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THE LOW-ENERGY MAGNETIC AND ELECTRIC DIPOLE EXCITATIONS IN $^{180-186}$W

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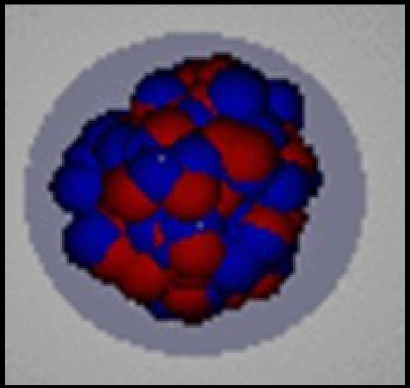
INTRODUCTION

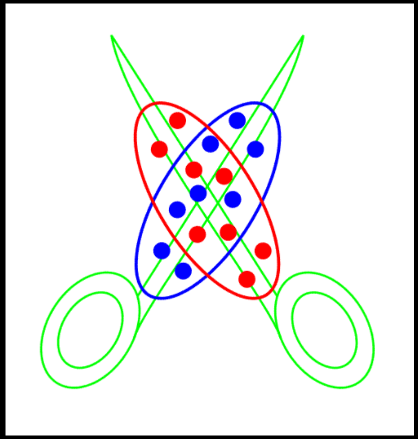
Magnetic (scissors) and electric dipole mode:

- great interest of modern nuclear structure physics.
- Found for isotopes from light nuclei (such as ^{46}Ti) up to actinides and also gama soft and transitional nuclei
- Gives information:
  - nuclear structure
  - nucleon-nucleon forces

- 2 characters in accordance with parities of dipole excitations:

1^- = electric dipole mode





1^+ = magnetic (scissors) mode

- Quadratic dependence
- Strong fragmentation
- Concentrated around 3 MeV

Goldstone (spirious state with zero energy) mode

- Hartree-Fock approximation: violates symmetries → rotational or transitional invariance broken
- RPA used to calculate scissors mode in heavy deformed nuclei

THEORY

The corresponding single-quasiparticle hamiltonian

(1)

$$[H_{sqp}, J_{\mu}] \neq 0$$

restored→separable isoscalar and isovector effective interaction

(2)

(3)

(4)

$$\eta = \frac{V_1}{4V_0}$$

V_0 and V_1 → the isoscalar and isovector depth of the potential wells

$$\gamma_0 = \gamma - \gamma_1 \qquad \gamma = \gamma_n + \gamma_p \qquad \gamma_1 = \gamma_1^n - \gamma_1^p$$

(5)

(6)

$$\gamma_1^{(-1)} = \gamma_1^{(+1)} \equiv \gamma_1 \qquad \gamma^{(-1)} = \gamma^{(+1)} \equiv \gamma$$

the translation invariance can be obtained by the substitution

$$J_\mu \rightarrow P_\mu$$

The model Hamiltonian of the system

$$V_{\sigma\tau} = \frac{1}{2}\chi_{\sigma\tau}\sum_{i\neq j}\vec{\sigma}_i\vec{\sigma}_j\vec{\tau}_i\,\vec{\tau}_j$$

1^+ states are considered as one-phonon excitations

$$\sum_{\mu\tau}[\psi_{\mu}^{i^2}(\tau)-\varphi_{\mu}^{i^2}(\tau)]=1$$

To obtain the excitations energies solve the equation of motion

The reduced *M1* transition probability

where

Excitation energies

$$\overline{\omega} = \frac{\sum_i \omega_i B(M1,\omega_i)}{\sum_i B(M1,\omega_i)}$$

Ground-state transition width Γ_0 (meV).

or

$$\Gamma_0^{red} = \frac{\Gamma_0}{\omega_i^3} (meV / MeV^3)$$

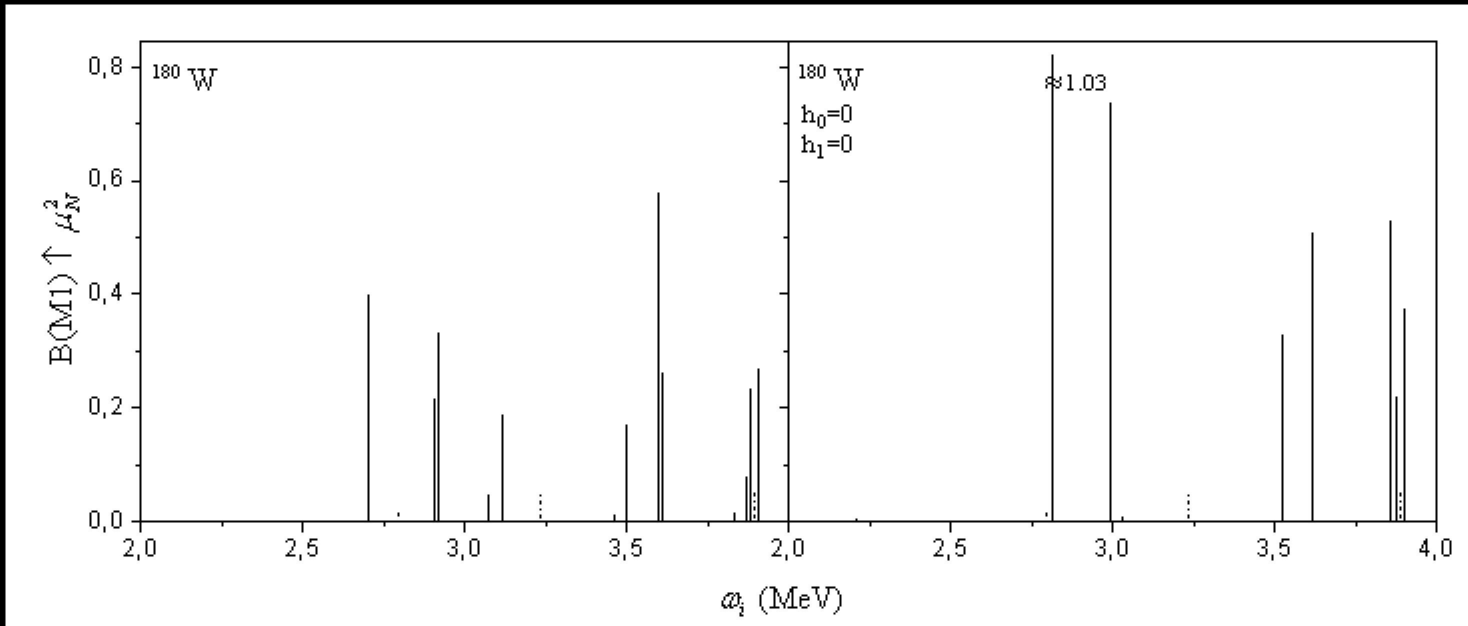
Results and Discussion

Table 1. The calculated values of the pairing correlation parameters (in MeV) and δ_2 values for the $^{180-186}W$ isotopes.

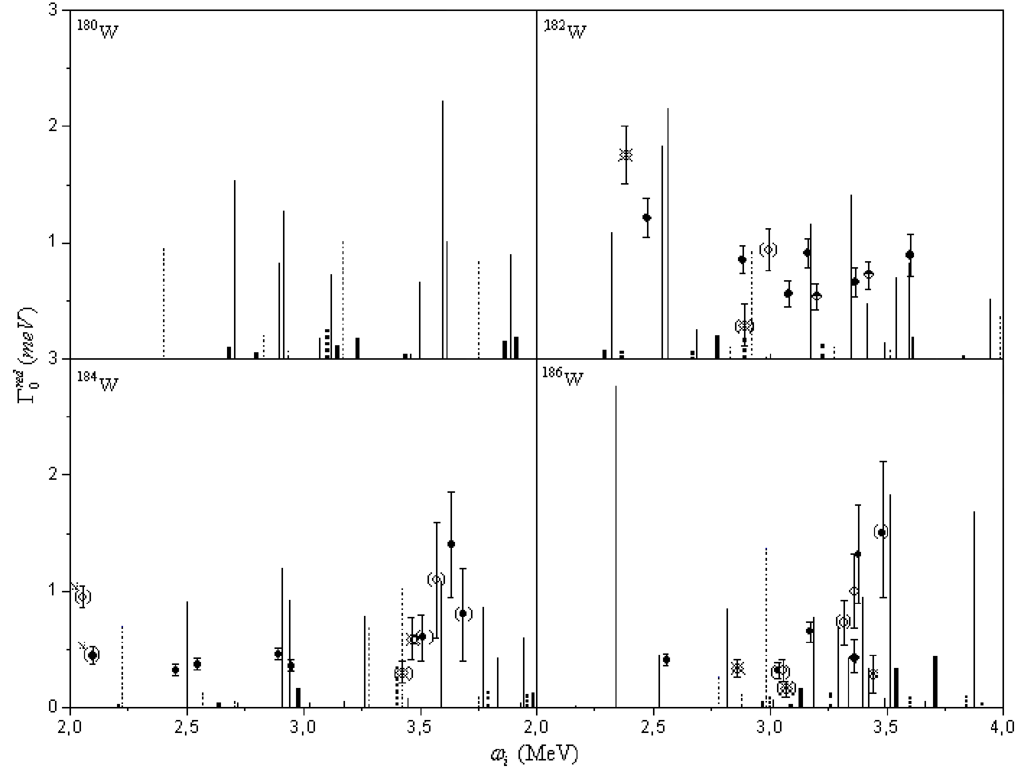
N	Δ_n	λ_n	Δ_p	λ_p	δ_2
106	1.20	-7.46	1.00	-5.80	0.210
108	0.90	-7.11	0.85	-6.47	0.207
110	0.97	-6.80	1.20	-6.98	0.201
112	1.00	-6.54	0.90	-7.62	0.190

$\chi_{\sigma\tau}$ =*40/A MeV* which has been obtained from magnetic moments calculations.

χ_1 =300 $A^{-5/3}$ fm^{-2} *which* is related to isovector symmetry potential.



Rotational invariant $H = H_{sqp} + h_0 + h_1 + V_{\sigma\tau}$				Rotational non-invariant $H = H_{sqp} + V_{\sigma\tau}$			
ω_n (MeV)	B(M1) (μ_N^2)	Structure $Nn_z\Lambda\Sigma$	Amplitudes $\psi^i_{ss'}$	ω_n (MeV)	B(M1) (μ_N^2)	Structure $Nn_z\Lambda\Sigma$	Amplitudes $\psi^i_{ss'}$
		nn521↑-510↑	0.167				
		nn 512↑-521↑	0.158				
		nn 512↑-512↓	-0.208				
3.596	0.576	nn 514↑-523↑	0.171	3.520	0.329	nn 503↑-505↓	-0.979
		nn 633↑-642↑	-0.289				
		nn 503↑-505↓	0.569				
		pp 402↑-411↑	0.278				
		pp 402↑-411↑	-0.261				
		pp 402↑-402↓	-0.456				



Nuclei	$\bar{\omega}_{th.}$ (MeV)	$\bar{\omega}_{exp.}$ (MeV)	Energy Range
^{180}W	3.17	-	2.4-3.7
^{182}W	2.99	3.1	2.4-3.7
^{184}W	3.14	3.3	2.4-3.7
^{186}W	2.99	3.2	2.4-3.5

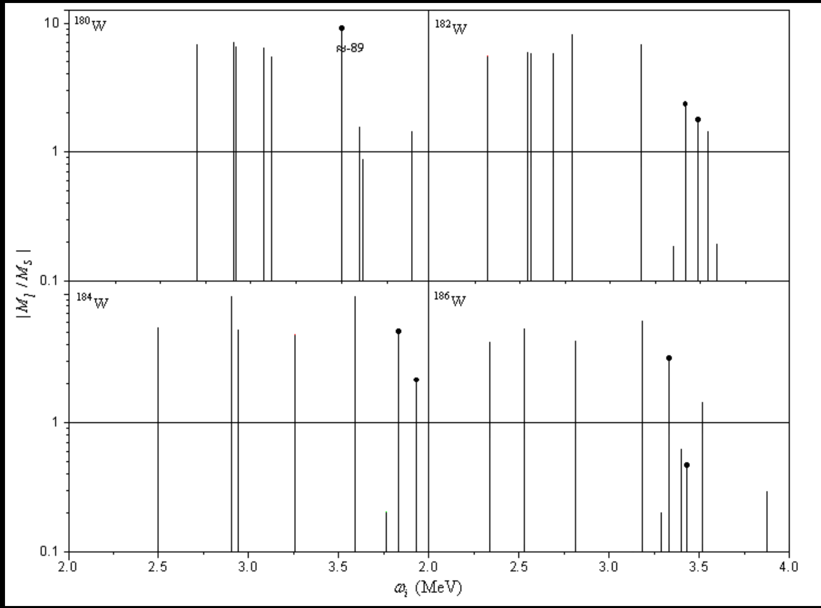


Table 3. The calculated ground-state M1, E1 and total Γ_o^{red} dipole transition widths (in meV/MeV^3) are compared with each other and the experimental data [9,10] in $^{180-186}W$.

Nuclei	*Energy interval (MeV)*	Γ_o^{red} *(meV/MeV^3)*	*K*			
			0	1	Unknown	Γ_o^{red} *(tot.)*
^{180}W	2.0-4.0	M1	0.42	9.37	-	9.79
		E1	0.65	3.13	-	3.78
		Γ_o^{red} *(tot.)*	1.07	12.5	-	13.6
		Exp.	-	-	-	-
^{182}W	2.0-3.7	M1	0.46	10.1	-	10.6
		E1	0.40	1.2	-	1.6
		Γ_o^{red} *(tot.)*	0.86	11.3	-	12.2
		Exp.	0.94±0.18	6.34±0.28	2.05±0.1	9.33±0.56
^{184}W	2.0-3.7	M1	0.24	5.30	-	5.54
		E1	0.34	2.62	-	2.96
		Γ_o^{red} *(tot.)*	0.58	7.92	-	8.50
		Exp.	2.05±0.59	4.73±1.28	0.89±0.28	7.67±2.15
^{186}W	2.5-3.5	M1	0.16	6.46		6.62
		E1	0.26	1.84		2.10
		Γ_o^{red} *(tot.)*	0.42	8.30		8.72
		Exp.	2.05±0.6	4.66±2.32	0.77±0.29	7.48±3.21

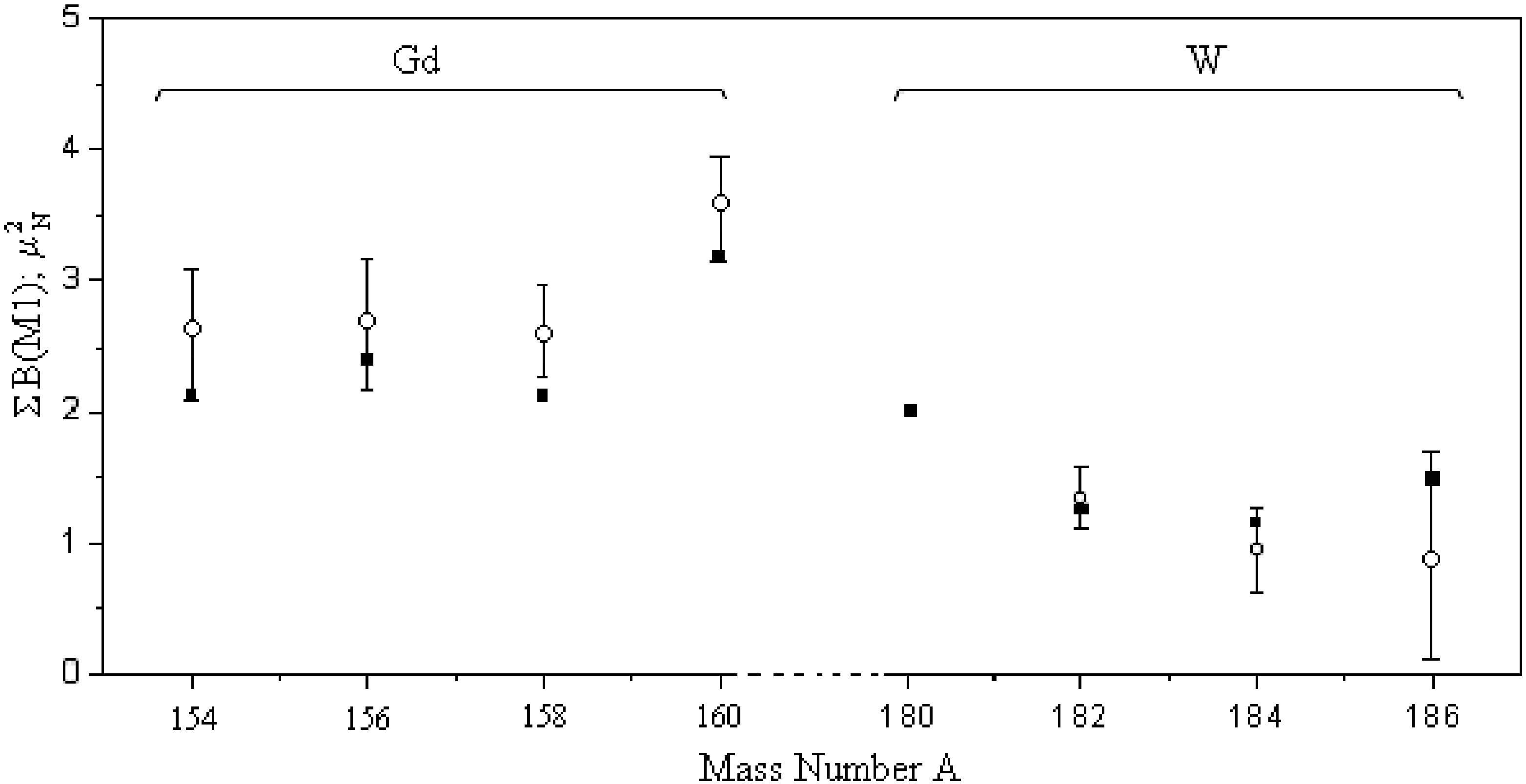


Fig. Compared calculated summed B(M1) strength (■) with experimental data (ϕ) results for $^{154\text{-}160}Gd$ and $^{180\text{-}186}W$.

CONCLUSION

- A separation of the spirious state from the 1+ states changes
  - The distribution of the B(M1) strength
  - Increases the fragmentation

- The calculations provided detailed information
  - the excitation energies
  - transitional probabilities
  - structure of low–lying dipole excitations

- The relative contribution of $\Delta K = 0$ below 4 MeV is quite small.
- A few prominent $K^{\pi}=1^{-}$ states in the low-energy.

Collaborators

E. Guliyev and A.A.Kuliev

and

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