Low-energy spectra of nobelium isotopes: Skyrme random-phase-approximation analysis

M.A. Mardyban[1,2], V. O. Nesterenko[1,2], R.V. Jolos[1,2],
P.-G. Reinhard[3], A. Repko[4]

[1]*Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Moscow Region 141980, Russia*

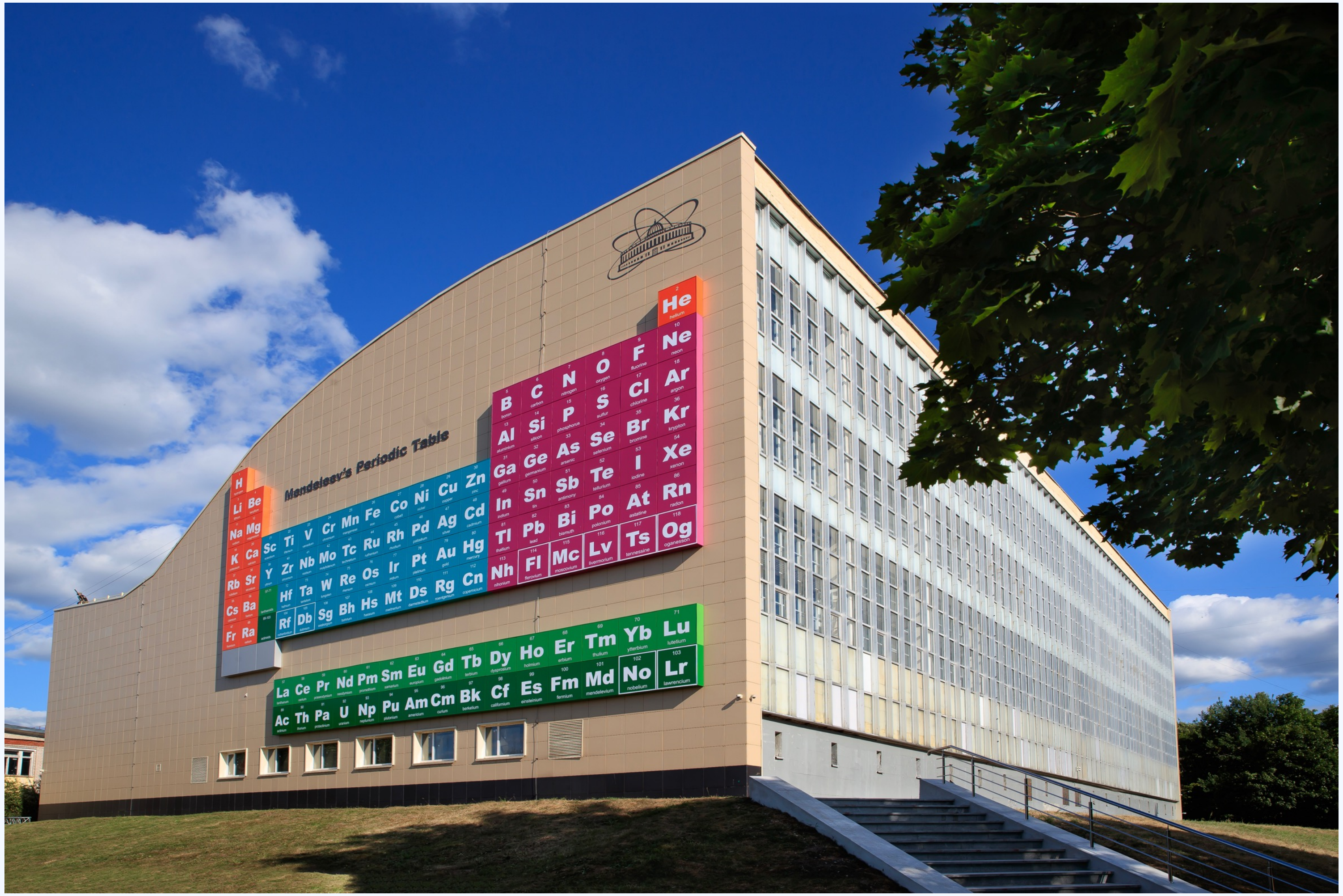
[2] *Dubna State University, Dubna, Moscow Region 141982, Russia*

[3] *Institut für Theoretische Physik II, Universität Erlangen, D-91058, Erlangen, Germany*

[4]*Institute of Physics, Slovak Academy of Sciences, 84511 Bratislava, Slovakia*

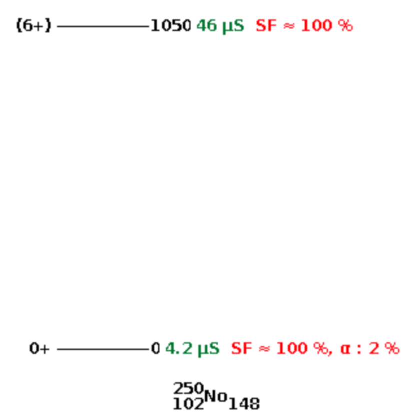
2024

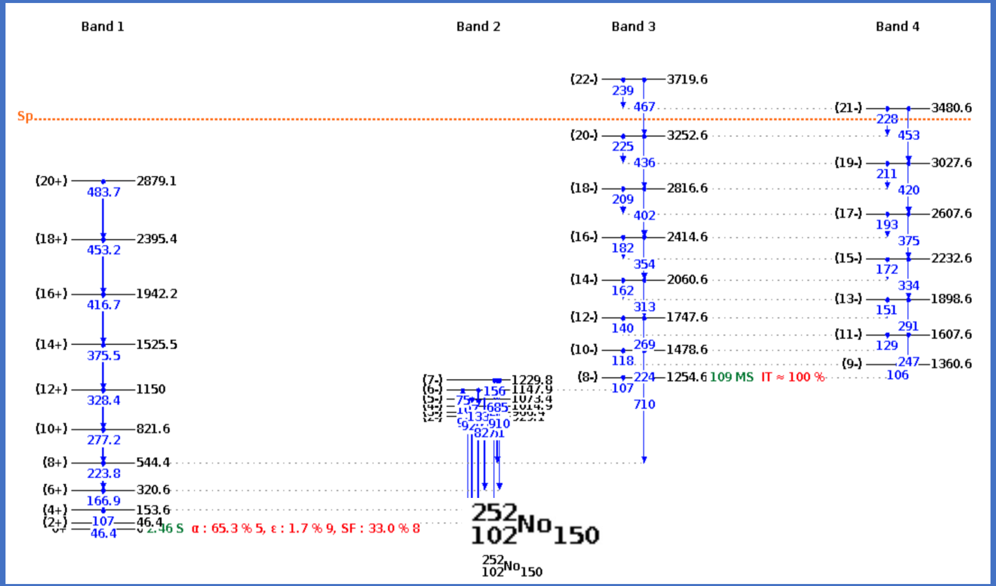
Spectroscopy of superheavy nuclei is now one of the most hot research areas

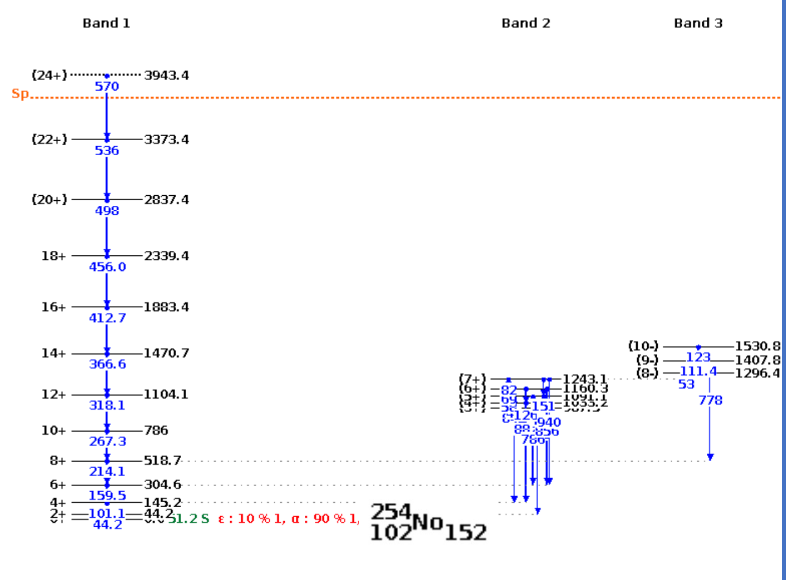


Perhaps, the most extensive experimental data are collected for transfermium region, in particular for nobelium isotopes

At the moment, there are experimental* spectroscopic data only for 3/7 nuclei: ^{250,252,254}No

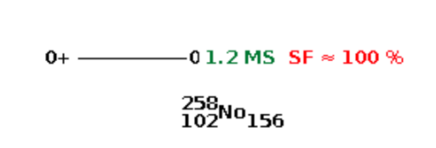


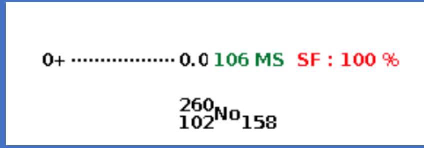


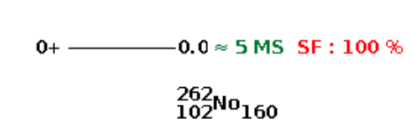


>>

>







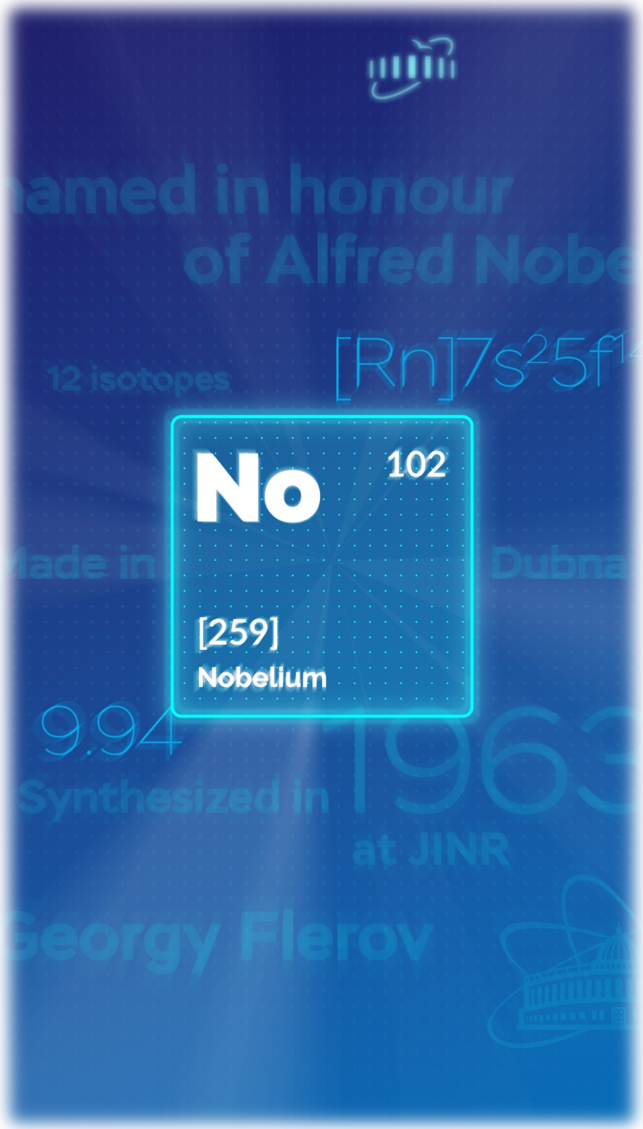
* NNDC data base

The chain of even-even Nobelium nuclei is one of the most studied superheavy nuclei:

- The low-lying spectrum of ^{250,252,254}No;
  [A. D. Efimov, I. N. Izosimov, JINR-E6-2022-19 (2022)]
  [G.G. Adamian, N.V. Antonenko and W. Scheid, Phys. Rev., 024320,C 81 (2010)]
  [R.V. Jolos, L.A. Malov, N.Yu Shirikova and A.V.Sushkov, J.Phys. G: Nucl. Part. Phys, 115103 (2011)]
- Quadrupole moment of ^{252,254}No
  [R.V. Jolos et all, Phys. Part. Nucl. Lett. Vol. 19, No. 6 (2022)]
- Dipole giant resonance in ^{252,254}No;
  [W. Kleinig et all, Phys. Rev. C 78, 044313 (2008)]
- The scissors mode of $^{250-256}$No;
  [E.B. Balbutsev, I.V. Molodtsova, preprint arXiv: 2309.09340v2 (2023)]
- Single-particle properties and rotational bands in the ^{252,254}No;
  [Yue Shi et all, Phys. Rev. C 89, 034309 (2014)]
  [J. Dobaczewski et all, Nucl. Phys. A 944, 388 (2015)]
- Spontaneous fission for the nuclei $^{250-260}$No
  [R. Rodriguez-Guzman, L.M. Robledo, Phys. Rev. C 98, 034308 (2018)]

But, despite the great interest in these nuclei, the characteristics of the ground state of these isotopes are still poorly studied…

Despite an impressive theoretical effort:



- Even modern self-consistent models still give rather different results and exhibit troubles in description of shell structures and other features seen in experiment

- This work was partly done within QPM, IBM, double nuclear system, and cluster models (however, the above models are not self-consistent)

- **It is worth to enlarge the scope of calculated characteristics of superheavy nuclei and inspect, within the same self-consistent theory, a full set of low-energy vibrational states of main multipolarities:** **$K^{\pi} = 0^+, 2^+, 3^+, 0^-, 1^-, 2^-, 8^-$**

250No 4.6 µs SF=100%	251No 0.8 s α=90% SF=1.4e-3% ε+β+>0%	252No 2.45 s α=65.3% SF=33% ε+β+=1.7%	253No 1.61 min α=55% ε+β+=45%	254No 51.2 s α=90% ε=10% SF=0.17%	255No 3.52 min ε+β+=70% α=30%	256No 2.93 s α=99.47% SF=0.53%	257No 24.5 s α=85% ε=15% SF<1.5%	258No 1.23 ms SF=100%	259No 58 min α=75% ε=25% SF<10%	260No 107 ms SF=100%

The main attention is paid to ^{252,254}No where calculated:

- **$K^\pi = 8^-$ isomers**
  (at 1.361 MeV in ^{252}No and 1.747 MeV in ^{254}No)
- **Pairing vibrations $K^\pi = 0^+$**
  (at 0.77 MeV in ^{252}No and 0.22 MeV in ^{254}No)
- **States $K^\pi=2^+$**
  (1.58 MeV in ^{252}No and 1.31 MeV in ^{254}No)
- **Hexadecapole states with $K^\pi = 3^+$ and 4^+**
- **Octupole states with $K^\pi = 0^-, 1^-, 2^-$ and 3^-**

^{250}No	^{251}No	^{252}No	^{253}No	^{254}No	^{255}No	^{256}No	^{257}No	^{258}No	^{259}No	^{260}No
4.6 μs	0.8 s	2.45 s	1.61 min	51.2 s	3.52 min	2.93 s	24.5 s	1.23 ms	58 min	107 ms
SF=100%	α=90%	α=65.3%	α=55%	α=90%	ε+β+=70%	α=99.47%	α=85%	SF=100%	α=75%	SF=100%
	SF=1.4e-3%	SF=33%	ε+β+=45%	ε=10%	α=30%	SF=0.53%	ε=15%		ε=25%	
	ε+β+>0%	ε+β+=1.7%		SF=0.17%			SF<1.5%		SF<10%	

The main attention is paid to $^{252,254}No$ where calculated:

- **K^{π}= 8^- isomers**
  (at 1.361 MeV in ^{252}No and 1.747 MeV in ^{254}No)
- **Pairing vibrations K^{π} = 0^+**
  (at 0.77 MeV in ^{252}No and 0.22 MeV in ^{254}No)
- **States K^{π}=2^+**
  (1.58 MeV in ^{252}No and 1.31 MeV in ^{254}No)
- **Hexadecapole states with K^{π} = 3^+ and 4^+**
- **Octupole states with K^{π} = 0^-, 1^-, 2^- and 3^-**

Skyrme forces

force	m/m*	kind of pairing
SVbas	0.90	surface
SkM*	0.79	volume
SLy6	0.69	volume

[P. Klupfel et al, PRC 79 034310 (2009)]
[J. Bartel et al, NPA 386, 79 (1982)]
[E. Chabanat et al, NPA, 635 231 (1998)]

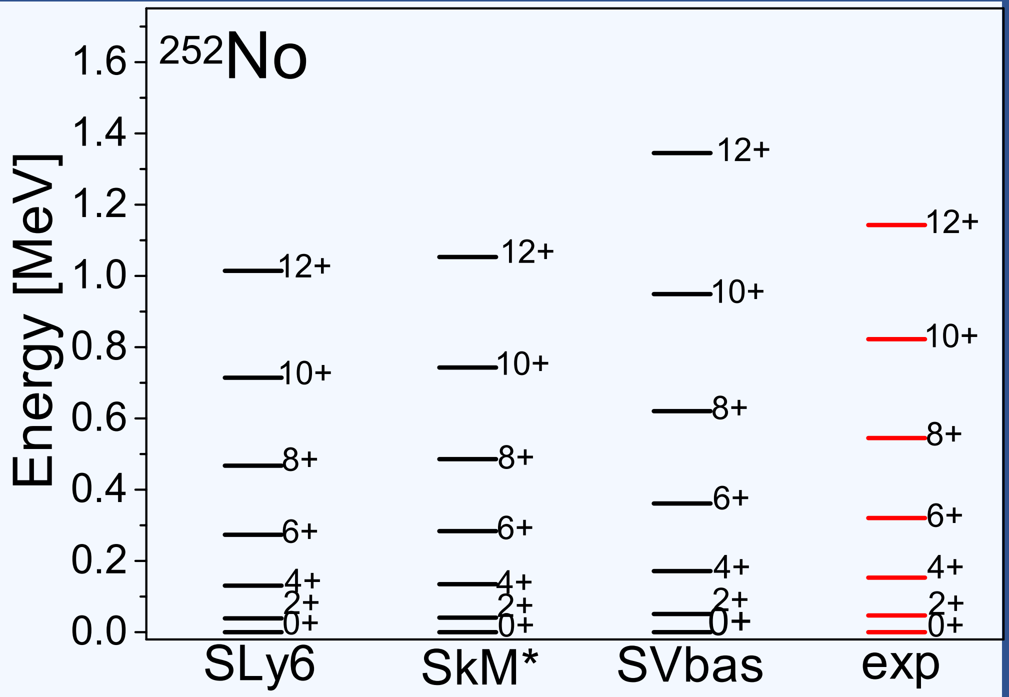
$$V^q_{\text{pair}}(\mathbf{r},\mathbf{r}') = G_q\left[1-\eta\left(\frac{\rho(\mathbf{r})}{\rho_{\text{pair}}}\right)\right]\delta(\mathbf{r}-\mathbf{r}')$$

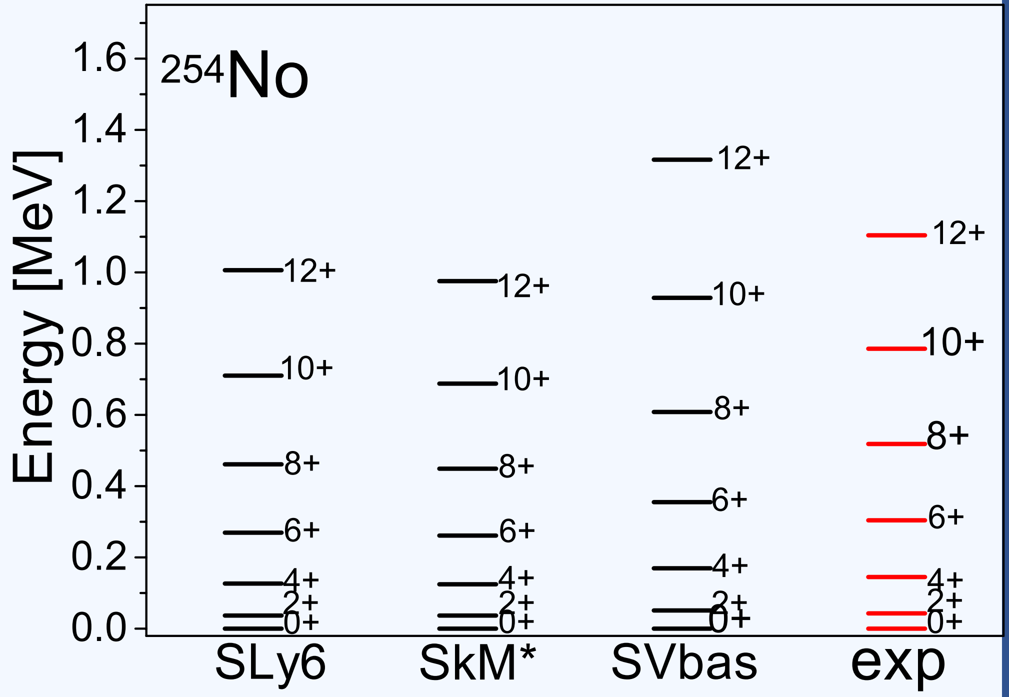
Where Gq are pairing strength constants ($q = p,n$).
We get so-called density-dependent surface pairing for η = 1 and volume pairing for η = 0

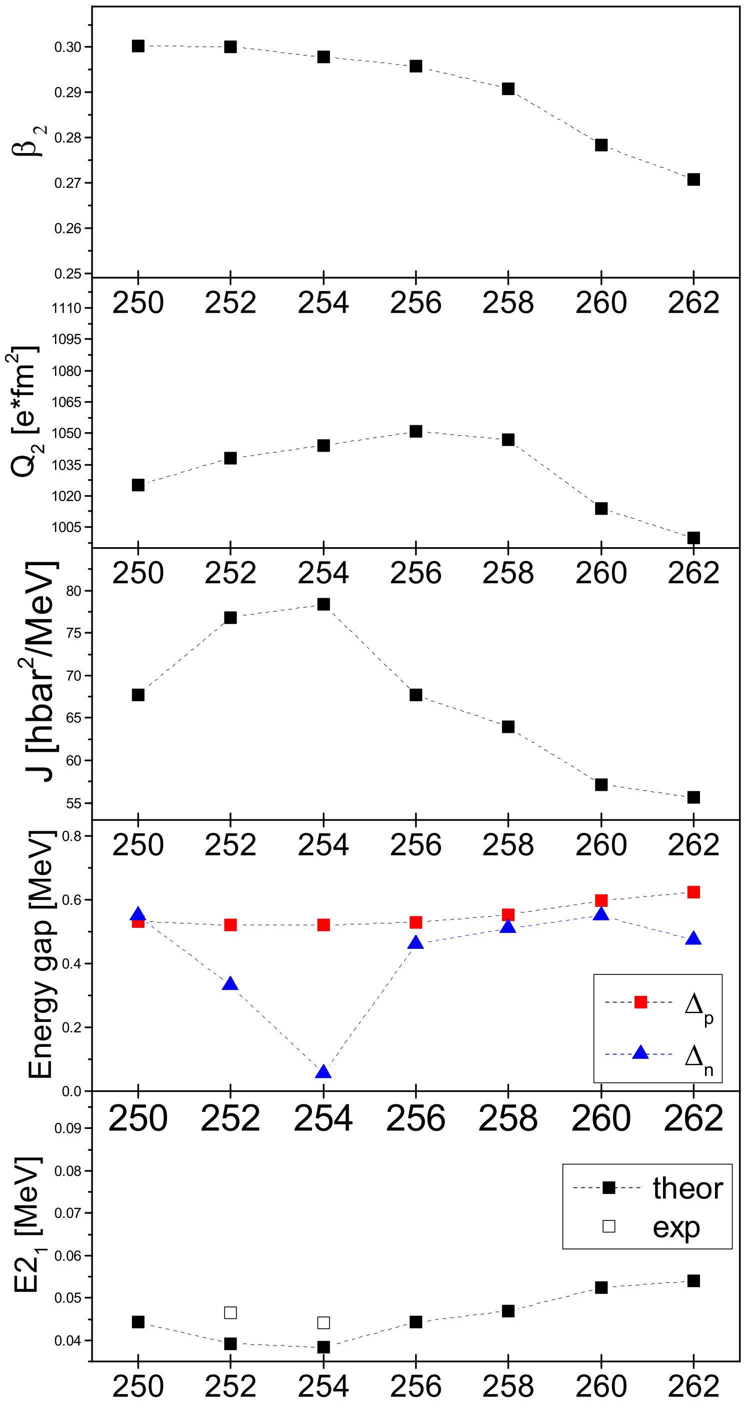
Calculation details:

Codes – SkyAx [P.-G. Reinhard et al, Comp. Phys. Communic. 258, 107603 (2021)]
QRPA [A. Repko et al, arXiv:1510.01248 (nucl-th), 2015]

- Accurate extraction of spurious admixtures
  [V. O. Nesterenko et al, Eur. Phys. J. A 55, 213 (2019)]
- 2D grid in cylindric coordinates
- All proton and neutron s-p levels up to +40 MeV







The characteristics of the ground states of $^{250\text{-}262}$No with increasing number neutrons

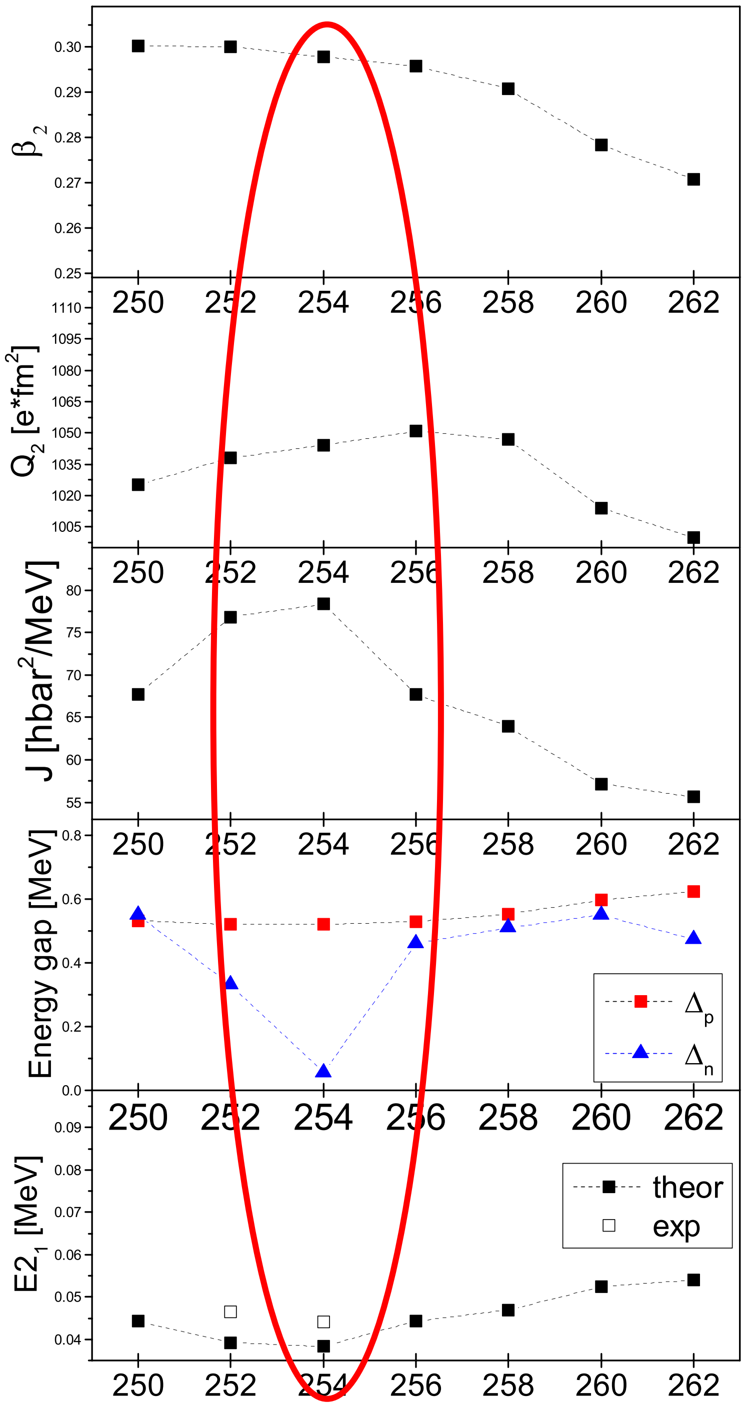
$$\beta_{20} = \frac{4\pi}{3}\frac{Q_{20}}{AR^2}\ ,\ R = R_0 A^{1/3}\ ,\ R_0 = 1.2\ \mathrm{fm}$$

$$J_{TV} = 2\sum_{\nu>0}\frac{|<\nu|J_x|0>|^2}{E_\nu - E_0}$$

$$V^q_{\text{pair}}(\mathbf{r},\mathbf{r}') = G_q\left[1-\eta\left(\frac{\rho(\mathbf{r})}{\rho_{\text{pair}}}\right)\right]\delta(\mathbf{r}-\mathbf{r}')$$

$$E_I = \frac{\hbar^2}{2\mathcal{J}}I(I+1),$$

Initially it was assumed that these characteristics would evolve monotonically, but we see irregularity at $^{252,\,254}$No



The characteristics of the ground states of $^{250-262}$No with increasing number neutrons

$$\beta_{20} = \frac{4\pi}{3}\frac{Q_{20}}{AR^2}\ ,\ R = R_0 A^{1/3}\ ,\ R_0 = 1.2\,\mathrm{fm}$$

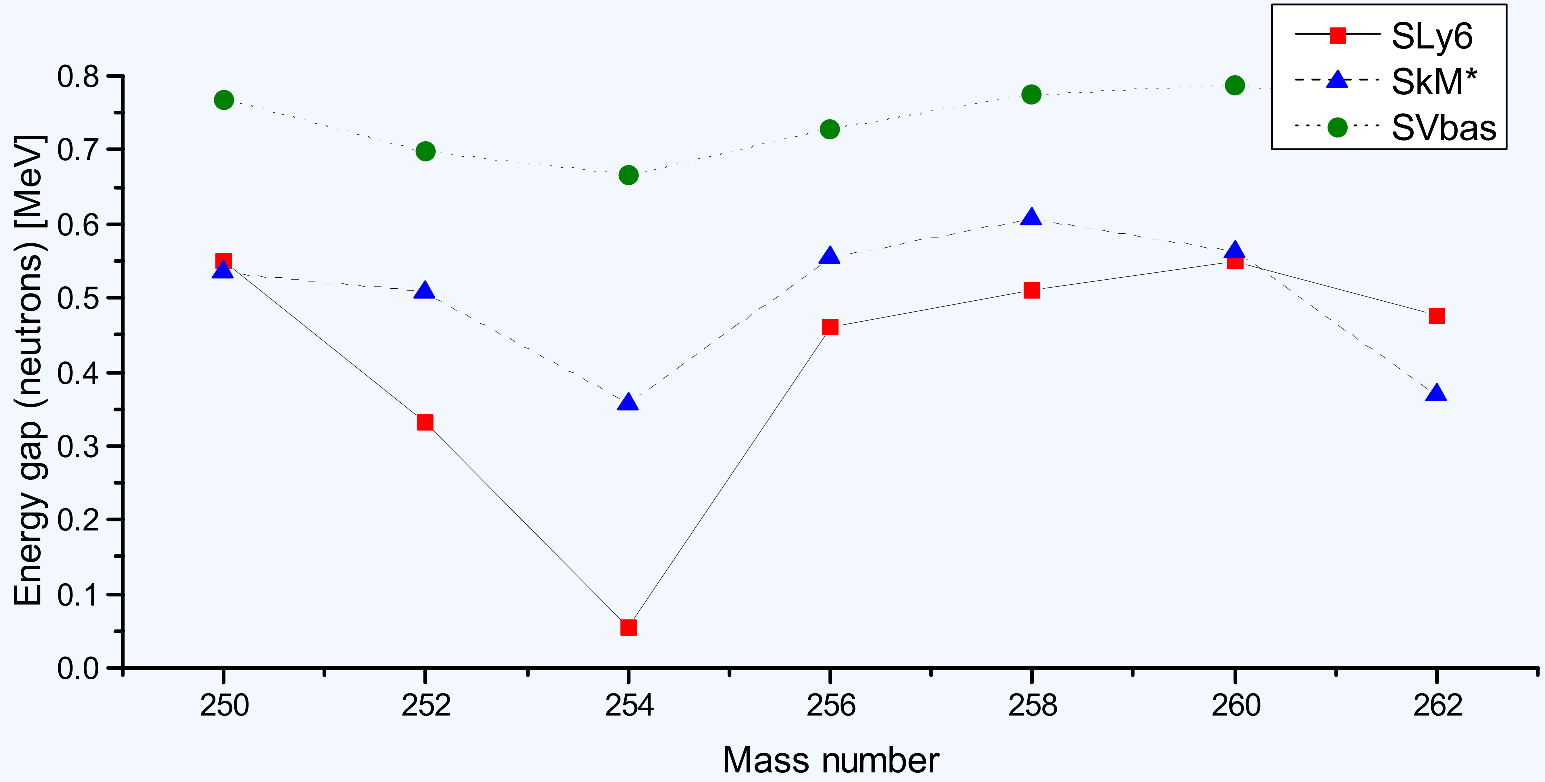
$$J_{TV} = 2\sum_{\nu>0}\frac{|<\nu|J_x|0>|^2}{E_\nu - E_0}$$

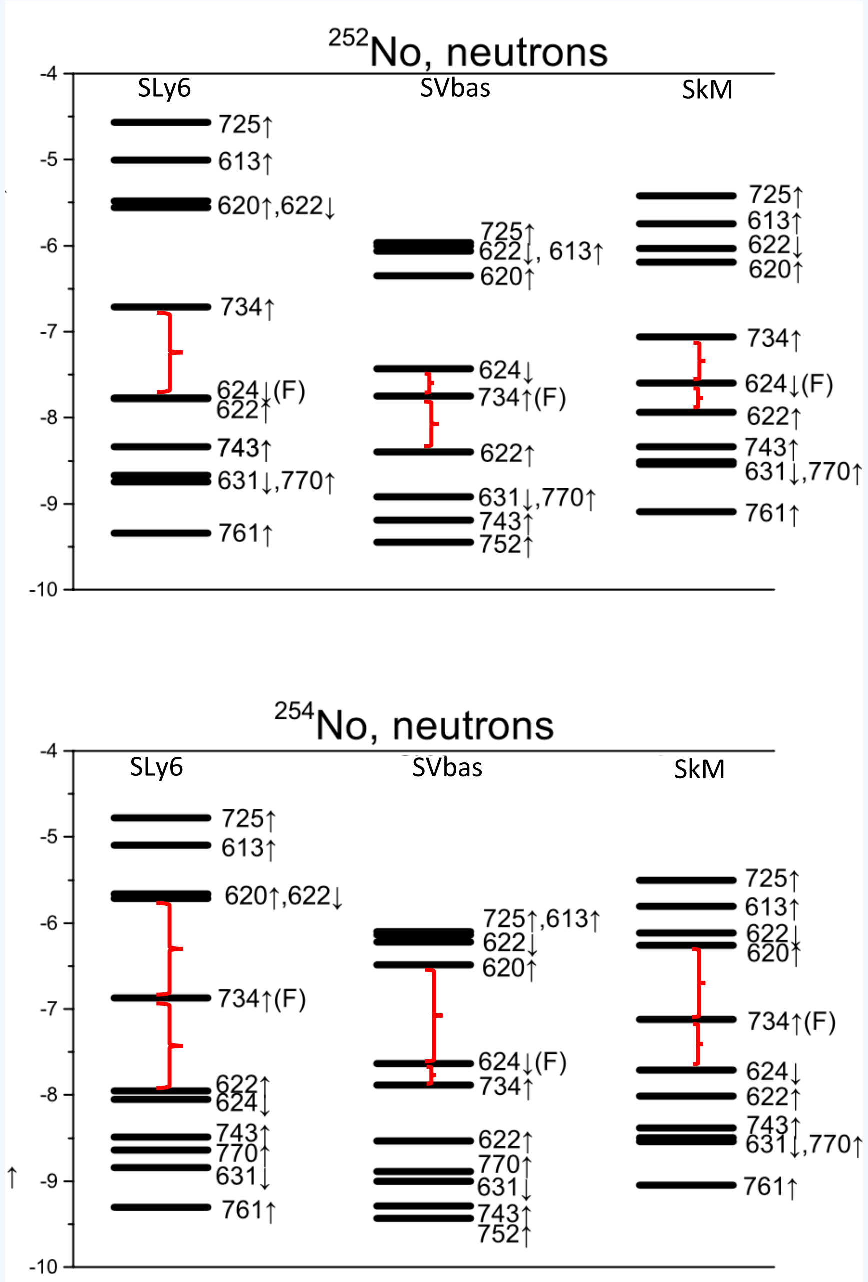
$$V^q_{\rm pair}(\mathbf{r},\mathbf{r}') = G_q\Big[1-\eta\left(\frac{\rho(\mathbf{r})}{\rho_{\rm pair}}\right)\Big]\delta(\mathbf{r}-\mathbf{r}')$$

$$E_I = \frac{\hbar^2}{2\mathcal{J}}I(I+1)$$

Initially it was assumed that these characteristics would evolve monotonically, but we see irregularity at $^{252,\ 254}$No

Does this irregularity (decline in neutron pairing) depend on the chosen Skyrme force?





- All 3 Skyrme forces support this irregularity;
- For ^{254}No the Fermi level isolated, so neutron pairing almost disappears;
- For ^{252}No the Fermi level is also quite far from neighboring levels, so pairing is also poorly developed

K^{π}= 8^- isomers

^{252}No: the 8^- state is usually assigned as neutron 2qp configuration nn[734 ↑, 624 ↓]

- R.-D. Herzberg and P.T. Greenlees, Prog. Part. Nucl. Phys. 61, 674 (2008)
- F.P. Heßberger, arXiv:2309.10468v2[nucl-ex].
- B. Sulignano et al, Eur. Phys. J. A 33, 327 (2007).

^{254}No: forces predict different 2qp configurations nn[734 ↑, 613 ↓] and pp[514 ↓, 624 ↑]

- V.G. Soloviev, A.V. Sushkov, A.Yu. Shirikova, Sov. J. Nucl. Phys. 54, 748 (1991)
- R.M. Clark et al, Phys. Lett. B690, 19 (2010)
- R.V. Jolos, L.A. Malov, N.Yu. Shirikova and A.V. Sushkov, J. Phys. G: Nucl. Part. Phys. 38, 115103 (2011).
- Xiao-Tao He, Shu-Young Zhao, Zhen-Hua Zhang and Zhong-Zhou Ren, Chines Physics C 44, 034106 (2020)
- G.G. Adamian, N.V. Antonenko, anf W. Scheid, Phys. Rev. C 81, 024320 (2010)
- F.P. Hessberger et al, Eur. Phys. J A43, 55 (2010)

Force	$E_{\nu=1}$ [MeV]	$B(E98)$ [W.u.]	qq'	$\epsilon_{qq'}$ [MeV]	$N_{qq'}$	F-scheme
^{252}No, E_x=1.254 MeV						
SLy6	1.361	0.038	$nn[624\downarrow, 734\uparrow]$	1.317	0.996	F,F+1
SkM*	1.330	0.025	$nn[734\uparrow, 624\downarrow]$	1.198	0.992	F,F+1
SVbas	1.913	0.119	$nn[624\downarrow, 734\uparrow]$	1.751	0.912	F,F+1
^{254}No, E_{exp}=1.295 MeV						
SLy6	1.747	0.014	$nn[734\uparrow, 613\uparrow]$	1.780	0.994	F,F+3
SkM*	1.554	0.333	$pp[514\downarrow, 624\uparrow,]$	1.482	0.990	F+1,F+2
SVbas	1.994	0.370	$pp[514\downarrow, 624\uparrow,]$	1.751	0.791	F+1,F+2
			$nn[734\uparrow, 613\uparrow]$	2.026	0.169	F,F+3

Features of calculated 8^- states in ^{252,254}No: QRPA excitation energies E_{ν} =1, reduced transition probabilities B(E98), the main 2qp component qq′, its energy $\varepsilon_{qq'}$, contribution to the state norm $N_{qq'}$ and F-scheme of 2qp excitation.

$K^{\pi}= 8^{-}$ isomers

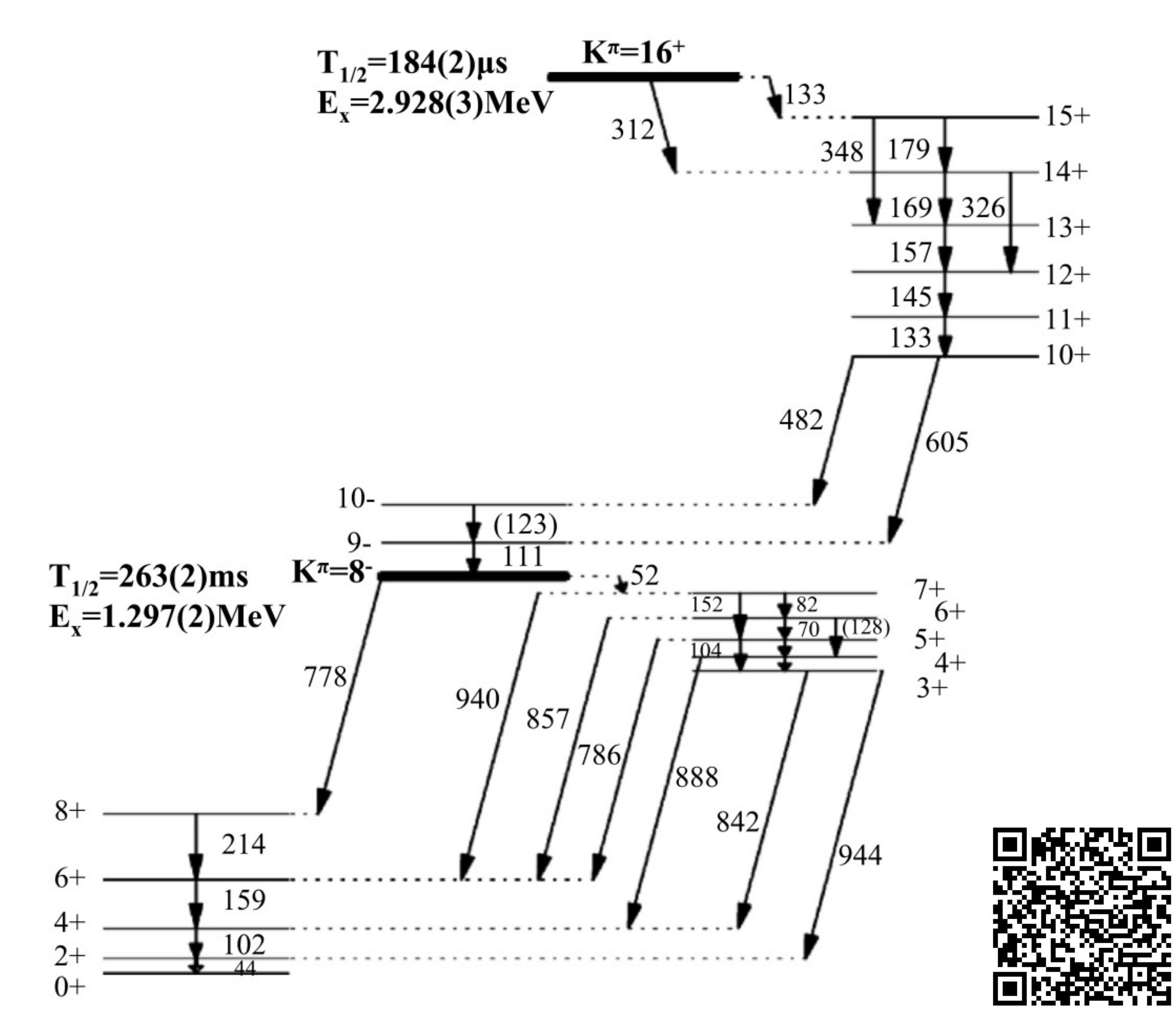
^{252}No: the 8^{-} state is usually assigned as neutron 2qp configuration nn[734 ↑, 624 ↓]

- R.-D. Herzberg and P.T. Greenlees, Prog. Part. Nucl. Phys. 61, 674 (2008)
- F.P. Heßberger, arXiv:2309.10468v2[nucl-ex].
- B. Sulignano et al, Eur. Phys. J. A 33, 327 (2007).

^{254}No: forces predict different 2qp configurations nn[734 ↑, 613 ↓] and pp[514 ↓, 624 ↑]

- V.G. Soloviev, A.V. Sushkov, A.Yu. Shirikova, Sov. J. Nucl. Phys. 54, 748 (1991)
- R.M. Clark et al, Phys. Lett. B690, 19 (2010)

- R.V. Jolos, L.A. Malov, N.Yu. Shirikova and A.V. Sushkov, J. Phys. G: Nucl. Part. Phys. 38, 115103 (2011).
- Xiao-Tao He, Shu-Young Zhao, Zhen-Hua Zhang and Zhong-Zhou Ren, Chines Physics C 44, 034106 (2020)
- G.G. Adamian, N.V. Antonenko, anf W. Scheid, Phys. Rev. C 81, 024320 (2010)
- F.P. Hessberger et al, Eur. Phys. J A43, 55 (2010)



R.M. Clark et al, Phys. Lett. B690, 19 (2010)

$K^{\pi}= 8^{-}$ isomers

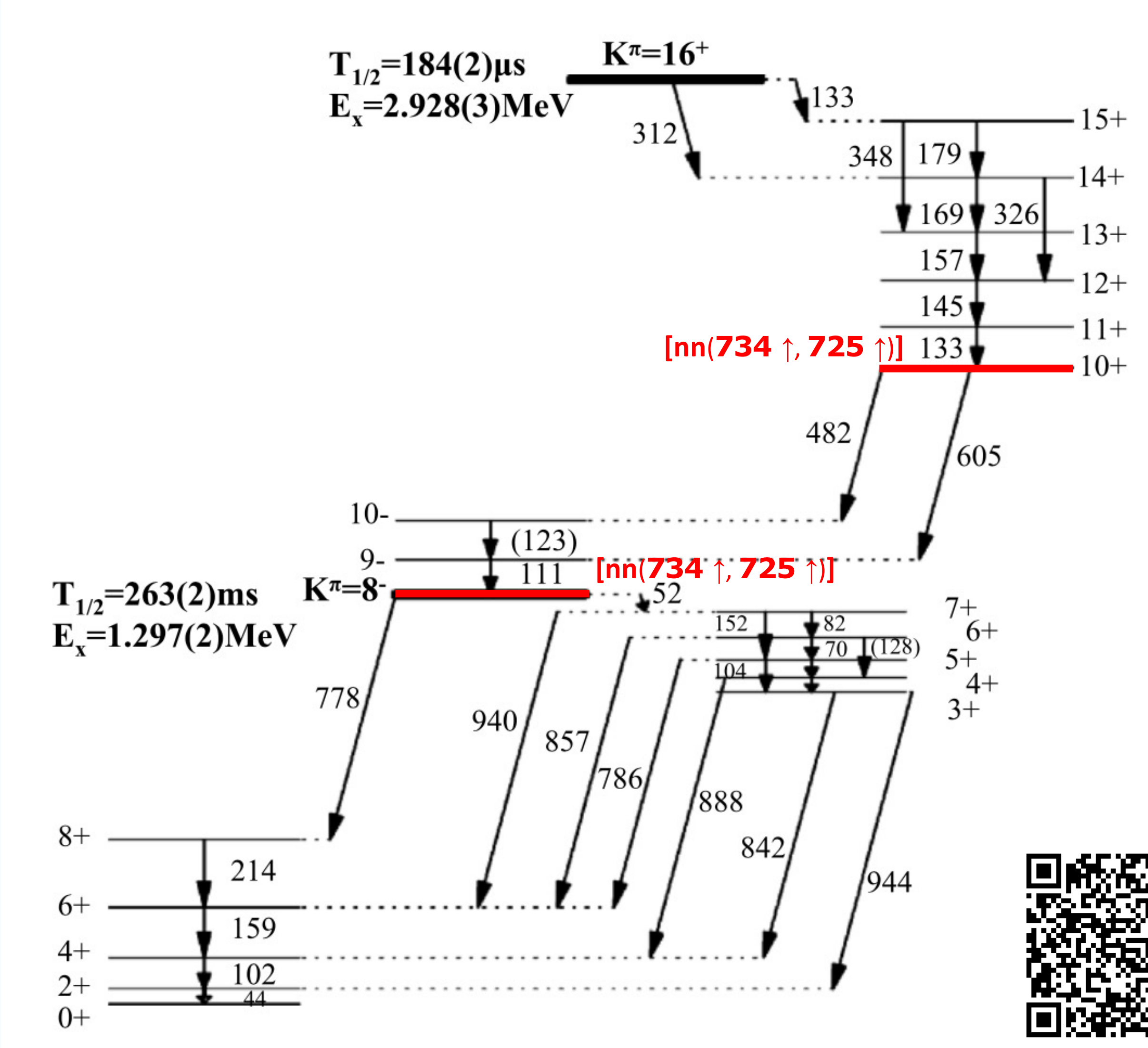
^{252}No: the 8^{-} state is usually assigned as neutron 2qp configuration nn[734 ↑, 624 ↓]

- R.-D. Herzberg and P.T. Greenlees, Prog. Part. Nucl. Phys. 61, 674 (2008)
- F.P. Heßberger, arXiv:2309.10468v2[nucl-ex].
- B. Sulignano et al, Eur. Phys. J. A 33, 327 (2007).

^{254}No: forces predict different 2qp configurations nn[734 ↑, 613 ↓] and pp[514 ↓, 624 ↑]

- V.G. Soloviev, A.V. Sushkov, A.Yu. Shirikova, Sov. J. Nucl. Phys. 54, 748 (1991)
- R.M. Clark et al, Phys. Lett. B690, 19 (2010)

- R.V. Jolos, L.A. Malov, N.Yu. Shirikova and A.V. Sushkov, J. Phys. G: Nucl. Part. Phys. 38, 115103 (2011).
- Xiao-Tao He, Shu-Young Zhao, Zhen-Hua Zhang and Zhong-Zhou Ren, Chines Physics C 44, 034106 (2020)
- G.G. Adamian, N.V. Antonenko, anf W. Scheid, Phys. Rev. C 81, 024320 (2010)
- F.P. Hessberger et al, Eur. Phys. J A43, 55 (2010)



R.M. Clark et al, Phys. Lett. B690, 19 (2010)

Pairing vibrations $K^\pi = 0^+$

Force	K^π_ν	E [MeV]	$B(E20)$ [W.u.]	$\rho^2(E0)$ (10^{-3})	qq'	$\epsilon_{qq'}$ [MeV]	$N_{qq'}$	F-struct
	^{252}No							
SLy6	0^+_1	0.77	0.03	0.08	$nn[734\downarrow,734\downarrow]$	1.07	0.58	F+1,F+1
					$nn[624\downarrow,624\downarrow]$	1.56	0.17	F,F
					$nn[622\uparrow,622\uparrow]$	1.53	0.16	F-1,F-1
	0^+_2	1.13	1.36	0.59	$pp[514\downarrow,514\downarrow]$	1.16	0.56	F+1, F+1
					$pp[521\downarrow,521\downarrow]$	1.16	0.38	F,F
SkM*	0^+_1	0.84	1.12	0.32	$pp[521\downarrow,521\downarrow]$	1.01	0.46	F,F
					$pp[514\downarrow,514\downarrow]$	1.09	0.42	F+1,F+1
	0^+_2	1.20	0.02	0.18	$nn[624\downarrow,624\downarrow]$	1.19	0.52	F,F
					$nn[734\uparrow,734\uparrow]$	1.21	0.44	F+1,F+1
SVbas	0^+_1	1.25	5.83	0.66	$pp[514\downarrow,514\downarrow]$	1.23	0.56	F+1,F+1
					$pp[521\downarrow,521\downarrow]$	1.20	0.36	F,F
	0^+_2	1.49	0.65	0.63	$pp[633\uparrow,633\uparrow]$	1.60	0.70	F-1,F-1
				-	$pp[521\downarrow,521\downarrow]$	1.20	0.28	F,F
	^{254}No							
SLy6	0^+_1	0.22	0.002	0.002	$nn[734\uparrow,734\uparrow]$	1.05	0.41	F,F
					$nn[620\uparrow,620\uparrow]$	1.27	0.27	F+1,F+1
					$nn[622\downarrow,622\downarrow]$	1.38	0.20	F+2,F+2
	0^+_2	1.13	1.31	0.53	$pp[514\downarrow,514\downarrow]$	1.16	0.56	F+1, F+1
					$pp[521\downarrow,521\downarrow]$	1.15	0.40	F,F
SkM*	0^+_1	0.77	0.17	0.02	$nn[624\downarrow,624\downarrow]$	1.41	0.33	F,F
					$nn[620\uparrow,620\uparrow]$	1.36	0.23	F+1, F+1
					$nn[734\uparrow,734\uparrow]$	1.81	0.12	F-1,F-1
	0^+_2	0.88	4.37	0.36	$pp[521\downarrow,521\downarrow]$	1.02	0.45	F,F
					$pp[514\downarrow,514\downarrow]$	1.08	0.43	F+1,F+1
SVbas	0^+_1	1.24	6.34	0.67	$pp[514\downarrow,514\downarrow]$	1.22	0.57	F+1,F+1
					$pp[521\downarrow,521\downarrow]$	1.19	0.34	F,F
	0^+_2	1.45	0.52	0.36	$pp[633\uparrow,633\uparrow]$	1.59	0.45	F-1,F-1
					$pp[521\downarrow,521\downarrow]$	1.19	0.25	F,F

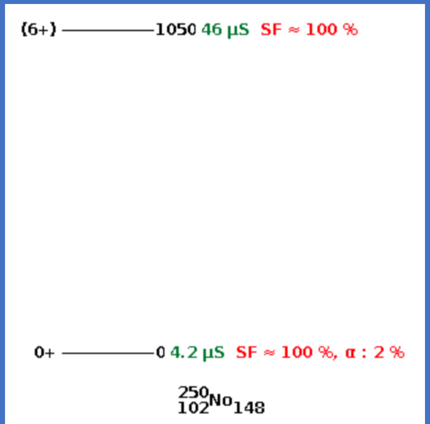
- **Calculations predict for the lowest $K^\pi = 0^+$** state in ^{254}No an exceptionally low excitation energy 0.22 MeV (this state is basically pairing vibrational)

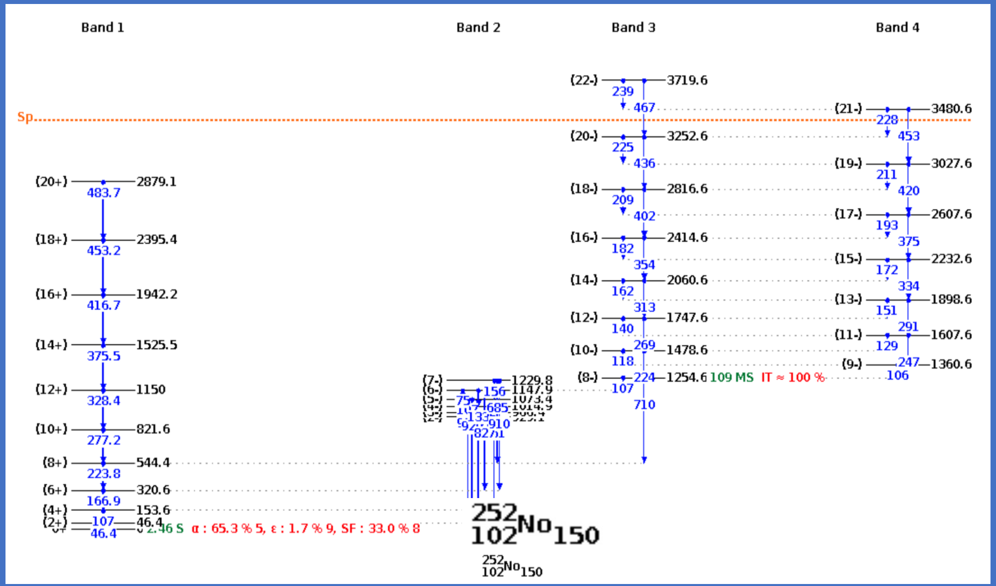
- Recent shell-model calculations with the projection after variation **also predicts $K^\pi = 0^+$ state with E=0.86 MeV as the lowest non-rotational state of ^{254}No**
(D.D. Dao and F. Nowacki, Phys. Rev. C 105, 054314 (2022))

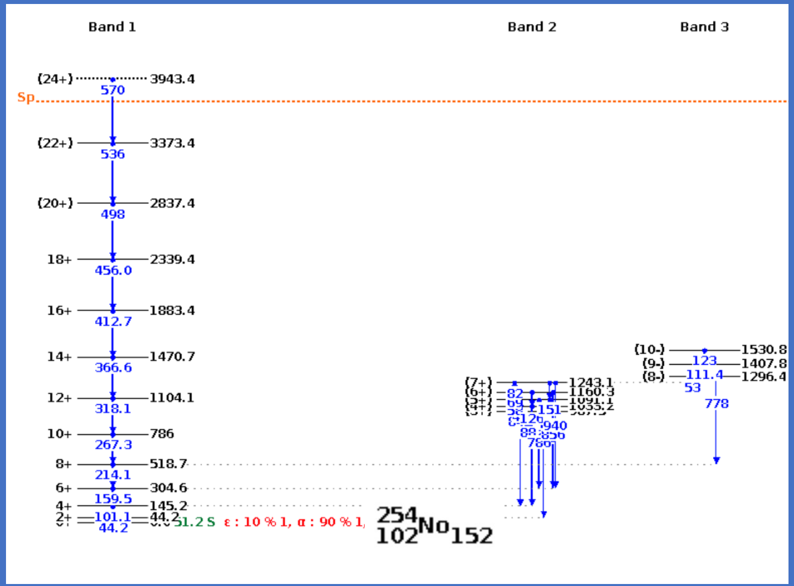
- [M. Forge et al 2023 J. Phys.: Conf. Ser. 2586 012083] **also predicts $K^\pi = 0^+$ state with E=0.89 MeV** (shape coexistence)

So, excited 0+ states below 1 MeV in superheavy nuclei are quite possible

At the moment, there are experimental* spectroscopic data only for 3/7 nuclei: ^{250,252,254}No

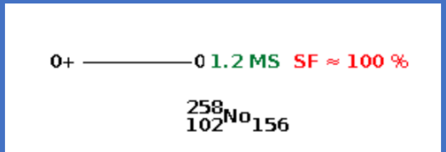


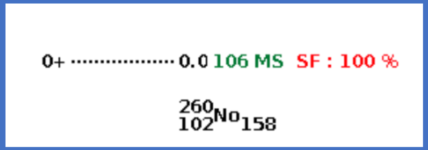


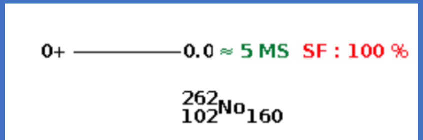


>>

>







* NNDC data base

Pairing vibrations $K^{\pi} = 0^{+}$

Force	K^{π}_{ν}	E [MeV]	$B(E20)$ [W.u.]	$\rho^2(E0)$ (10^{-3})	qq'	$\epsilon_{qq'}$ [MeV]	$N_{qq'}$	F-struct
				^{252}No				
SLy6	0^+_1	0.77	0.03	0.08	$nn[734\downarrow, 734\downarrow]$	1.07	0.58	F+1,F+1
					$nn[624\downarrow, 624\downarrow]$	1.56	0.17	F,F
					$nn[622\uparrow, 622\uparrow]$	1.53	0.16	F-1,F-1
	0^+_2	1.13	1.36	0.59	$pp[514\downarrow, 514\downarrow]$	1.16	0.56	F+1, F+1
					$pp[521\downarrow, 521\downarrow]$	1.16	0.38	F,F
SkM*	0^+_1	0.84	1.12	0.32	$pp[521\downarrow, 521\downarrow]$	1.01	0.46	F,F
					$pp[514\downarrow, 514\downarrow]$	1.09	0.42	F+1,F+1
	0^+_2	1.20	0.02	0.18	$nn[624\downarrow, 624\downarrow]$	1.19	0.52	F,F
					$nn[734\uparrow, 734\uparrow]$	1.21	0.44	F+1,F+1
SVbas	0^+_1	1.25	5.83	0.66	$pp[514\downarrow, 514\downarrow]$	1.23	0.56	F+1,F+1
					$pp[521\downarrow, 521\downarrow]$	1.20	0.36	F,F
	0^+_2	1.49	0.65	0.63	$pp[633\uparrow, 633\uparrow]$	1.60	0.70	F-1,F-1
				-	$pp[521\downarrow, 521\downarrow]$	1.20	0.28	F,F
				^{254}No				
SLy6	0^+_1	0.22	0.002	0.002	$nn[734\uparrow, 734\uparrow]$	1.05	0.41	F,F
					$nn[620\uparrow, 620\uparrow]$	1.27	0.27	F+1,F+1
					$nn[622\downarrow, 622\downarrow]$	1.38	0.20	F+2,F+2
	0^+_2	1.13	1.31	0.53	$pp[514\downarrow, 514\downarrow]$	1.16	0.56	F+1, F+1
					$pp[521\downarrow, 521\downarrow]$	1.15	0.40	F,F
SkM*	0^+_1	0.77	0.17	0.02	$nn[624\downarrow, 624\downarrow]$	1.41	0.33	F,F
					$nn[620\uparrow, 620\uparrow]$	1.36	0.23	F+1, F+1
					$nn[734\uparrow, 734\uparrow]$	1.81	0.12	F-1,F-1
	0^+_2	0.88	4.37	0.36	$pp[521\downarrow, 521\downarrow]$	1.02	0.45	F,F
					$pp[514\downarrow, 514\downarrow]$	1.08	0.43	F+1,F+1
SVbas	0^+_1	1.24	6.34	0.67	$pp[514\downarrow, 514\downarrow]$	1.22	0.57	F+1,F+1
					$pp[521\downarrow, 521\downarrow]$	1.19	0.34	F,F
	0^+_2	1.45	0.52	0.36	$pp[633\uparrow, 633\uparrow]$	1.59	0.45	F-1,F-1
					$pp[521\downarrow, 521\downarrow]$	1.19	0.25	F,F

- **Calculations predict for the lowest $K^{\pi} = 0^{+}$** state in ^{254}No an exceptionally low excitation energy 0.22 MeV (this state is basically pairing vibrational)

- Recent shell-model calculations with the projection after variation **also predicts $K^{\pi} = 0^{+}$ state with E=0.86 MeV as the lowest non-rotational state of ^{254}No**
  (D.D. Dao and F. Nowacki, Phys. Rev. C 105, 054314 (2022))

- [M. Forge et al 2023 J. Phys.: Conf. Ser. 2586 012083] **also predicts $K^{\pi} = 0^{+}$ state with E=0.89 MeV** (shape coexistence)

So, excited 0+ states below 1 MeV in superheavy nuclei are quite possible

Hexadecapole states with $K^{\pi} = 3^{+}$ and 4^{+}

Force	E	$B(E43)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No					
SLy6	1.10	3.04	$pp[521\downarrow, 514\downarrow]$	1.16	0.99	F,F+1
	2.13	2.91	$pp[521\downarrow, 512\uparrow]$	2.11	0.95	F,F+3
SkM*	1.00	3.61	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.69	2.67	$pp[521\downarrow, 512\uparrow]$	1.61	0.94	F,F+3
SVbas	1.19	2.73	$pp[521\downarrow, 514\downarrow]$	1.21	0.98	F,F+1
	1.93	2.43	$pp[521\downarrow, 512\uparrow]$	1.86	0.95	F,F+3
	^{254}No, E_x=0.987 MeV					
SLy6	1.11	2.41	$pp[521\uparrow, 514\downarrow]$	1.15	0.99	F,F+1
	1.89	1.78	$nn[620\uparrow, 613\uparrow]$	1.89	1.00	F+1,F+3
SkM*	1.01	3.24	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.41	2.15	$nn[624\downarrow], 620\uparrow]$	1.39	1.00	F,F+1
SVbas	1.17	3.00	$pp[521\downarrow, 514\downarrow]$	1.20	0.99	F,F+1
	1.87	3.28	$nn[620\uparrow, 613\uparrow]$	1.98	0.48	F+1,F+3
			$pp[521\downarrow, 512\uparrow]$	1.89	0.47	F,F+3

Force	E	$B(E44)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No					
SLy6	1.16	$5.5\ 10^{-4}$	$pp[521\downarrow, 514\uparrow]$	1.16	1.00	F,F+1
	2.11	1.78	$nn[624\downarrow, 620\uparrow]$	2.34	0.50	F,F+2
			$nn[622\uparrow, 622\downarrow]$	2.41	0.42	F-1,F+3
SkM*	1.00	3.61	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.69	2.67	$pp[521\downarrow, 512\uparrow]$	1.61	0.94	F,F+3
SVbas	1.19	2.73	$pp[521\downarrow, 514\downarrow]$	1.21	0.98	F,F+1
	1.93	2.43	$pp[521\downarrow, 512\uparrow]$	1.86	0.95	F,F+3
	^{254}No, E_x=0.987 MeV					
SLy6	1.16	0.07	$pp[521\downarrow, 514\downarrow]$	1.15	1.00	F,F+1
	1.89	$1\ 10^{-4}$	$nn[620\uparrow, 613\uparrow]$	1.89	1.00	F+1,F+3
SkM*	1.01	3.24	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.41	2.15	$nn[624\downarrow], 620\uparrow]$	1.39	1.00	F,F+1
SVbas	1.17	3.00	$pp[521\downarrow, 514\downarrow]$	1.20	0.99	F,F+1
	1.87	3.28	$nn[620\uparrow, 613\uparrow]$	1.98	0.48	F+1,F+3
			$pp[521\downarrow, 512\uparrow]$	1.89	0.47	F,F+3

- The first 3+ state is **purely 2qp**

- All the forces predict for this state **the proton 2qp configuration** pp[521 ↓, 514 ↓]

So, we see that effect of the hexadecapole residual interaction for 3^{+} states in ^{252,254}No is negligible

- **The calculated 4+ states in ^{252,254}No have the energies and structure very similar to 3+ states.** This is not surprising since both kinds of states are basically formed by the same proton 2qp configuration pp[521 ↓, 514 ↓] with |K1 − K2|=3 and K1 + K2=4.

Hexadecapole states with $K^{\pi} = 3^{+}$ and 4^{+}

Force	E	$B(E43)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No					
SLy6	1.10	3.04	$pp[521\downarrow, 514\downarrow]$	1.16	0.99	F,F+1
	2.13	2.91	$pp[521\downarrow, 512\uparrow]$	2.11	0.95	F,F+3
SkM*	1.00	3.61	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.69	2.67	$pp[521\downarrow, 512\uparrow]$	1.61	0.94	F,F+3
SVbas	1.19	2.73	$pp[521\downarrow, 514\downarrow]$	1.21	0.98	F,F+1
	1.93	2.43	$pp[521\downarrow, 512\uparrow]$	1.86	0.95	F,F+3
	^{254}No, E_x=0.987 MeV					
SLy6	1.11	2.41	$pp[521\uparrow, 514\downarrow]$	1.15	0.99	F,F+1
	1.89	1.78	$nn[620\uparrow, 613\uparrow]$	1.89	1.00	F+1,F+3
SkM*	1.01	3.24	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.41	2.15	$nn[624\downarrow], 620\uparrow]$	1.39	1.00	F,F+1
SVbas	1.17	3.00	$pp[521\downarrow, 514\downarrow]$	1.20	0.99	F,F+1
	1.87	3.28	$nn[620\uparrow, 613\uparrow]$	1.98	0.48	F+1,F+3
			$pp[521\downarrow, 512\uparrow]$	1.89	0.47	F,F+3

Force	E	$B(E44)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No					
SLy6	1.16	5.5 10^{-4}	$pp[521\downarrow, 514\uparrow]$	1.16	1.00	F,F+1
	2.11	1.78	$nn[624\downarrow, 620\uparrow]$	2.34	0.50	F,F+2
			$nn[622\uparrow, 622\downarrow]$	2.41	0.42	F-1,F+3
SkM*	1.00	3.61	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.69	2.67	$pp[521\downarrow, 512\uparrow]$	1.61	0.94	F,F+3
SVbas	1.19	2.73	$pp[521\downarrow, 514\downarrow]$	1.21	0.98	F,F+1
	1.93	2.43	$pp[521\downarrow, 512\uparrow]$	1.86	0.95	F,F+3
	^{254}No, E_x=0.987 MeV					
SLy6	1.16	0.07	$pp[521\downarrow, 514\downarrow]$	1.15	1.00	F,F+1
	1.89	1 10^{-4}	$nn[620\uparrow, 613\uparrow]$	1.89	1.00	F+1,F+3
SkM*	1.01	3.24	$pp[521\downarrow, 514\downarrow]$	1.05	0.97	F,F+1
	1.41	2.15	$nn[624\downarrow], 620\uparrow]$	1.39	1.00	F,F+1
SVbas	1.17	3.00	$pp[521\downarrow, 514\downarrow]$	1.20	0.99	F,F+1
	1.87	3.28	$nn[620\uparrow, 613\uparrow]$	1.98	0.48	F+1,F+3
			$pp[521\downarrow, 512\uparrow]$	1.89	0.47	F,F+3

- The first 3+ state is **purely 2qp**

- All the forces predict for this state **the proton 2qp configuration** pp[521 ↓, 514 ↓]

So, we see that effect of the hexadecapole residual interaction for 3^{+} states in ^{252,254}No is negligible

- **The calculated 4+ states in ^{252,254}No have the energies and structure very similar to 3+ states.** This is not surprising since both kinds of states are basically formed by the same proton 2qp configuration pp[521 ↓, 514 ↓] with |K1 − K2|=3 and K1 + K2=4.

Octupole states with Kπ = 0⁻, 1⁻, 2⁻ and 3⁻

- In agreement with the experimental analysis, all three Skyrme forces suggest for the first 2^- state in ^{252}No the 2qp configuration nn[734 ↑, 622 ↑]

- In the QPM study [R.V. Jolos, L.A. Malov, N.Yu. Shirikova and A.V. Sushkov, J. Phys. G: Nucl. Part. Phys. 38, 115103 (2011)], the first 2^- state is the lowest among the octupole excitations in ^{252}No. We get the same result for SLy6 but not for SkM* and SVbas.

- In ^{254}No, our calculations for the first 2^- stat give rather high energies (1.80-2.12 MeV) and essentially different structure and collectivity.

Force	K^π	E	$B(E3K)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct	K^π	E	$B(E3K)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No							^{254}No						
SLy6	0^-	1.24	9.1	$pp[514\downarrow, 633\uparrow]$	1.35	0.93	F+1,F-1	0^-	1.25	11.2	$pp[514\downarrow, 633\uparrow]$	1.38	0.87	F+1,F-1
	1^-	1.41	1.5	$nn[734\uparrow, 624\downarrow]$	1.32	0.98	F+1,F	1^-	1.54	8.4	$nn[734\uparrow, 613\uparrow]$	1.78	0.82	F,F+3
	2^-	0.95	11.5	$nn[734\uparrow, 622\uparrow]$	1.30	0.92	F+1,F-1	2^-	2.12	0.6	$nn[734\uparrow, 622\uparrow]$	2.13	0.94	F,F-1
	3^-	1.35	0.1	$pp[633\uparrow, 521\downarrow]$	1.35	1.00	F-1,F	3^-	1.28	0.03	$nn[734\uparrow, 622\downarrow]$	1.213	0.94	F,F+2
SkM*	0^-	1.35	20.7	$pp[514\downarrow, 633\uparrow]$	1.52	0.79	F+1, F-1	0^-	1.37	16.3	$pp[514\downarrow, 633\uparrow]$	1.51	0.84	F+1,F-1
	1^-	1.16	2.2	$nn[734\uparrow, 624\downarrow]$	1.20	0.97	F,F+1	1^-	1.47	1.5	$pp[624\uparrow, 514\downarrow]$	1.48	0.95	F+2,F+1
	2^-	1.46	6.2	$nn[734\uparrow, 622\uparrow]$	1.61	0.92	F,F-1	2^-	1.80	3.7	$nn[725\uparrow, 624\downarrow]$	1.71	0.85	F+3,F
	3^-	1.48	0.05	$pp[633\uparrow, 521\downarrow]$	1.48	1.00	F-2,F	3^-	1.48	0.04	$pp[633\uparrow, 521\downarrow]$	1.48	1.00	F-1,F
SVbas	0^-	1.32	7.7	$pp[514\downarrow, 633\uparrow]$	1.42	0.92	F+1, F-1	0^-	1.30	7.4	$pp[514\downarrow, 633\uparrow]$	1.40	0.92	F+1,F-1
	1^-	1.71	6.1	$nn[734\uparrow, 624\downarrow]$	1.75	0.77	F+1,F	1^-	1.72	12.3	$nn[734\uparrow, 613\uparrow]$	2.03	0.42	F,F+3
				$pp[633\uparrow, 512\uparrow]$	2.06	0.10	F-1,F+3				$pp[633\uparrow, 512\uparrow]$	2.09	0.30	F-1,F+3
										-	$pp[624\uparrow, 514\downarrow]$	1.86	0.10	F+2,F+1
	2^-	1.62	12.6	$nn[734\downarrow, 622\uparrow]$	1.9	0.72	F+1,F-1	2^-	1.90	14.5	$pp[633\uparrow, 521\downarrow]$	2.15	0.44	F-1,F
			-	$pp[633\uparrow, 521\uparrow]$	2.15	0.13	F-1,F-2			-	$nn[734\uparrow, 622\uparrow]$	2.33	0.26	F,F-2
	3^-	1.40	0.06	$pp[633\uparrow, 521\downarrow]$	1.40	1.00	F-1,F	3^-	1.39	0.05	$pp[633\uparrow, 521\downarrow]$	1.40	1.00	F-1,F

Octupole states with $K^{\pi} = 0^-, 1^-, 2^-$ and 3^-

- In agreement with the experimental analysis, all three Skyrme forces suggest for the first 2^- state in ^{252}No the 2qp configuration nn[734 ↑, 622 ↑]
- In the QPM study [R.V. Jolos, L.A. Malov, N.Yu. Shirikova and A.V. Sushkov, J. Phys. G: Nucl. Part. Phys. 38, 115103 (2011)], the first 2^- state is the lowest among the octupole excitations in ^{252}No. We get the same result for SLy6 but not for SkM* and SVbas.
- In ^{254}No, our calculations for the first 2^- stat give rather high energies (1.80-2.12 MeV) and essentially different structure and collectivity.

Force	K^π	E	$B(E3K)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct	K^π	E	$B(E3K)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No							^{254}No						
SLy6	0^-	1.24	9.1	$pp[514\downarrow, 633\uparrow]$	1.35	0.93	F+1,F-1	0^-	1.25	11.2	$pp[514\downarrow, 633\uparrow]$	1.38	0.87	F+1,F-1
	1^-	1.41	1.5	$nn[734\uparrow, 624\downarrow]$	1.32	0.98	F+1,F	1^-	1.54	8.4	$nn[734\uparrow, 613\uparrow]$	1.78	0.82	F,F+3
	2^-	0.95	11.5	$nn[734\uparrow, 622\uparrow]$	1.30	0.92	F+1,F-1	2^-	2.12	0.6	$nn[734\uparrow, 622\uparrow]$	2.13	0.94	F,F-1
	3^-	1.35	0.1	$pp[633\uparrow, 521\downarrow]$	1.35	1.00	F-1,F	3^-	1.28	0.03	$nn[734\uparrow, 622\downarrow]$	1.213	0.94	F,F+2
SkM*	0^-	1.35	20.7	$pp[514\downarrow, 633\uparrow]$	1.52	0.79	F+1, F-1	0^-	1.37	16.3	$pp[514\downarrow, 633\uparrow]$	1.51	0.84	F+1,F-1
	1^-	1.16	2.2	$nn[734\uparrow, 624\downarrow]$	1.20	0.97	F,F+1	1^-	1.47	1.5	$pp[624\uparrow, 514\downarrow]$	1.48	0.95	F+2,F+1
	2^-	1.46	6.2	$nn[734\uparrow, 622\uparrow]$	1.61	0.92	F,F-1	2^-	1.80	3.7	$nn[725\uparrow, 624\downarrow]$	1.71	0.85	F+3,F
	3^-	1.48	0.05	$pp[633\uparrow, 521\downarrow]$	1.48	1.00	F-2,F	3^-	1.48	0.04	$pp[633\uparrow, 521\downarrow]$	1.48	1.00	F-1,F
SVbas	0^-	1.32	7.7	$pp[514\downarrow, 633\uparrow]$	1.42	0.92	F+1, F-1	0^-	1.30	7.4	$pp[514\downarrow, 633\uparrow]$	1.40	0.92	F+1,F-1
	1^-	1.71	6.1	$nn[734\uparrow, 624\downarrow]$	1.75	0.77	F+1,F	1^-	1.72	12.3	$nn[734\uparrow, 613\uparrow]$	2.03	0.42	F,F+3
				$pp[633\uparrow, 512\uparrow]$	2.06	0.10	F-1,F+3				$pp[633\uparrow, 512\uparrow]$	2.09	0.30	F-1,F+3
										-	$pp[624\uparrow, 514\downarrow]$	1.86	0.10	F+2,F+1
	2^-	1.62	12.6	$nn[734\downarrow, 622\uparrow]$	1.9	0.72	F+1,F-1	2^-	1.90	14.5	$pp[633\uparrow, 521\downarrow]$	2.15	0.44	F-1,F
			-	$pp[633\uparrow, 521\uparrow]$	2.15	0.13	F-1,F-2			-	$nn[734\uparrow, 622\uparrow]$	2.33	0.26	F,F-2
	3^-	1.40	0.06	$pp[633\uparrow, 521\downarrow]$	1.40	1.00	F-1,F	3^-	1.39	0.05	$pp[633\uparrow, 521\downarrow]$	1.40	1.00	F-1,F

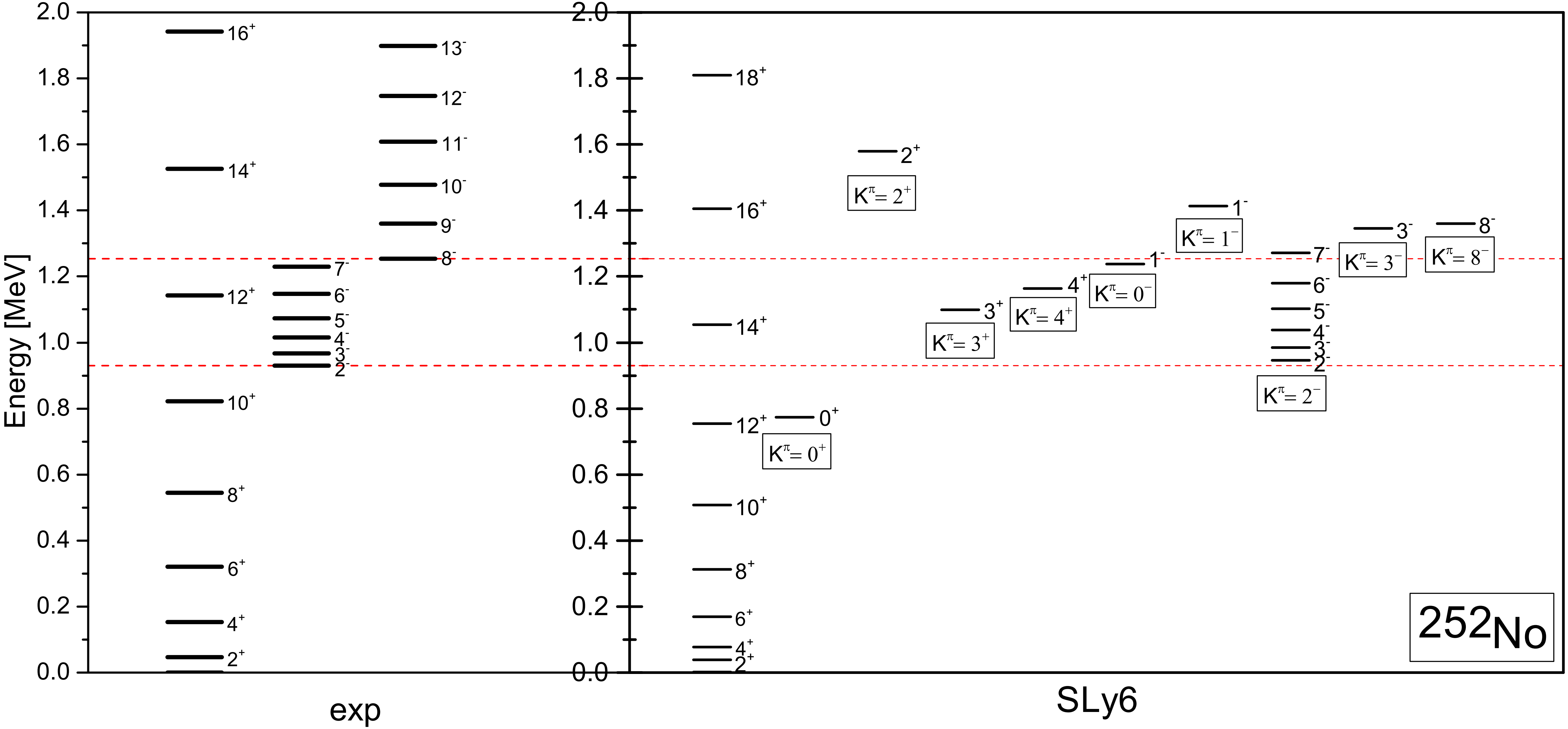
Octupole states with K^{π} = 0^-, 1^-, 2^- and 3^-

- In agreement with the experimental analysis, all three Skyrme forces suggest for the first 2^- state in ^{252}No the 2qp configuration nn[734 ↑, 622 ↑]

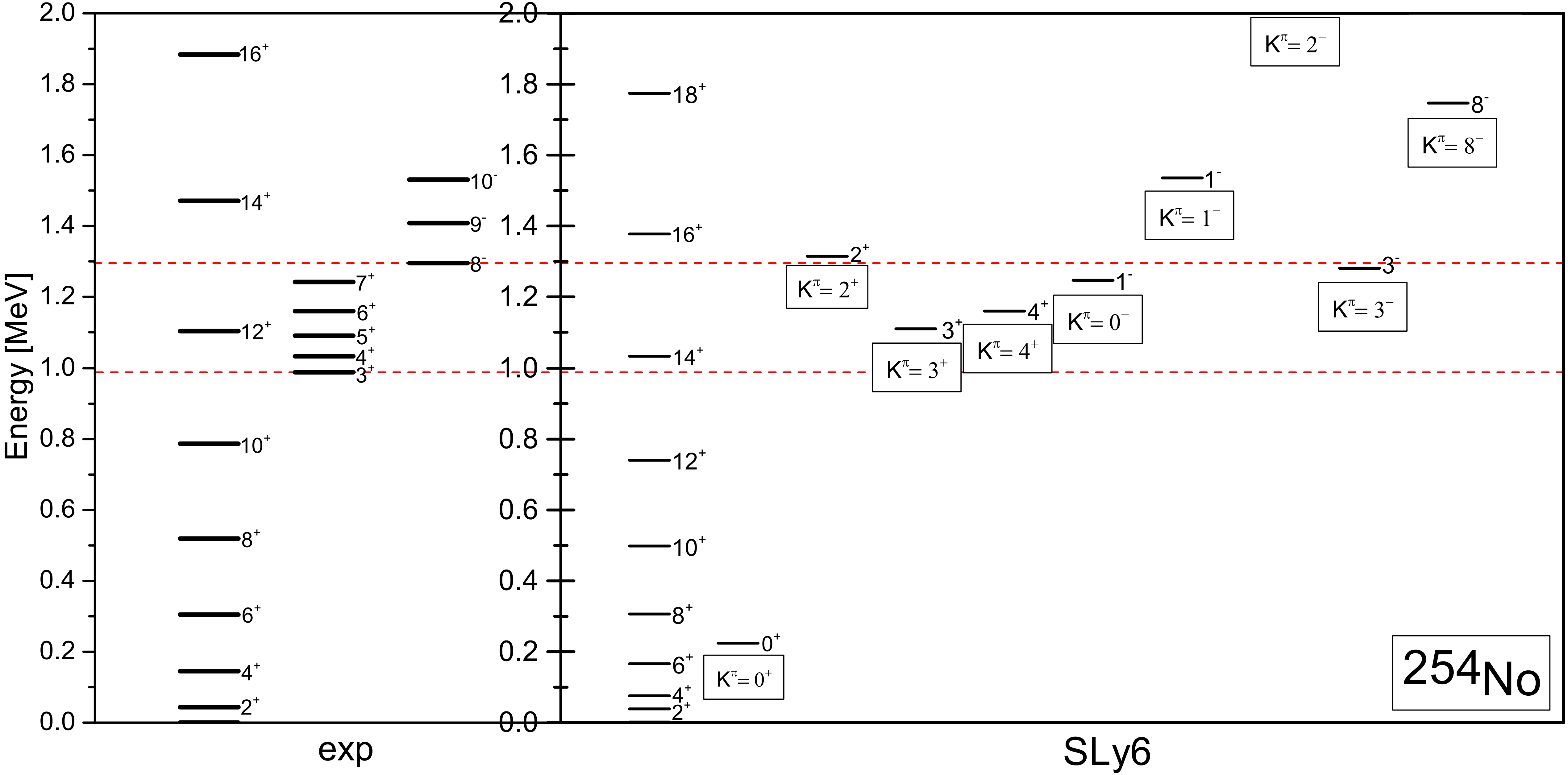
- In the QPM study [R.V. Jolos, L.A. Malov, N.Yu. Shirikova and A.V. Sushkov, J. Phys. G: Nucl. Part. Phys. 38, 115103 (2011)], the first 2^- state is the lowest among the octupole excitations in ^{252}No. We get the same result for SLy6 but not for SkM* and SVbas.

- In ^{254}No, our calculations for the first 2^- stat give rather high energies (1.80-2.12 MeV) and essentially different structure and collectivity.

Force	K^{π}	E	$B(E3K)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct	K^{π}	E	$B(E3K)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
	^{252}No							^{254}No						
SLy6	0^-	1.24	9.1	$pp[514\downarrow, 633\uparrow]$	1.35	0.93	F+1,F-1	0^-	1.25	11.2	$pp[514\downarrow, 633\uparrow]$	1.38	0.87	F+1,F-1
	1^-	1.41	1.5	$nn[734\uparrow, 624\downarrow]$	1.32	0.98	F+1,F	1^-	1.54	8.4	$nn[734\uparrow, 613\uparrow]$	1.78	0.82	F,F+3
	2^-	0.95	11.5	$nn[734\uparrow, 622\uparrow]$	1.30	0.92	F+1,F-1	2^-	2.12	0.6	$nn[734\uparrow, 622\uparrow]$	2.13	0.94	F,F-1
	3^-	1.35	0.1	$pp[633\uparrow, 521\downarrow]$	1.35	1.00	F-1,F	3^-	1.28	0.03	$nn[734\uparrow, 622\downarrow]$	1.213	0.94	F,F+2
SkM*	0^-	1.35	20.7	$pp[514\downarrow, 633\uparrow]$	1.52	0.79	F+1, F-1	0^-	1.37	16.3	$pp[514\downarrow, 633\uparrow]$	1.51	0.84	F+1,F-1
	1^-	1.16	2.2	$nn[734\uparrow, 624\downarrow]$	1.20	0.97	F,F+1	1^-	1.47	1.5	$pp[624\uparrow, 514\downarrow]$	1.48	0.95	F+2,F+1
	2^-	1.46	6.2	$nn[734\uparrow, 622\uparrow]$	1.61	0.92	F,F-1	2^-	1.80	3.7	$nn[725\uparrow, 624\downarrow]$	1.71	0.85	F+3,F
	3^-	1.48	0.05	$pp[633\uparrow, 521\downarrow]$	1.48	1.00	F-2,F	3^-	1.48	0.04	$pp[633\uparrow, 521\downarrow]$	1.48	1.00	F-1,F
SVbas	0^-	1.32	7.7	$pp[514\downarrow, 633\uparrow]$	1.42	0.92	F+1, F-1	0^-	1.30	7.4	$pp[514\downarrow, 633\uparrow]$	1.40	0.92	F+1,F-1
	1^-	1.71	6.1	$nn[734\uparrow, 624\downarrow]$	1.75	0.77	F+1,F	1^-	1.72	12.3	$nn[734\uparrow, 613\uparrow]$	2.03	0.42	F,F+3
				$pp[633\uparrow, 512\uparrow]$	2.06	0.10	F-1,F+3				$pp[633\uparrow, 512\uparrow]$	2.09	0.30	F-1,F+3
										-	$pp[624\uparrow, 514\downarrow]$	1.86	0.10	F+2,F+1
	2^-	1.62	12.6	$nn[734\downarrow, 622\uparrow]$	1.9	0.72	F+1,F-1	2^-	1.90	14.5	$pp[633\uparrow, 521\downarrow]$	2.15	0.44	F-1,F
			-	$pp[633\uparrow, 521\uparrow]$	2.15	0.13	F-1,F-2			-	$nn[734\uparrow, 622\uparrow]$	2.33	0.26	F,F-2
	3^-	1.40	0.06	$pp[633\uparrow, 521\downarrow]$	1.40	1.00	F-1,F	3^-	1.39	0.05	$pp[633\uparrow, 521\downarrow]$	1.40	1.00	F-1,F



- The band of the ground state is slightly compressed
- The band, which built on state 2^- is described well and the two others bands are also described satisfactorily



We also describing the 3 experimental bands quite well and working to carry out the more detailed analyzes about the band starting with 8^-

Planned collaborations:

- **FLNR, JINR**
  Low-lying spectrum analysis for ^{254}No
- **France + FNR**
  Investigation $K^{\pi} = 0^{+}$ in ^{250}No (energy, structure)
- **China**
  Study of $^{250-262}$No low-lying spectrum structure + pairing effects
- **South Africa**
  Analysis of ^{252,254}No characteristics

Conclusion

- The low-energy spectra of the Nobelium chain were studied within the framework of three Skyrme forces (SLy6, SkM*, SVbas) with different types of pairing

- It was shown that for the ground state bands of $^{250-260}$No the irregularity occurs in the region $^{252-254}$No

- For ^{252,254}No isotopes this irregularity associated with pairing effect and evolution of the single-particle spectrum

- All three Skyrme forces maintain this irregularity, despite different types of neutron pairing (volume/surface)

- The theoretically obtained bands for the lower spectrum for $^{252,\,254}$No are in good agreement with experiment

- We also make the predictions about low-energy bands of different multipolarity ($K^{\pi} = 0^+, 2^+, 3^+, 0^-, 1^-, 2^-, 8^-$), some of then can be found experimentally for ^{252,254}No

Thank you for your attention!

Мардыбан Мария Александровна

- Закончила магистратуру в 2021г.
  (магистерская диссертация на тему «Исследование тяжелых ядер на основе коллективного гамильтониана» под руководством Е.А. Колгановой)

- С 2021г. и по н.в. работаю под руководством В.О. Нестеренко, занимаясь исследование характеристик ядер в рамках самосогласованной микроскопической модели ядра

Основные публикации (2023-2024):

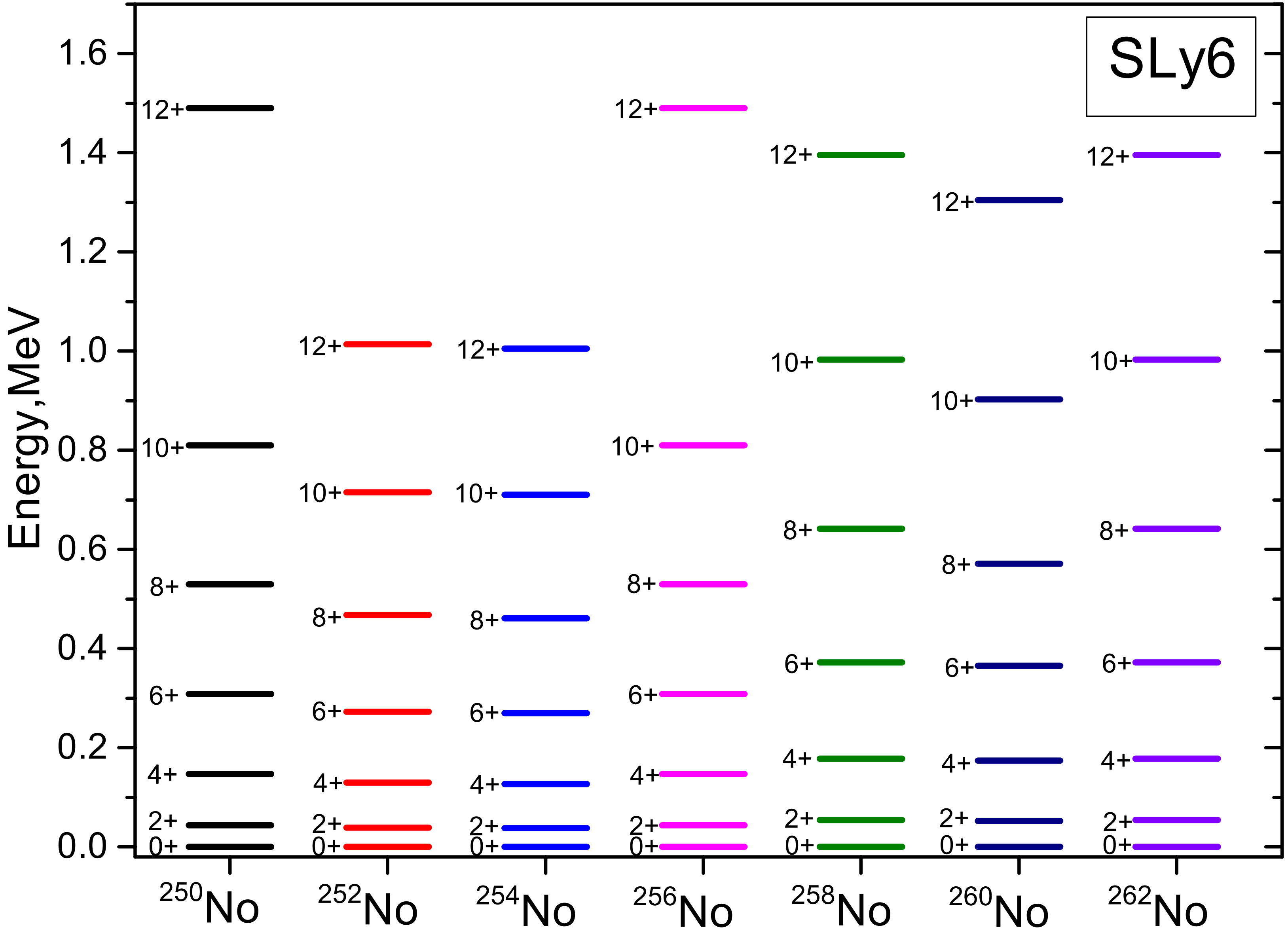
- V. O. Nesterenko, M. A. Mardyban, P.-G. Reinhard, A. Repko, and J. Kvasil,
  International Journal of Modern Physics E, Vol. 33, No. 05, 2450021, 2024
  (*«Moments of inertia in light deformed nuclei: Pairing and mean-field impacts»*)

- Balt Batgerel, ... , Mariia A. Mardyban, ... ,
  Computer Algebra in Scientific Computing, ISSN:0302-9743, eISSN:1611-3349, Изд:Springer, 2024
  (*«Symbolic-Numeric Solving Boundary Value Problems: Collective Models of Atomic Nuclei»*)

- V.O. Nesterenko, M.A. Mardyban, P.-G. Reinhard, A. Repko and J. Kvasil,
  arXiv.org e-Print archive, 2023
  («Anomalous deformation dependence of moments of inertia in light deformed nuclei»)

Backup slides

The irregularity in ^{252}No and ^{254}No at low-energy spectrum



Our tasks are:

- to analyze the occurrence of the irregularity for ^{252,254}No

- to make predictions not only for the ground state energy band, but for other bands too

States Kᴨ = 2

- In most of the cases, if the first state is collective, then the next one is 2qp and vice versa, but:

- The first Kᴨ = 2^+ - states are <u>γ-vibrational collective</u> in ^{252}No (SLy6, SV-bas) and in ^{254}No (SkM*, SV-bas)

- Instead, the first 2^+ states are <u>purely 2qp</u> in ^{252}No (SkM*) and in ^{254}No (SLy6)

Anyway, all the calculated 2+ lie above the observed 2^- (^{252}No) and 3^+ (^{252}No) K-isomers

- We know only IBM calculations
  [A. D. Efimov and I. N. Izosimov, Phys. Atom. Nucl. 84, 660 (2021)];
  [A. D. Efimov and I. N. Izosimov, JINR-E6-2022-19 (2022)]

- In contrast to our results, calculations predict Kᴨ = 2^+ states at 1.09 MeV (^{252}No) and 0.94 MeV (^{254}No).

To estimate the true relevance of various theoretical results for No isotopes, the experimental data are necessary.

Force	E	$B(E22)$	qq'	$\epsilon_{qq'}$	$N_{qq'}$	F-struct
			^{252}No			
SLy6	1.58	3.87	$nn[622\uparrow, 620\uparrow]$	2.33	0.39	F-1,F+2
			$pp[521\downarrow, 521\uparrow]$	2.06	0.32	F,F-2
			$nn[624\downarrow, 622\downarrow]$	2.42	0.21	F,F+3
	2.08	-	$pp[514\downarrow], 521\uparrow]$	2.06	1.00	F+1,F-2
SkM*	1.70	0.06	$pp[512\uparrow, 521\downarrow]$	1.61	0.99	F+3,F
	1.78	-	$nn[622\uparrow], 620\uparrow]$	2.28	0.35	F-1,F+2
			$nn[624\downarrow], 622\downarrow]$	2.14	0.29	F+1,F+3
			$pp[514\downarrow], 521\uparrow]$	2.06	1.00	F+1,F-2
SVbas	1.62	2.72	$pp[521\uparrow], 521\downarrow]$	1.95	0.38	F-2,F
			$nn[622\uparrow, 620\uparrow]$	2.48	0.29	F-1,F+2
			$nn[624\downarrow], 622\downarrow]$	2.24	0.19	F,F+3
	1.89	-	$pp[512\uparrow, 521\downarrow]$	1.86	0.99	F+3,F
			^{254}No			
SLy6	1.31	0.17	$nn[622\uparrow, 620\uparrow]$	1.32	0.97	F-1,F+1
	1.53	-	$nn[622\uparrow, 620\uparrow]$	2.24	0.42	F-1,F+1
			$pp[521\uparrow], 521\downarrow]$	2.05	0.27	F-2,F
			$nn[624\downarrow], 622\downarrow]$	2.39	0.20	F-2,F+2
SkM*	1.32	2.62	$nn[624\downarrow, 622\downarrow]$	1.63	0.60	F,F+2
			$nn[622\downarrow], 620\uparrow]$	1.60	0.18	F+2,F+1
			$nn[622\uparrow], 620\uparrow]$	2.20	0.11	F-2,F+1
	1.62	-	$nn[622\downarrow], 620\uparrow]$	1.60	0.80	F-2,F+1
			$nn[624\downarrow, 622\downarrow]$	1.63	019	F,F+2
SVbas	1.45	4.46	$nn[622\downarrow, 620\uparrow]$	1.77	0.40	F+2,F+1
			$pp[521\uparrow], 521\downarrow]$	1.95	0.20	F-2,F
			$nn[624\downarrow], 622\downarrow]$	2.15	0.17	F-1,F+2
	1.87	-	$nn[622\downarrow], 620\uparrow]$	1.77	0.56	F-1,F+2
			$pp[521\uparrow], 521\downarrow]$	1.95	0.21	F-2,F
			$nn[622\uparrow, 620\uparrow]$	2.28	0.14	F+2,F+1

TABLE X. The lowest SLy6 neutron and proton 2qp configurations $K = K_1 + K_2$ and $K = |K_1 + K_2|$ in ^{252,254}No.

$\epsilon_{qq'}$	qq'	F-struct	K_1+K_2	K_1-K_2
		^{252}No		
1.16	$pp[521\downarrow, 514\downarrow]$	F,F+1	$\underline{4^+}$	$\underline{3^+}$
1.35	$pp[633\uparrow, 514\downarrow]$	F-1,F+1	7^-	$\underline{0^-}$
1.35	$pp[633\uparrow, 521\downarrow]$	F-1,F+1	4^-	$\underline{3^-}$
2.06	$pp[521\uparrow, 521\downarrow]$	F-2,F	$\underline{2^+}$	1^+
2.25	$pp[521\uparrow, 633\uparrow]$	F-2,F-1	5^-	$\underline{2^-}$
2.30	$pp[633\uparrow, 512\uparrow]$	F-1,F+3	6^-	$\underline{1^-}$
1.30	$nn[734\uparrow, 622\uparrow]$	F,F-2	7^-	$\underline{2^-}$
1.32	$nn[624\downarrow, 734\uparrow]$	F,F+1	$\underline{8^-}$	$\underline{1^-}$
2.08	$nn[624\downarrow, 743\uparrow]$	F,F-2	7^-	$\underline{0^-}$
2.33	$nn[622\uparrow, 620\uparrow]$	F-1,F+2	$\underline{3^+}$	$\underline{2^+}$
2.34	$nn[624\downarrow, 620\uparrow]$	F,F+2	$\underline{4^+}$	3^+
		^{254}No		
1.15	$pp[521\downarrow, 514\downarrow]$	F,F+1	$\underline{4^+}$	$\underline{3^+}$
1.38	$pp[633\uparrow, 514\downarrow]$	F-1,F+1	7^-	$\underline{0^-}$
1.38	$pp[633\uparrow, 521\downarrow]$	F-1,F	4^-	$\underline{3^-}$
2.05	$pp[521\uparrow, 521\downarrow]$	F-2,F	$\underline{2^+}$	1^+
2.27	$pp[521\uparrow, 633\uparrow]$	F-2,F-1	5^-	$\underline{2^-}$
2.43	$pp[633\uparrow, 512\uparrow]$	F-1,F+3	6^-	$\underline{1^-}$
1.21	$nn[734\uparrow, 622\downarrow]$	F,F+2	6^-	$\underline{3^-}$
1.32	$nn[622\uparrow, 620\uparrow]$	F-1,F+1	$\underline{2^+}$	1^+
1.78	$nn[734\uparrow, 613\uparrow]$	F,F+3	8^-	$\underline{1^-}$
1.89	$nn[620\uparrow, 613\uparrow]$	F+1,F+3	$\underline{4^+}$	$\underline{3^+}$
2.13	$nn[622\uparrow, 734\uparrow]$	F-1,F	7^-	$\underline{2^-}$
2.17	$nn[734\uparrow, 615\downarrow]$	F,F+5	9^-	$\underline{0^-}$