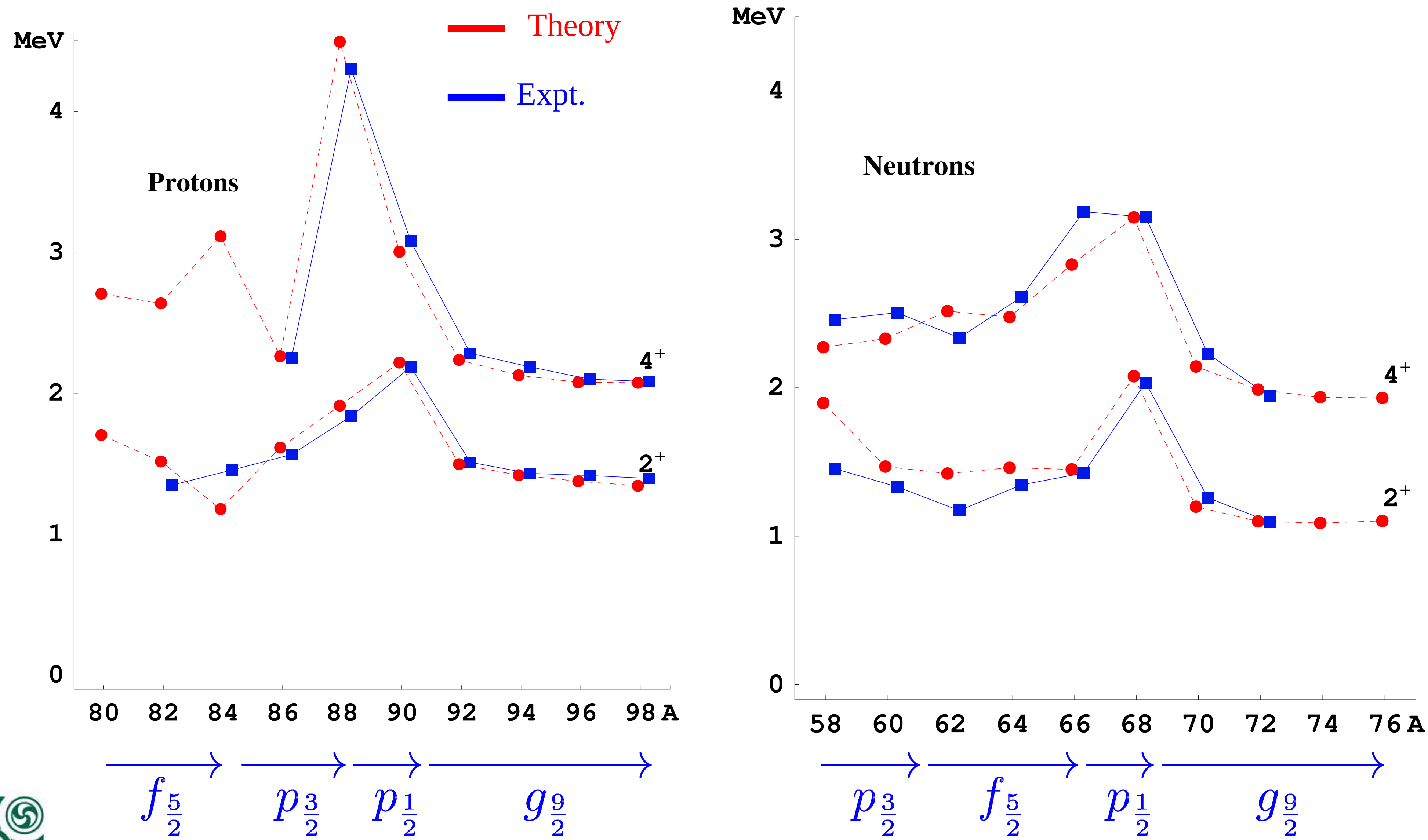
SPE's



<57Cu>
57 Ni
77 Ni
79 Cu
<99Sn>
99 In
g9 4.733
2.676
p1 1.627
1.327
f5 0.836
0.146
p3 0.0
- 9.988
- 8.538
g9 4.533
1.927
p1 1.394
1.277
p3 0.0
0.0
f5 - 1.501
- 14.939
- 4.246
- 9.012

2^+ and 4^+ states



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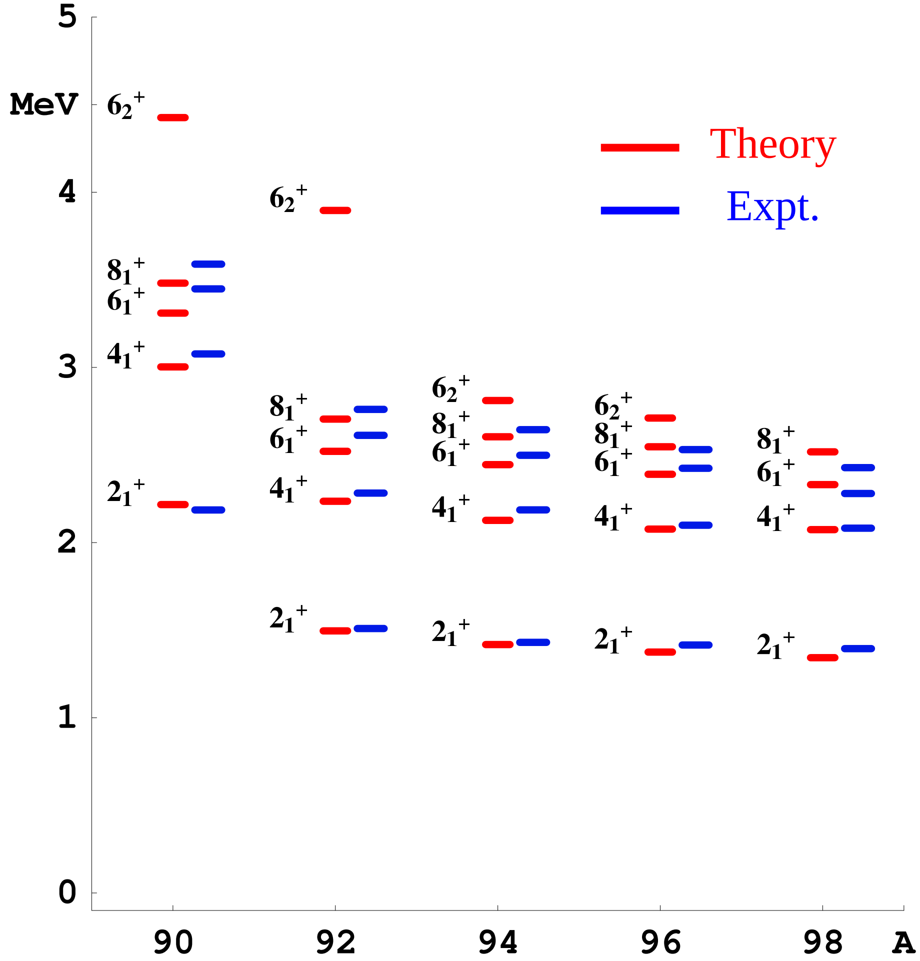
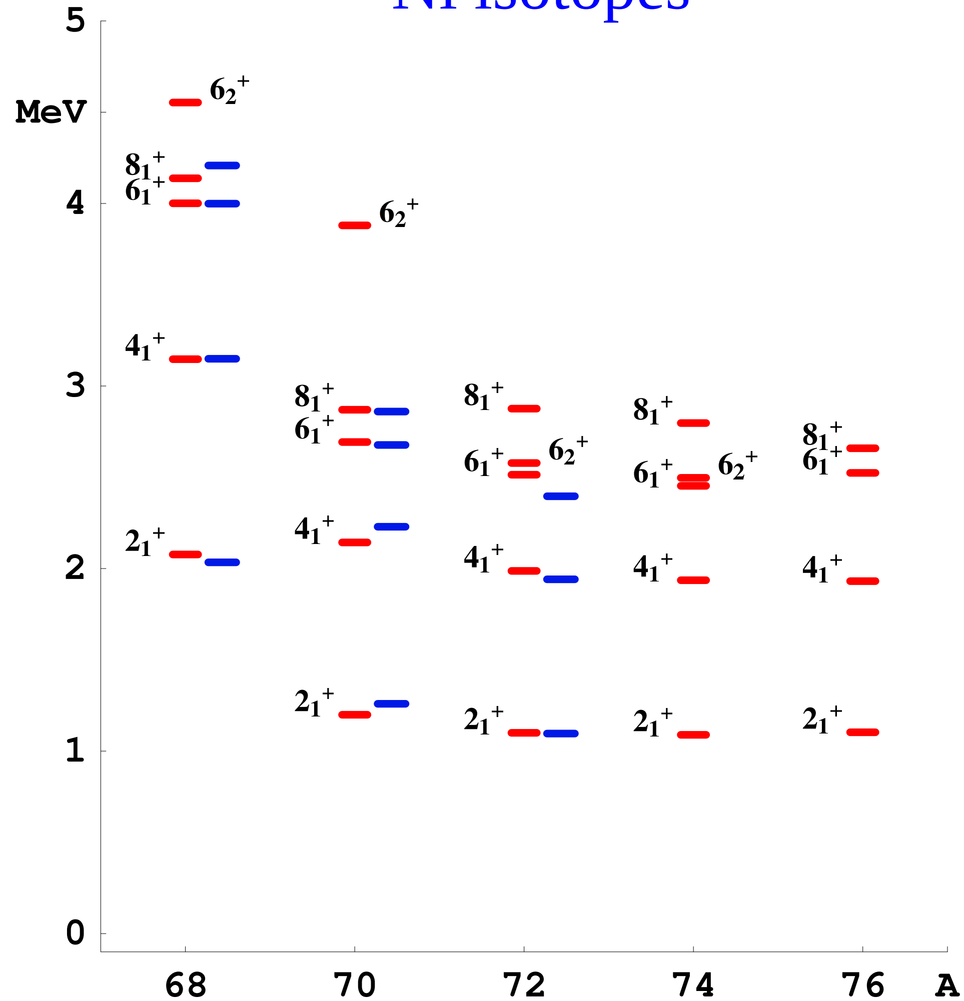
Spectra of Valence Mirror Symmetry partners

^{90}Zr - ^{98}Cd $N = 50$ isotones



$^{68-76}$Ni isotopes



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Ni-isotopes: B(E2) values and lifetimes of 8^+ states

B(E2; $J_i^\pi \rightarrow J_f^\pi$), [$e^2$fm^4], e_n=1.0

J_i^π	J_f^π	^{70}Ni	^{72}Ni	^{74}Ni	^{76}Ni
2_1^+	0_1^+	64	84	76	46
4_1^+	2_1^+	51	94	85	54
6_1^+	4_1^+	31	29	34	37
8_1^+	6_1^+	12	1.9	9.2	15
	6_2^+	3.3	52	47	-
$\tau(8_1^+)$	Th.	326.0 ns	6.1 ns	5.1 ns	1.2 μs
	Expt.	335(4) ns	$<$26 ns	$<$87 ns	

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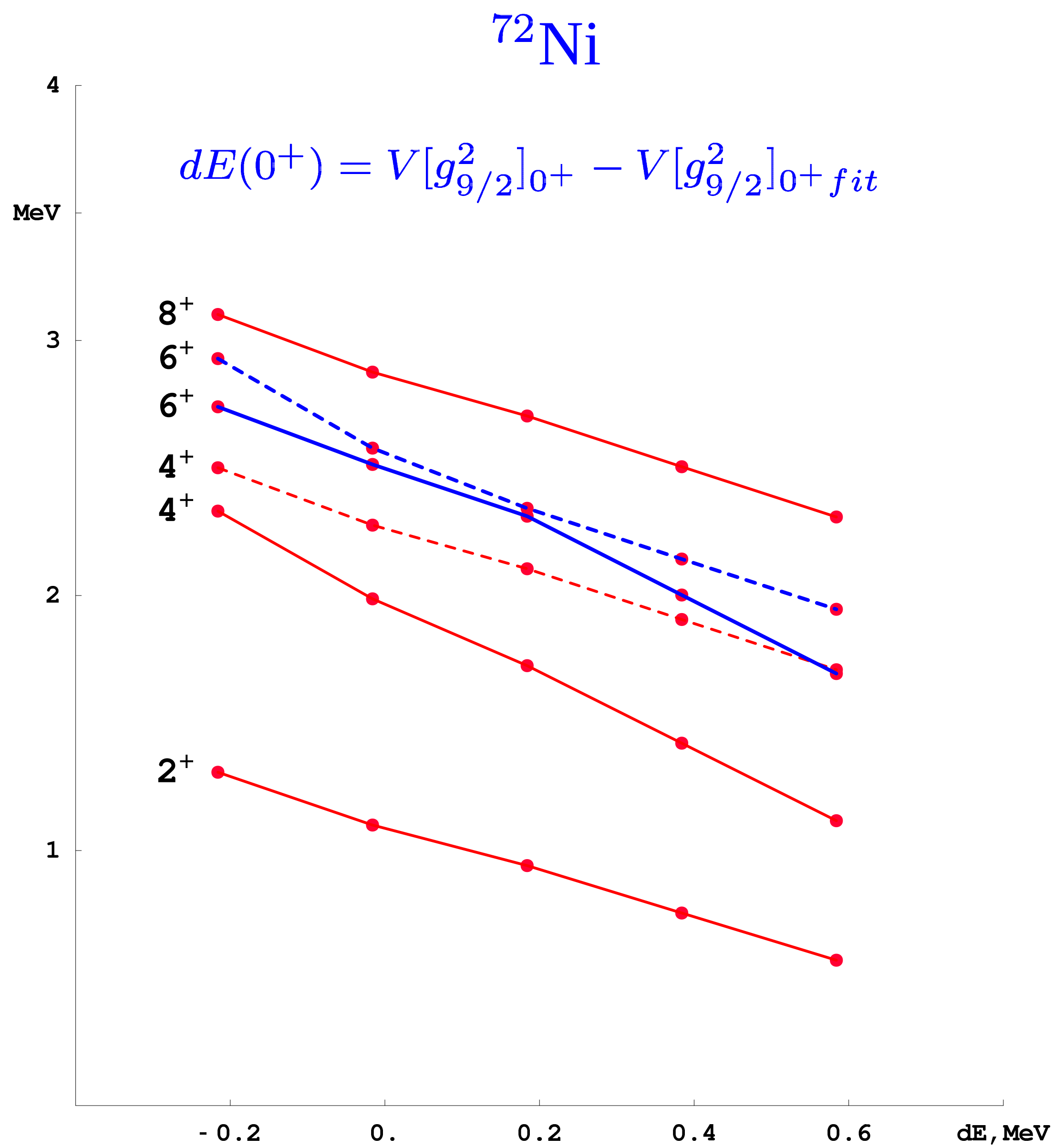
Lifetimes of 8^+ isomers in $N = 50$ isotones

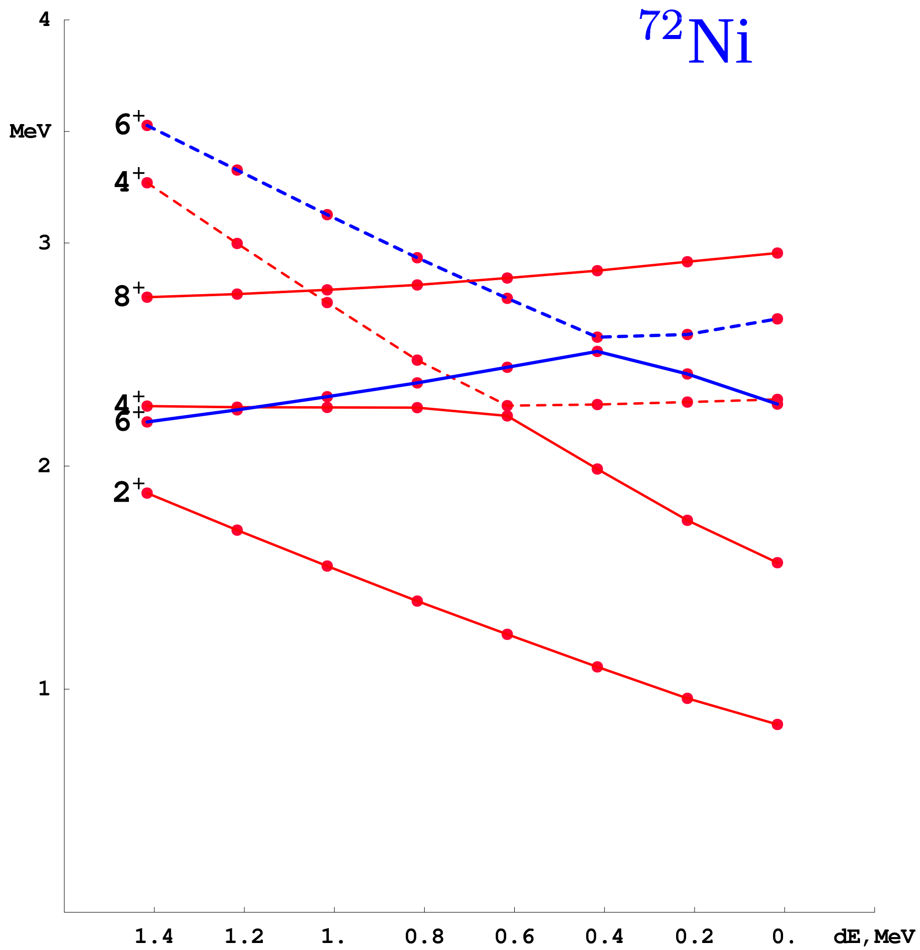
B(E2; $J_i^\pi \rightarrow J_f^\pi$), [$e^2$fm^4], e_p=2.0

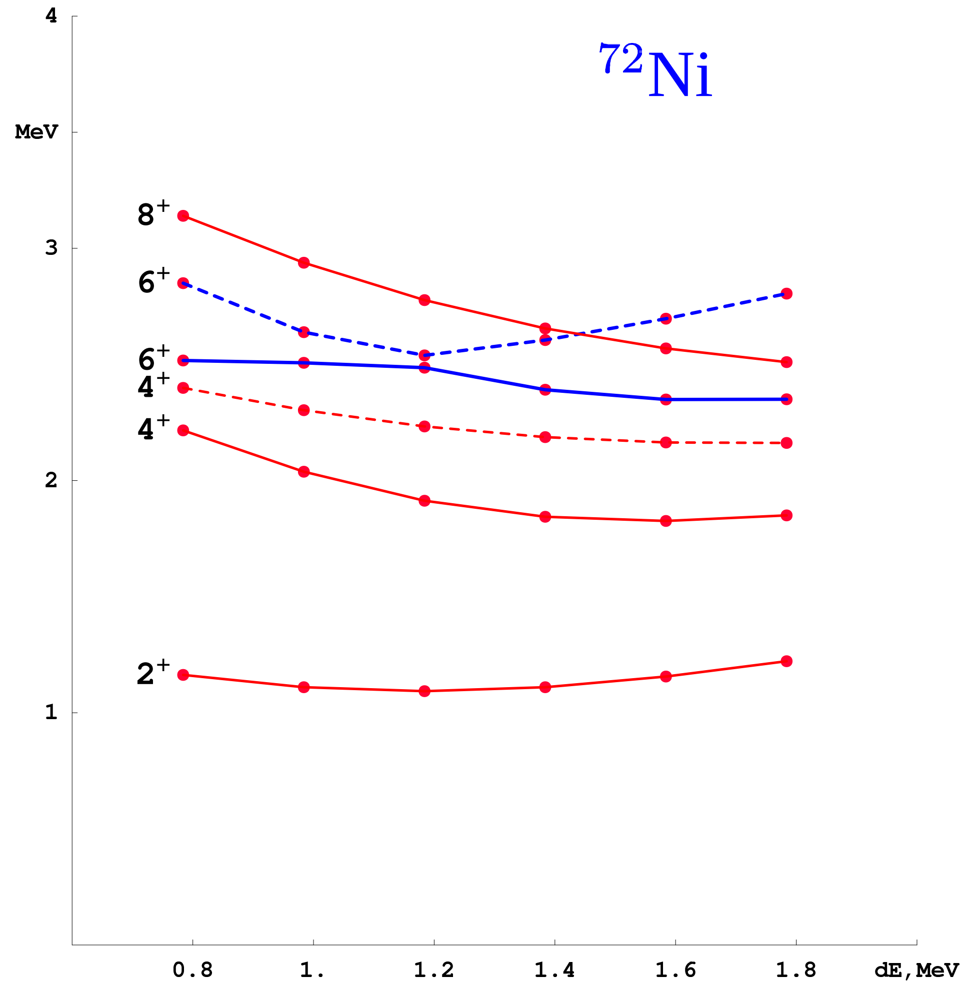
J_i^π	^{92}Mo		^{94}Ru		^{96}Pd		^{98}Cd	
	Th.	Expt.	Th.	Expt.[a]	Th.	Expt.[a]	Th.	Expt.[b]
2_1^+	235	207(12)	304	-	283	-	181	-
4_1^+	164	<605	9.2	-	40	-	214	-
6_1^+	110	81(2)	8.2	2.9(1)	20	20(3)	149	-
8_1^+	42	32.4(5)	2.7	0.09(1)	7.1	8.9(12)	60	35(11)
$\tau(8_1^+)$, [μs]	0.213	0.274(4)	4.4	102(6)	4.0	3.2(4)	0.19	0.69(23)

Effect of 0^+ $g_{9/2}^2$ tbme on excitation energies



Effect of 2^+ and 4^+ $g_{9/2}^2$ tbme's on excitation energies





$$dE(2^+) = V[g_{9/2}^2]_{2^+} - V[g_{9/2}^2]_{0^+\,fit}$$

$\mathrm{dE}_p(2^+) = 0.7$ MeV

$\mathrm{dE}_n(2^+) = 0.4$ MeV

$$dE(4^+) = V[g_{9/2}^2]_{4^+} - V[g_{9/2}^2]_{0^+\,fit}$$

$\mathrm{dE}_p(4^+) = 1.5$ MeV

$\mathrm{dE}_n(4^+) = 1.1$ MeV

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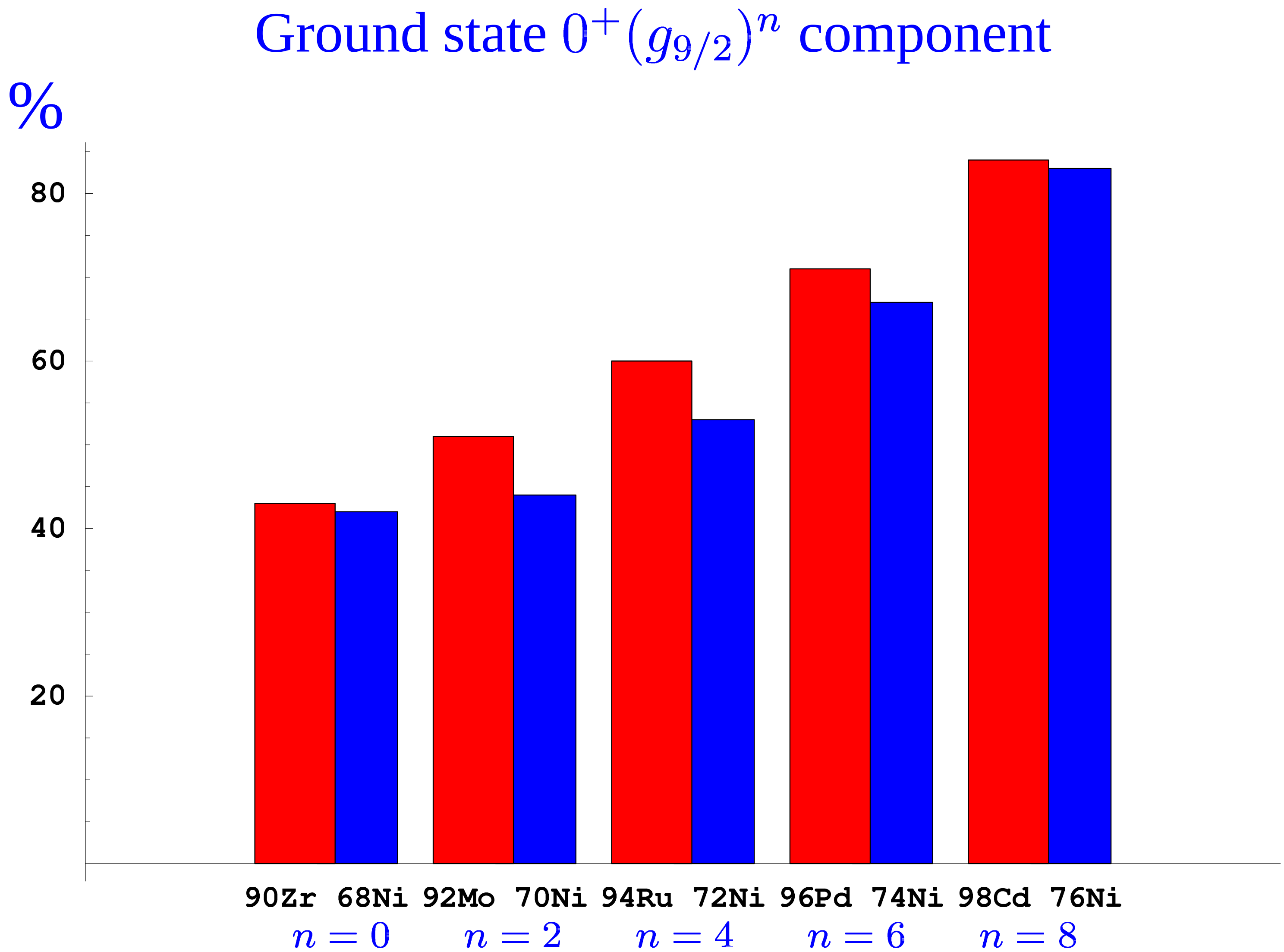
$g_{9/2}$ content



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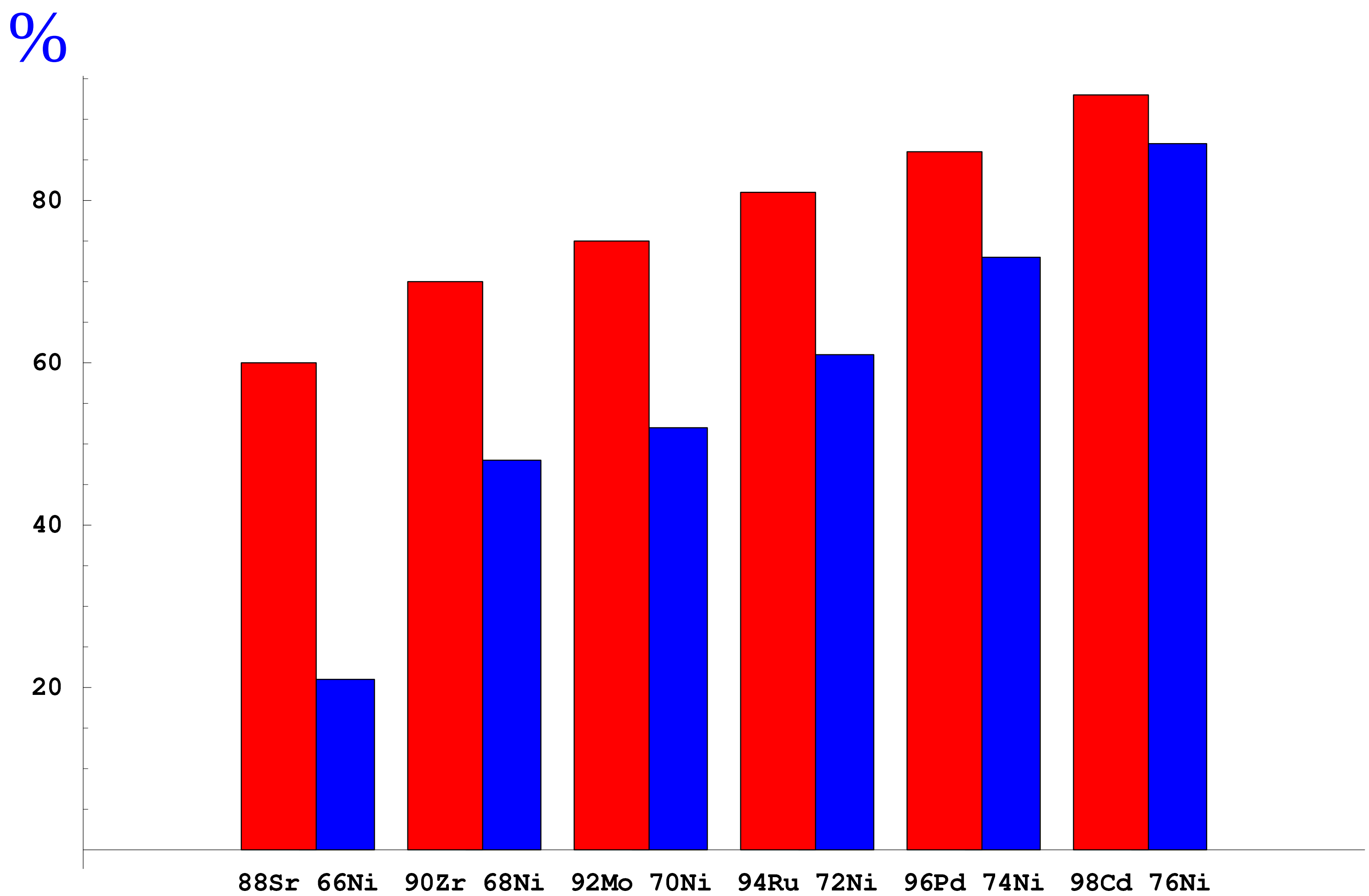
Contribution of the $(f_{5/2}^6 p_{3/2}^4)_{0^+}$ component

closed shells $(f_{5/2}^6 p_{3/2}^4)_{0^+}$ contribution



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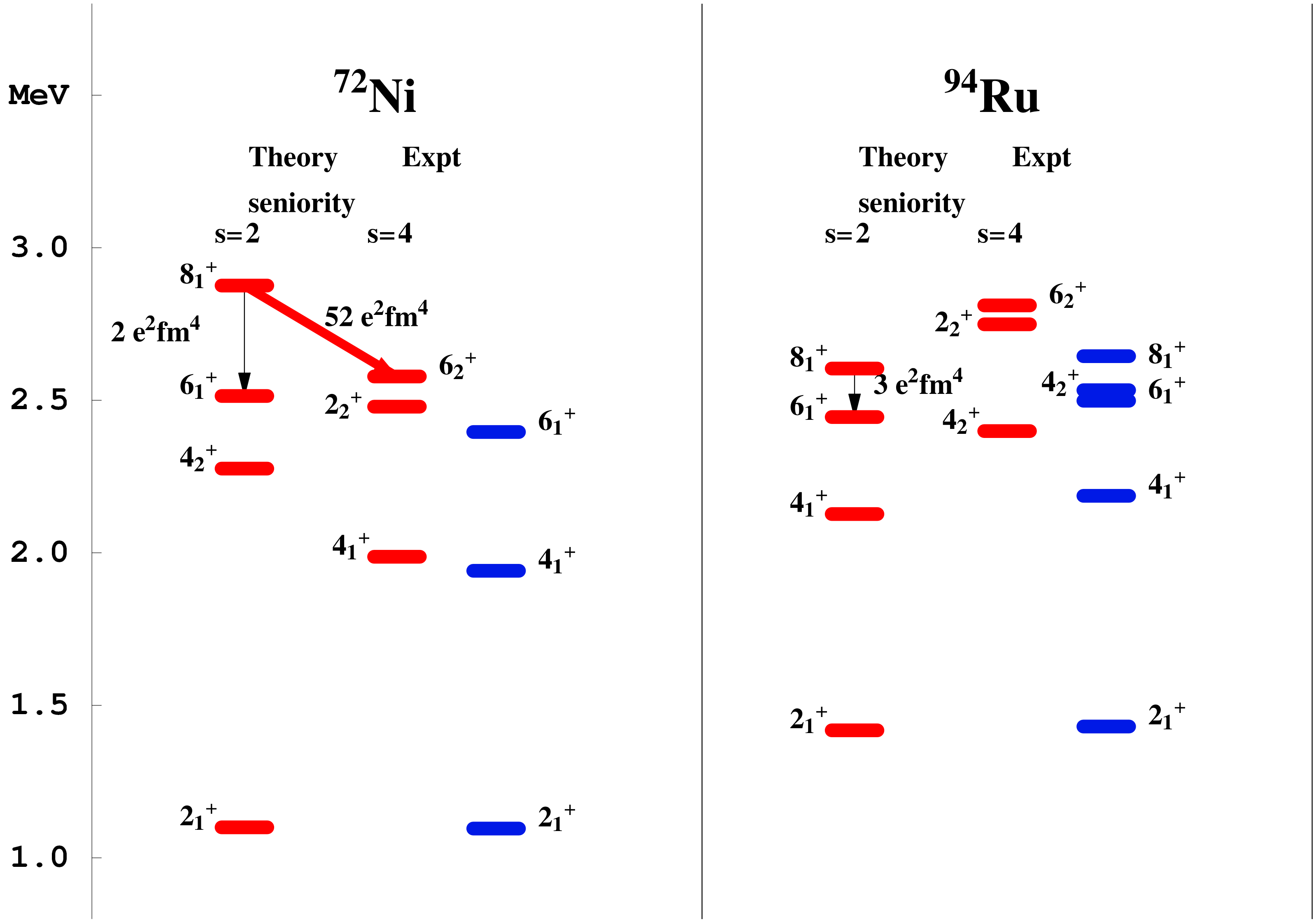
Mechanism of Isomerism Disappearance in Ni isotopes



Comparison of $(g_{9/2}^2)_J$ tbmes