Investigation of rotational properties in superheavy Nobelium isotopes

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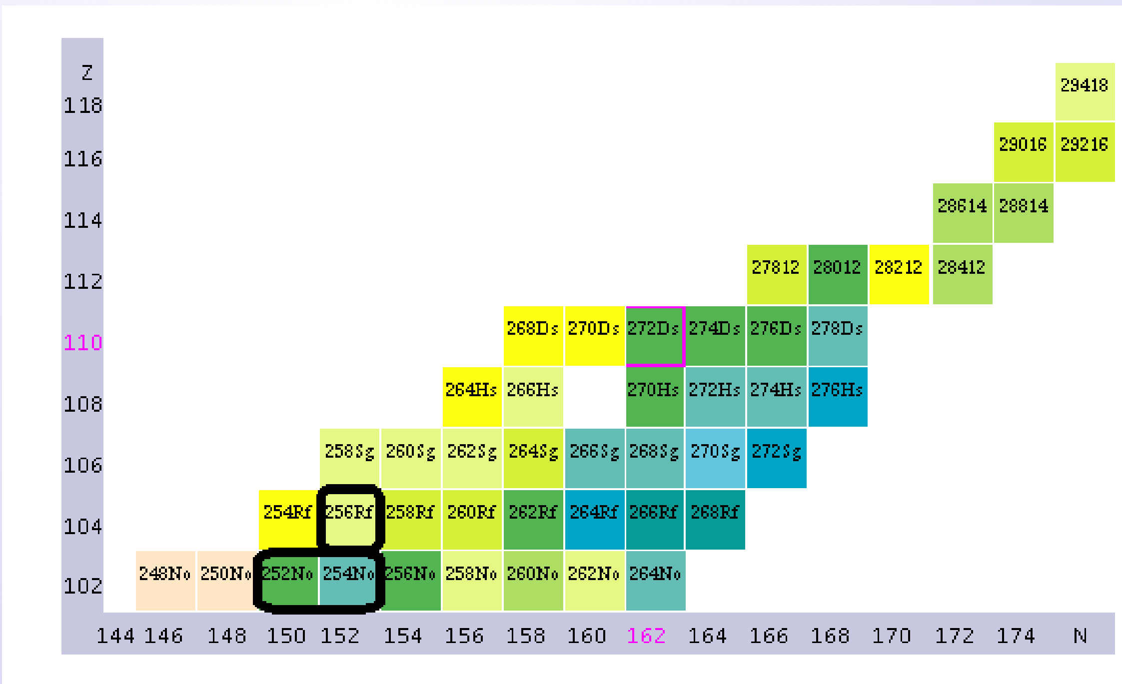
10-13 August, 2012

Outline

- *Introduction*
- *Theoretical Method*
- *Results and Discussions*
- *Summary*

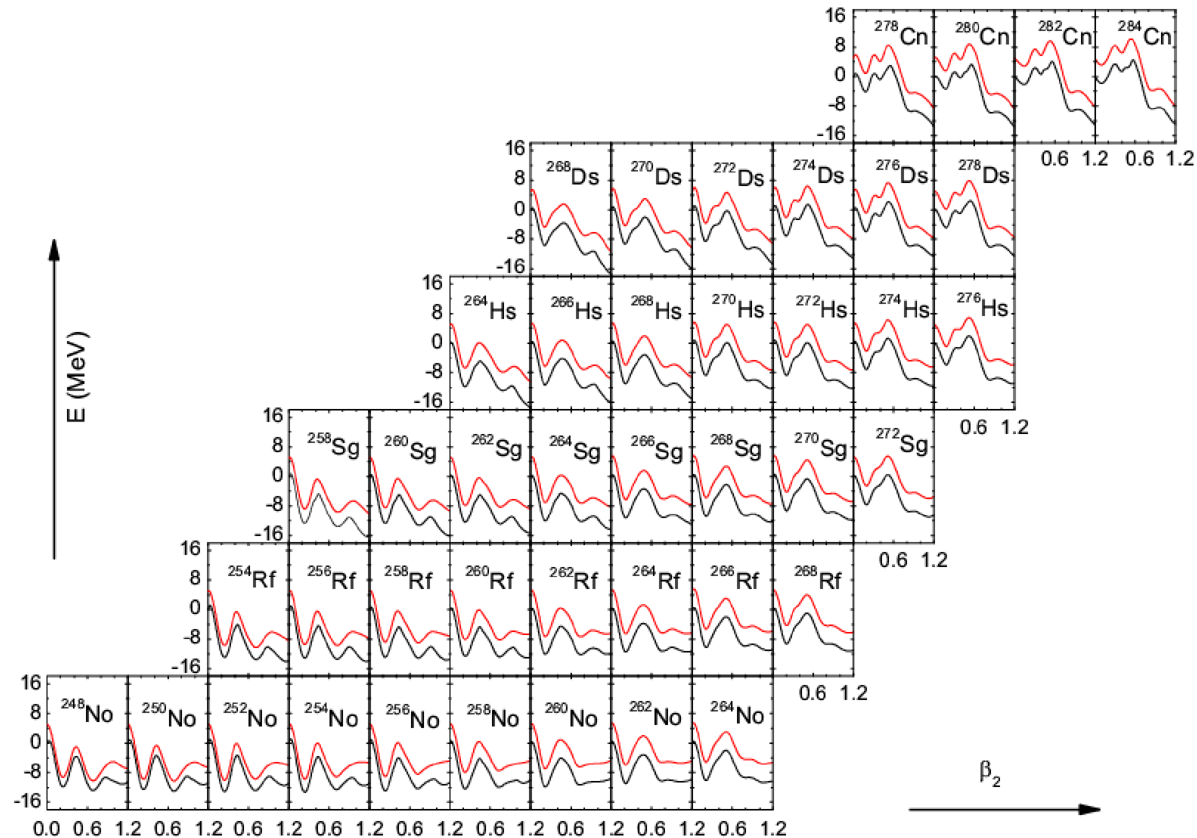
1. Introduction

1.1. Status of synthesis of superheavy nuclei with Z>100



From http://www.nndc.bnl.gov/chart/

Octupole correlation effects of superheavy nuclei with 100<Z<114

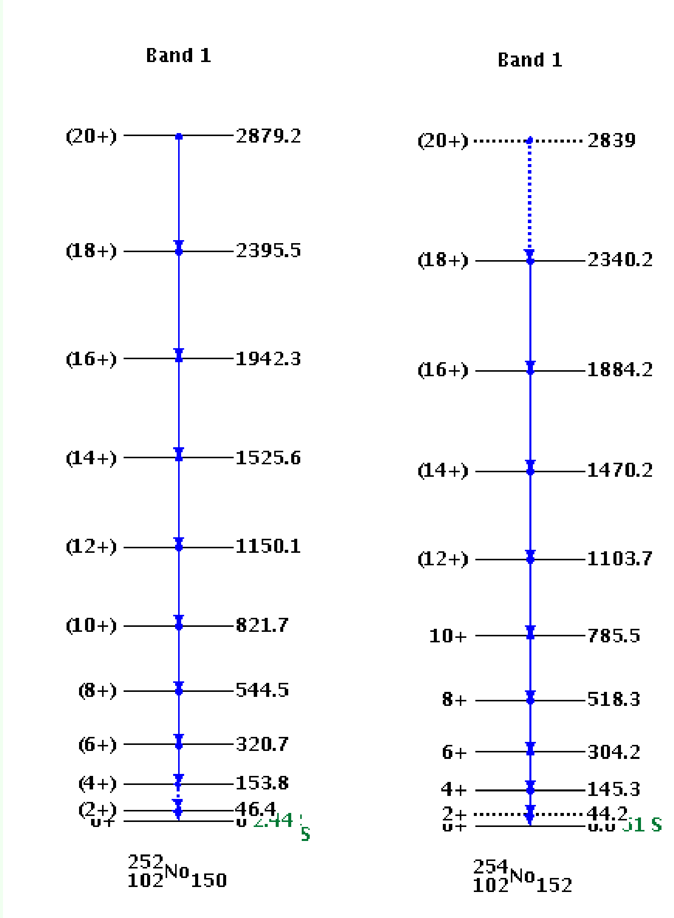


♣ There are no octupole-correlation effects at the normal deformed minima.

H.L Wang et al., Chin. Sci. Bull,57:1761,2012.

1.2. High-spin structure of superheavy nuclei

The high-spin level schemes have been constructed in ^{252,254}No and ^{256}Rf.



Refs: R.D.Herzberg et al., PRC65,014303(2001);S.Eeckhaudt et al., EPJA26,227(2005);P.T.Greenlees et al.,PRL 109,012501(2012).

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2. Theoretical method

Refs: Phys. Lett. B **435**, 257 (1998); Nucl. Phys. A **578**, 45 (1994); Nucl. Phys. A **536**, 20 (1992); Nucl. Phys. A **81**, 1 (1966); Nucl. Phys. A **669**, 119 (2000); Nucl. Phys. A **435**, 397 (1985); Phys. Rev. C **83**, 011303 (2011).

2.1. The Hamiltonian

The cranking Hamiltonian

$$\hat{H}_\omega = \hat{H}_{WS} + \hat{H}_{pair} - \lambda_1 \hat{N} - \lambda_2 \hat{N}^2 - \omega \hat{j}_x \quad (1)$$

2.2. Total-Routhian-surface Method

Single-particle potential

$$H_{WS} = T + V(r, \hat{\beta}) + V_{l \cdot s}(r, \hat{\beta}) + \frac{1}{2}(1 + \tau_3) V_c(r, \hat{\beta}) \quad (2)$$

Lipkin-Nogami pairing

$$E_{LN} = \sum_{j=1}^{S} e_{k_j} + \sum_{k \neq k_j} 2v_k^2 e_k - \frac{\Delta^2}{G} - G \sum_{k \neq k_j} v_k^4 + G\frac{N-S}{2} - 4\lambda_2 \sum_{k \neq k_j} (u_k v_k)^2 \quad (3)$$

Strutinsky shell corretion

$$\delta E_{shell} = E_{LN} - \tilde{E}_{Strut.} \quad (4)$$

Hartree-Fock-Bogoliubov-Cranking equation

$$\begin{aligned}
\sum_{\beta>0} \left\{ \left[(e_\alpha - \lambda)\delta_{\alpha\beta} - \omega(j_x)_{\alpha\beta} - G\rho^*_{\bar{\alpha}\bar{\beta}} + 4\lambda_2 \rho_{\alpha\beta} \right] U_{\beta\kappa} - \Delta\delta_{\alpha\beta} V_{\bar{\beta}\kappa} \right\} &= E_\kappa U_{\alpha\kappa} \\
\sum_{\beta>0} \left\{ \left[(e_\alpha - \lambda)\delta_{\alpha\beta} + \omega(j_x)_{\alpha\beta} - G\rho_{\alpha\beta} + 4\lambda_2 \rho^*_{\bar{\alpha}\bar{\beta}} \right] V_{\bar{\beta}\kappa} + \Delta^*\delta_{\alpha\beta} U_{\beta\kappa} \right\} &= E_\kappa V_{\bar{\alpha}\kappa}
\end{aligned} \quad (5)$$

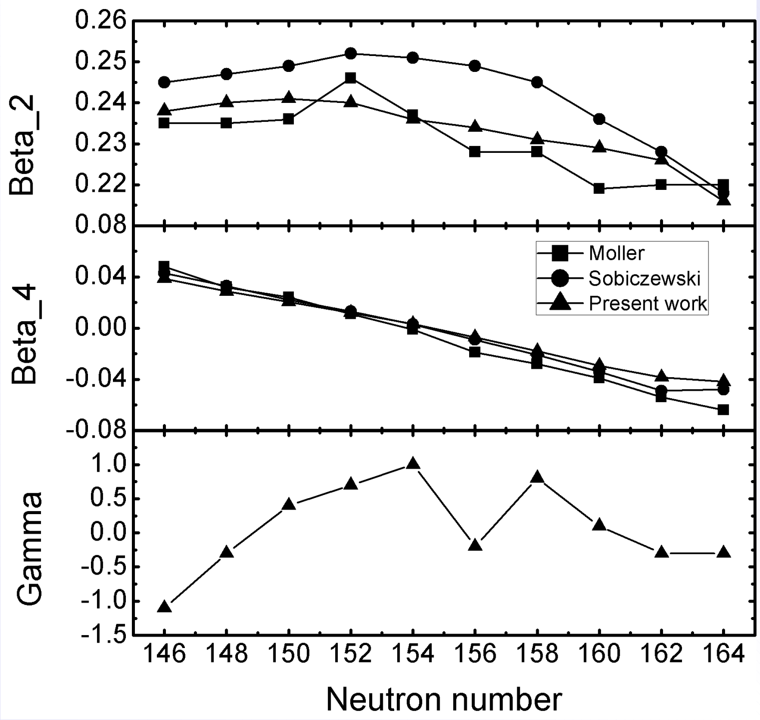
Macroscopic liquid drop energy

$$E_{LDM}(N, Z, \tilde{\beta}) = \{[B_s(\tilde{\beta}) - 1] + 2\chi[B_c(\tilde{\beta}) - 1]\} E_s^{(0)} \quad (6)$$

3. Results and Discussions

3.1. Ground-state properties of No isotopes

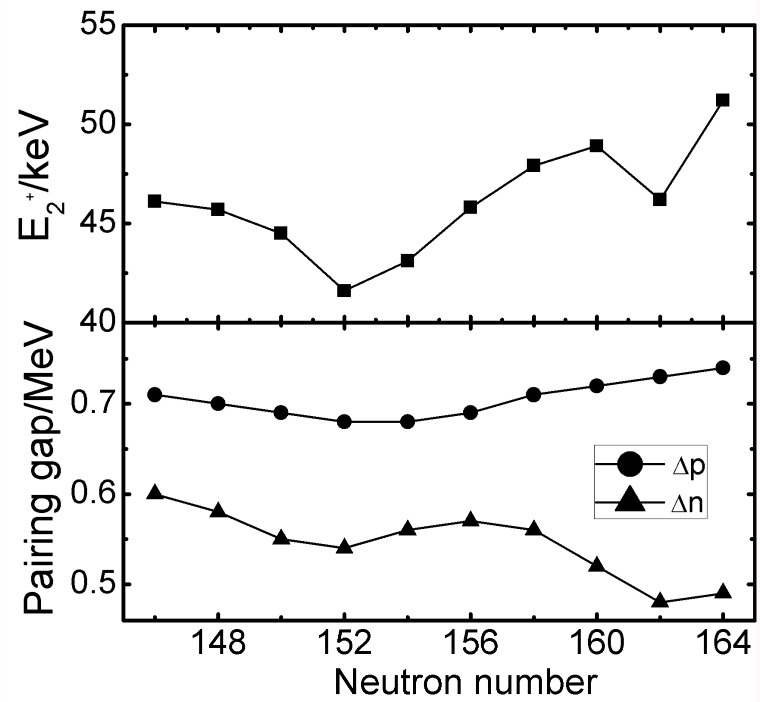
Ground-state β_2, β_4 and γ deformations with increasing N



P. Möller et al., At Data Nucl Data Tables,59:195(1995);

A.Sobiczewski et al., PRC 63,034306(2001).

Dependence of the energy E_{2^+} and pairing gaps on neutron number

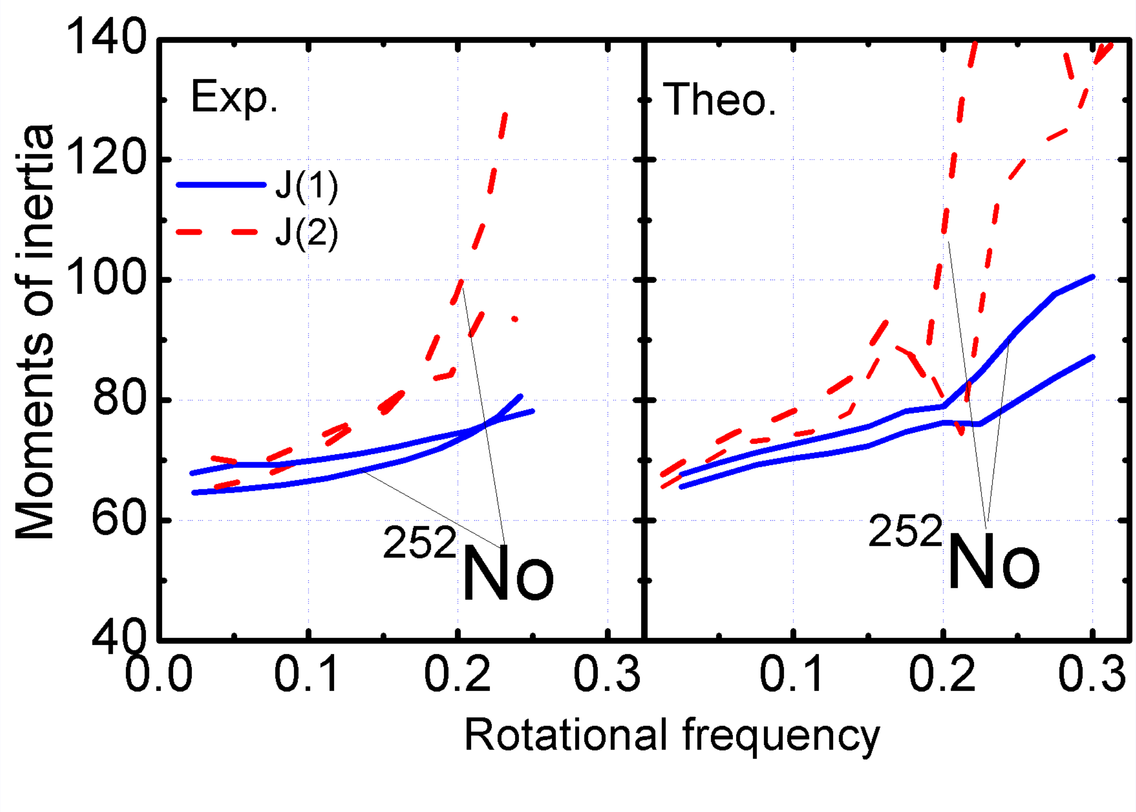


The numbers of $N = 152$ and 162 are suggested to be shell closures.

The 2^+-state data are taken from: A.Sobiczewski et al., PRC 63,034306(2001).

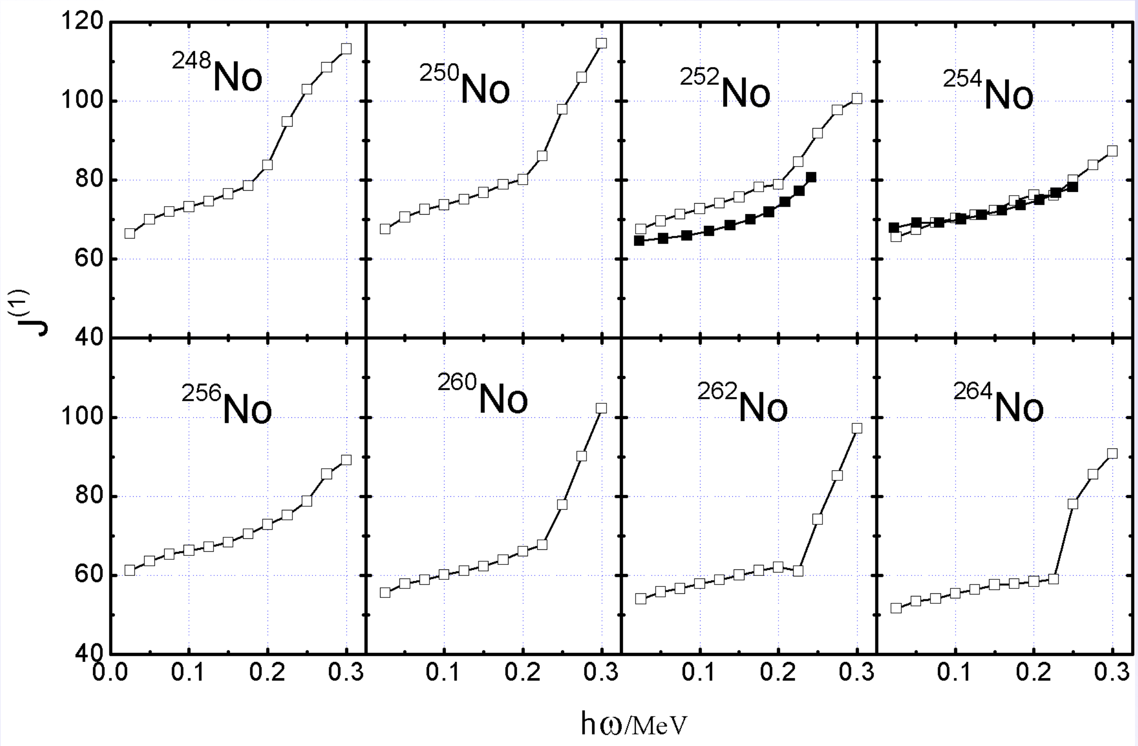
3.2. High-spin properties of No isotopes

Kinematic and dynamic moments of inertia for ^{252,254}No



Refs: R.D.Herzberg et al., PRC65,014303(2001);S.Eeckhaudt et al., EPJA26,227(2005)

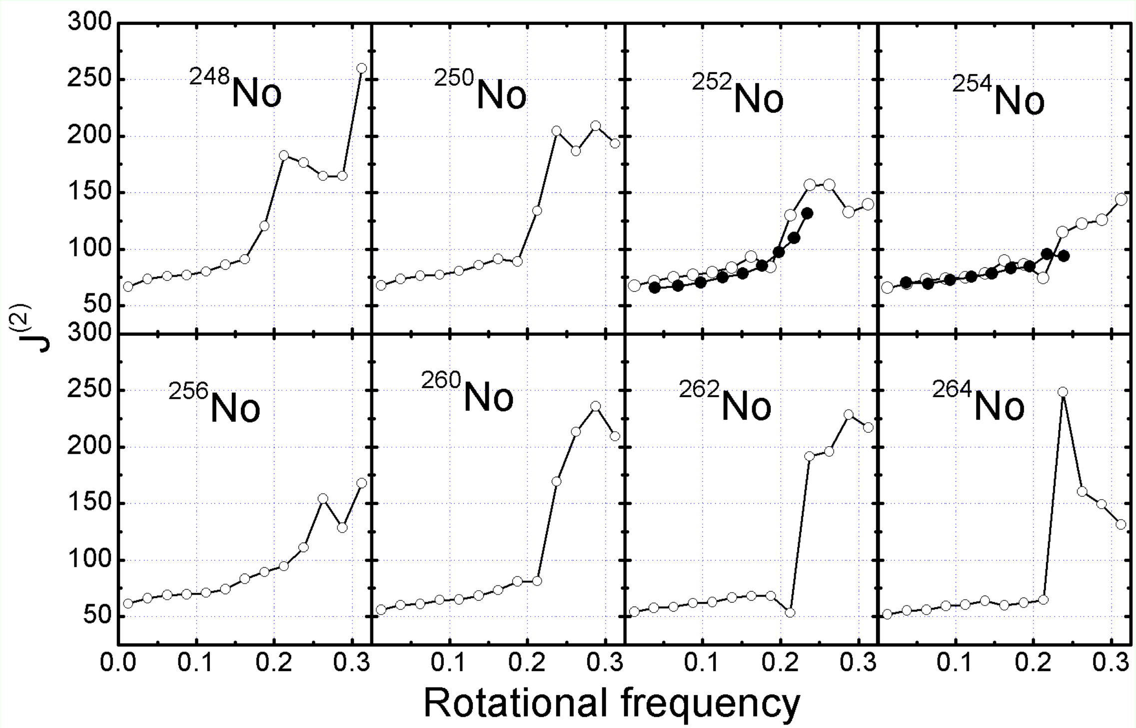
Calculated kinematic moments of inertia for $^{248-264}$No



♣ The kinematic moments of inertia increase slowly at low spins and increase rapidly after a critical(band-crossing) spin.

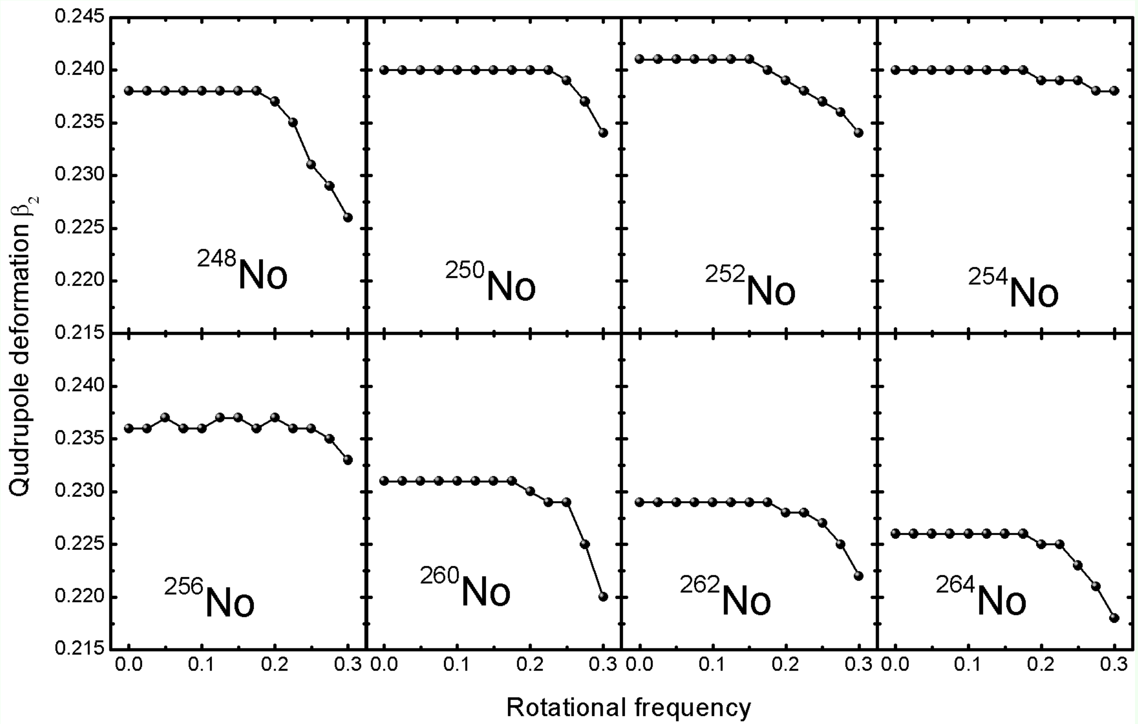
♣ In general, this changing behavior of the moments of inertia is related to deformations and pairing correlations.

Calculated dynamic moments of inertia for $^{248-264}$No



♣ The steep increase of the dynamic moment of inertia can be explained by a band crossing of the $\pi i_{13/2}$ or $\nu j_{15/2}$ two-quasiparticle band with the zero-quasiparticle band.

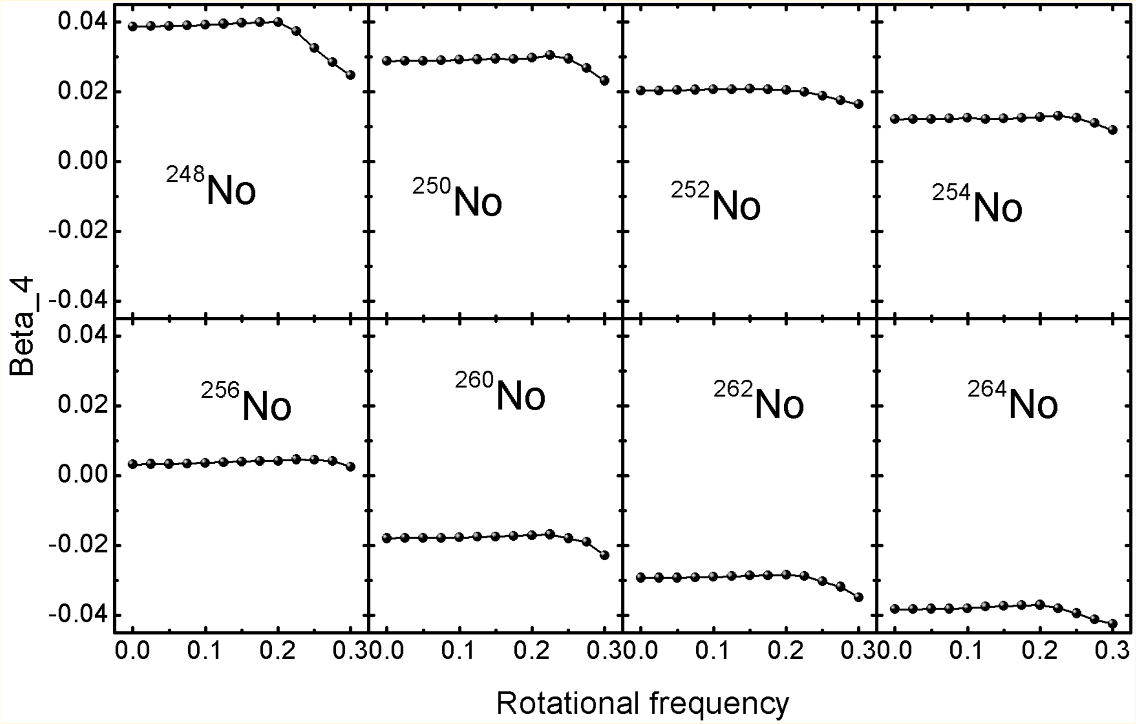
Evolutions of β_2 deformations under rotation



♠ β_2 maintains a constant value at low spins and decreases after a critical spin.

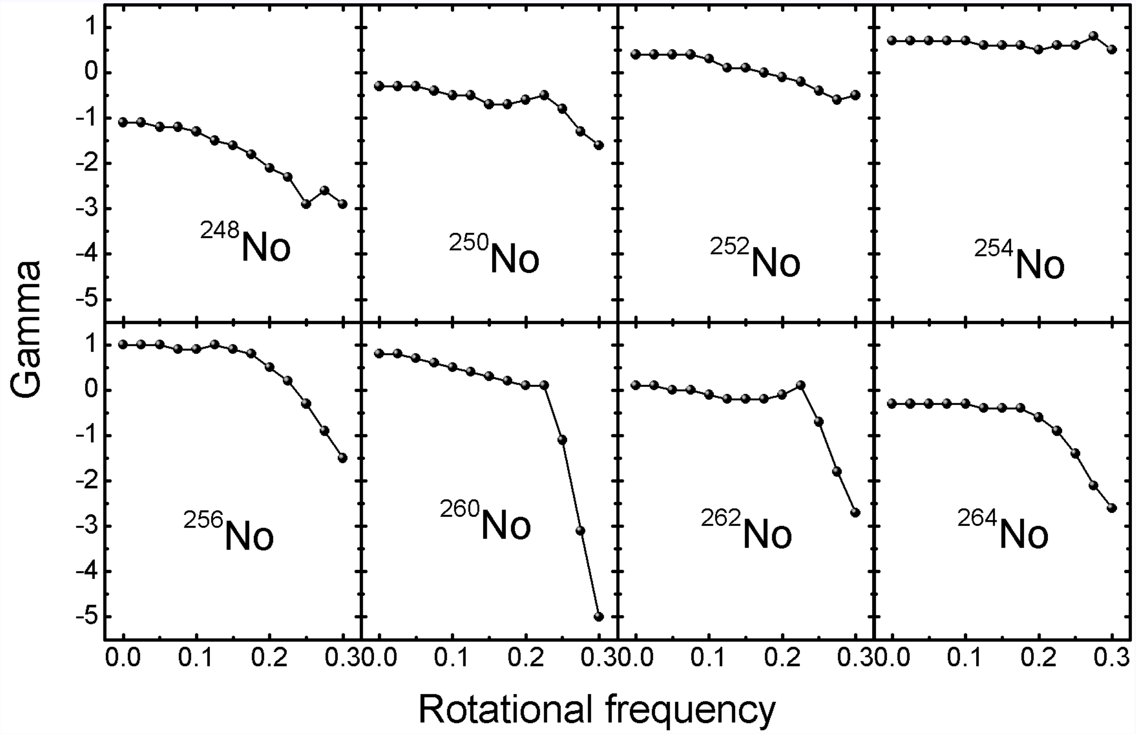
♠ The increasing moments of inertia with spin can not be explained by the behavior of decreasing β_2 deformations under rotation.

Evolutions of β_4 deformations under rotation



♠ β_4 maintains a constant value at low spins and decreases after a critical spin.

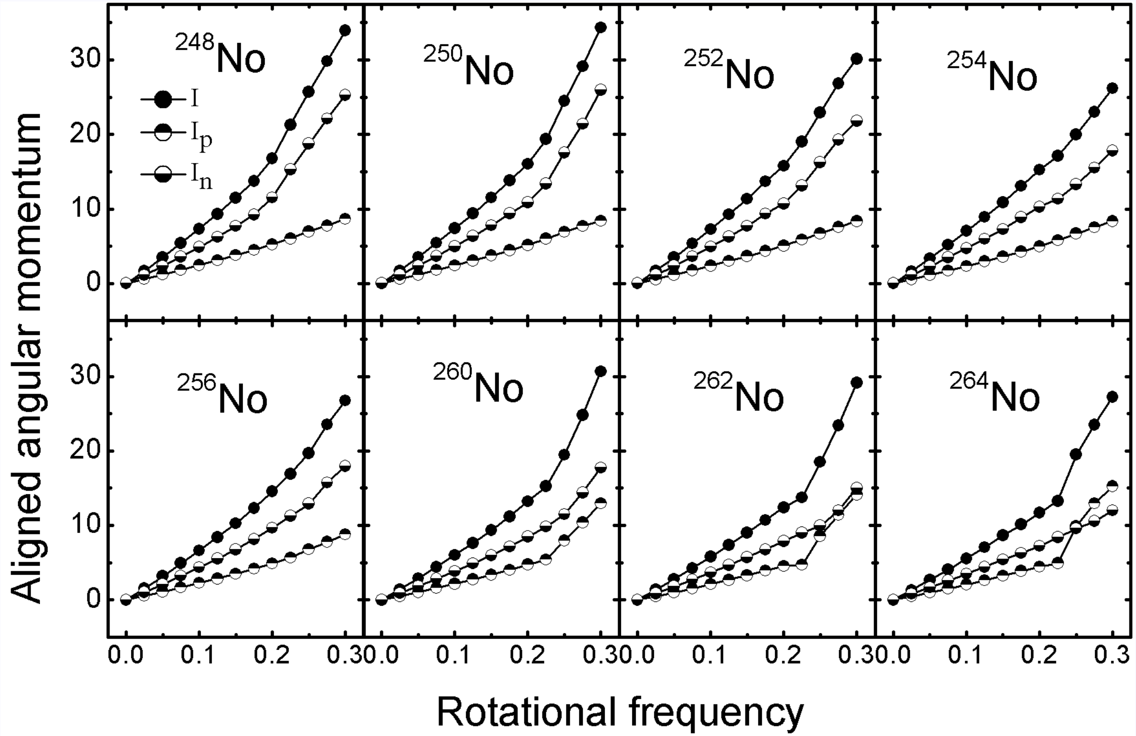
Evolutions of γ deformations under rotation



♠With increasing rotational frequency,there is a trend that γ deformations change from positive to negative values;

♠Very recently, Liu et al find that high-order deformation β_6 plays a important role, especially, around N=152.(H.L Liu et al., PRC 86,011301(2012).)

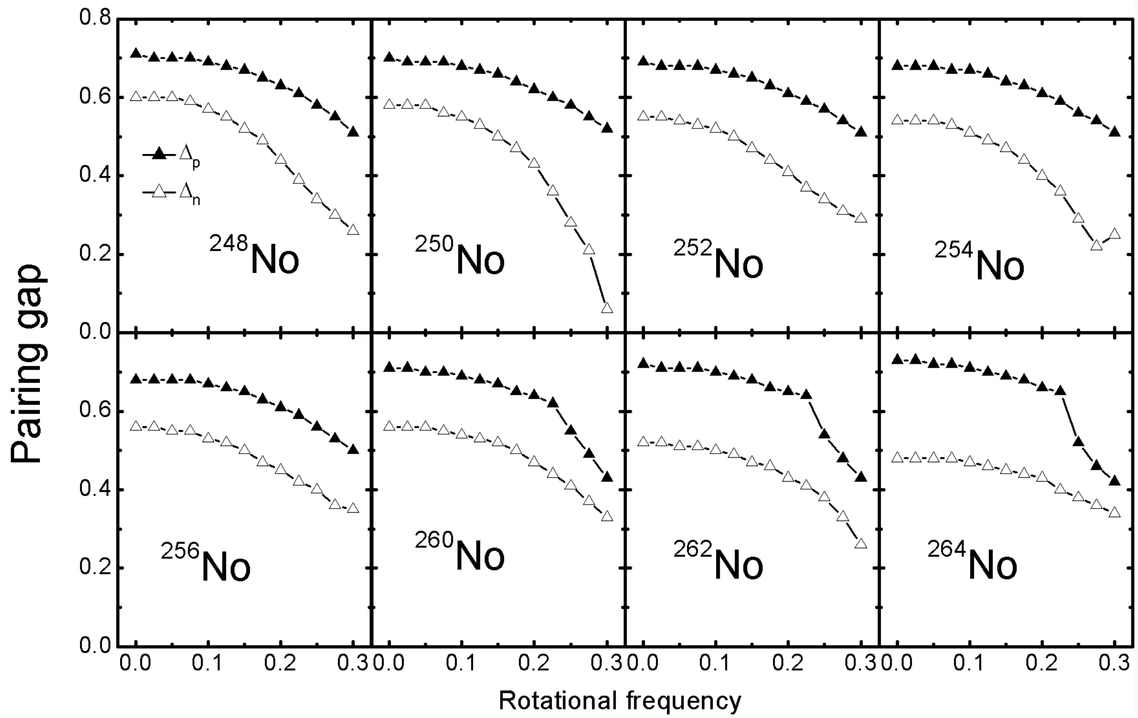
Aligned angular momentum under rotation



♠The aligned angular momentum increases with rotational frequency, and the neutron component increases more rapidly.

♠ After a critical (band-crossing) point, the aligned angular momentum changes quickly. The competition of neutron and proton alignments can be seen.

Pairing gap of No isotopes under rotation



♠The pairing energy gap for proton is larger than that for neutron.

♠The pairing energy gap decreases with increasing rotational frequency, which maybe result in the decrease of MOI with spins.

4. Summary

- **Ground-state and rotational properties in No isotopes have been investigated using TRS calculations.**

- **To some extent, the observed alignments in ^{252,254}No nuclei are reproduced.**

- **The variations of moments of inertia, deformations, aligned angular momentum and pairing energy gap have been analyzed as functions of mass and rotational frequency.**

- **This work provides a systematic investigation on superheavy No isotopes synthesized and a test of the present model.**


Thank
You!