Search for the High-Rank Symmetries in Subatomic Physics - K. Mazurek - J. Dudek

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Participants

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- **Results (2008 - 2011):**

17 articles, 18 conference talks

Outline

Introduction: Macroscopic-Microscopic Method

- Jacobi/Poincaré Shape Transition
- Shape-Dependent Congruence Energy
- Octupole Vibrations

Summary

Macroscopic-Microscopic Method

$$M(Z, N; def) = ZM_H + NM_n - 0.00001433Z^{2.39}$$
$$+E_{LSD}(Z, N; def) + E_{micr}(Z, N; def)$$

Macroscopic Energy: Lublin - Strasbourg Drop, Finite Range Liquid Drop Model Microscopic Energy

$$E_{micr} = E_{pair} + E_{shell}$$

'Pairing' Energy

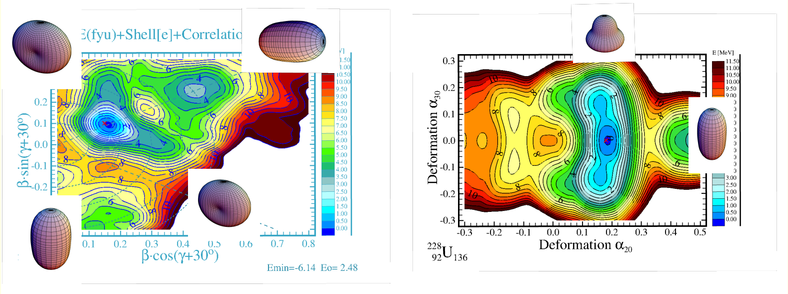
$$E_{pair} = E_{BCS} + \overline{E}_{pc}$$

or with Particle Number Projection method

Macroscopic-Microscopic Method

Nuclear surface parametrization:

$$\mathcal{R}(\vartheta,\varphi) = R_0\, c(\{\alpha\}) \sum_{\lambda,\mu} [1 + \alpha_{\lambda,\pm\mu}\, Y_{\lambda,\pm\mu}(\vartheta,\varphi)]$$

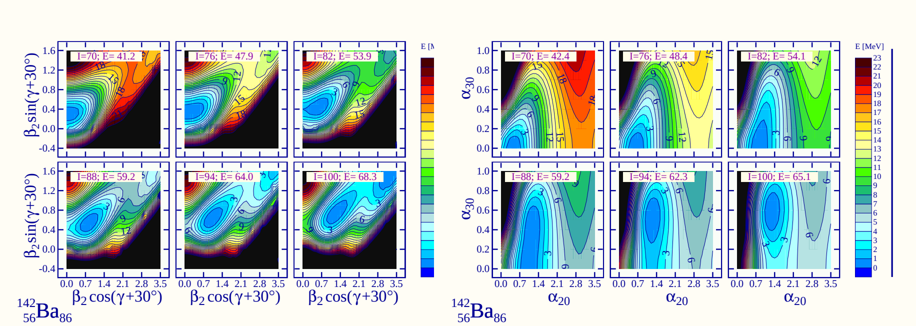


$\{\beta,\gamma\} \to \{\alpha_{20},\alpha_{22}\}$

Jacobi/Poincaré Shape Transition

Jacobi shape transition

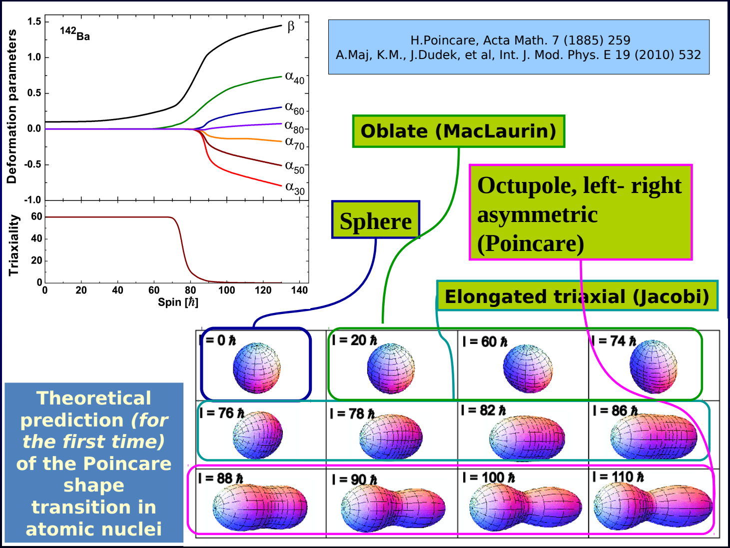
Poincaré shape transition



The ^{142}Ba with spin $I = 0 - 110\ \hbar$ A. Maj et al. Int.J.Mod.Phys.E 19 (2010).

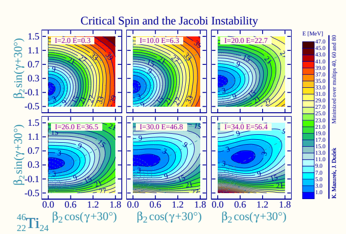
Investigation of the temperature influence into the Poincare shape transition is in progress.

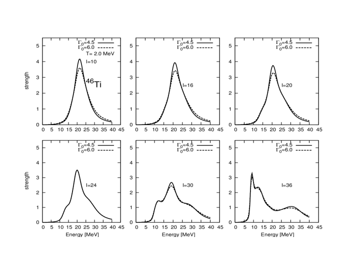
Jacobi/Poincaré Shape Transition

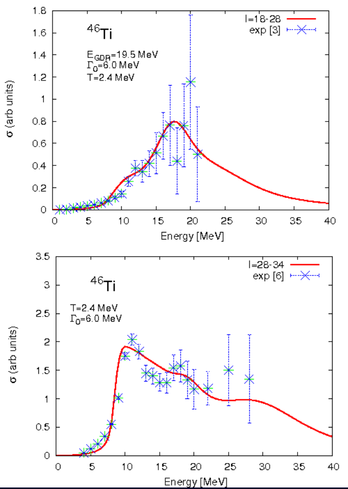


Jacobi/Poincaré Shape Transition

Giant Dipole Resonances

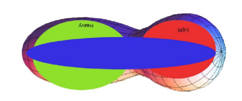


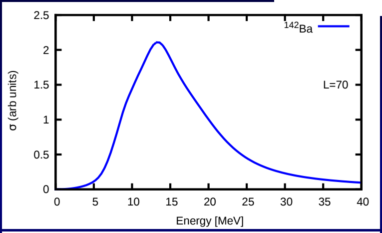


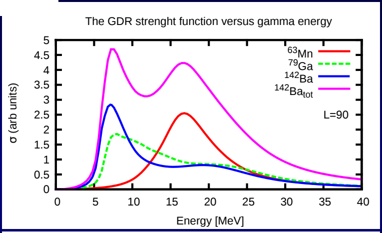


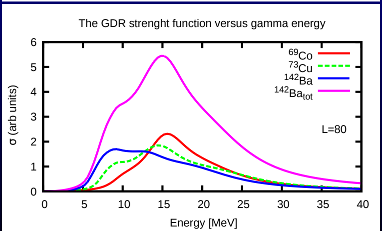
Eksperiment: A. Maj et al., Nucl. Phys. A 731, 319 (2004).

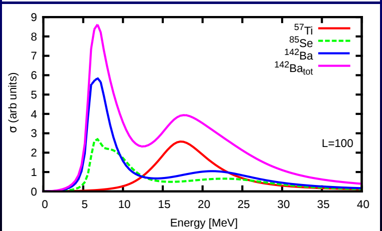
Jacobi/Poincaré Shape Transition



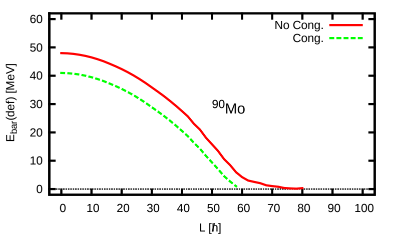


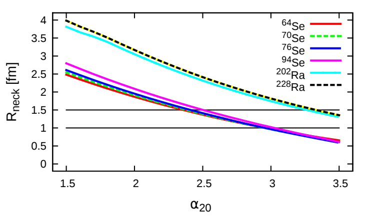


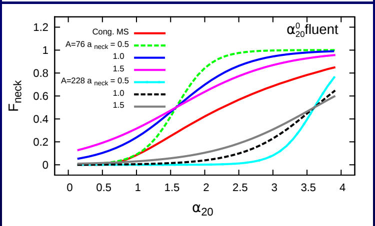




Shape-Dependent Congruence Energy







New definition of the shape dependence

$$E_{cong}(\alpha_{20}) = W_0(Z,N)\cdot F_{neck}(\alpha_{20})$$

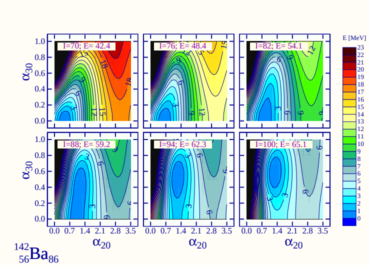
$$F_{neck}(\alpha_{20}) = 1 + \frac{1}{2}\left\{1 + \tanh\left[(\alpha_{20} - \alpha^0_{20})/a_{neck}\right]\right\}.$$

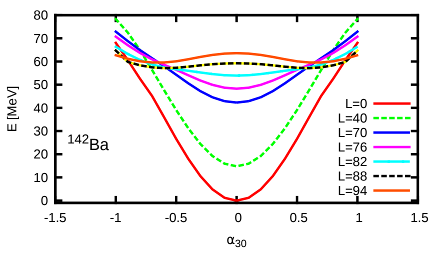
$$W_0(Z,N) = -C_0 \exp(-W|I|/C_0) \quad \textit{with} \quad I \equiv (N-Z)/A$$

Wigner E, Phys. Rev. 51 (1937) 106,947

Myers W D, Swiatecki W J, Nucl. Phys. A 81 (1966) 1, Nucl. Phys. A 612 (1997) 249

Octupole Vibrations





$$\hat{H} = \frac{\hbar^2}{2B}\frac{\delta^2}{\delta\alpha_{30}^2} + \frac{1}{2}C\alpha_{30}^2$$

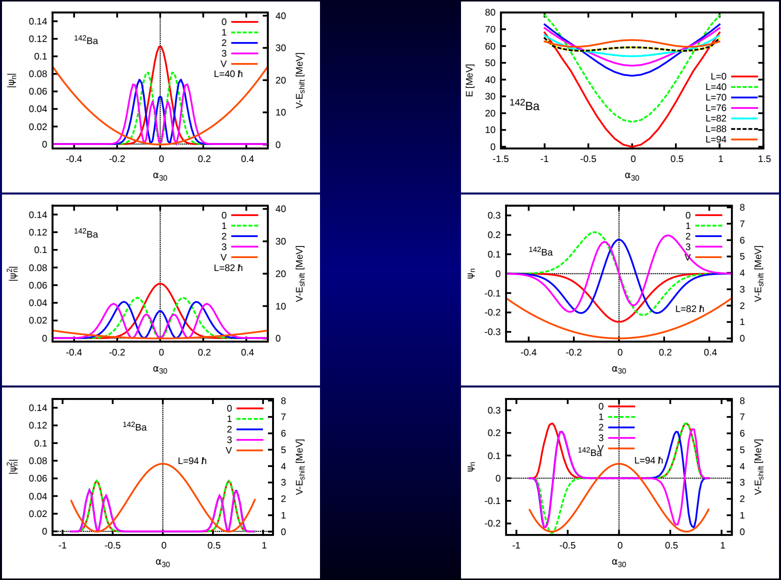
where B is the mass parameter and C the stiffness of the potential.

$$\langle\psi_n|\hat{H}|\psi_m\rangle = e_n\delta_{nm}$$

$$\hat{H} = \frac{\hbar^2}{2B}\frac{\delta^2}{\delta\alpha_{30}^2} + V(\alpha_{30})$$

A. Bohr, B. Mottelson, Nuclear Structure vol. II

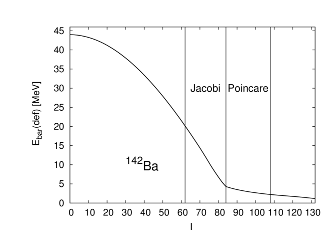
Octupole Vibrations



Octupole Vibrations

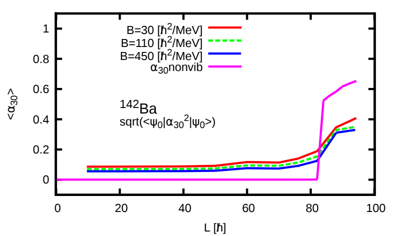
The first $\mathbf{1^-}$ state is usually described as 0 - point motion vibration. For ^{142}**Ba** the energy of this level is 1.326 MeV.

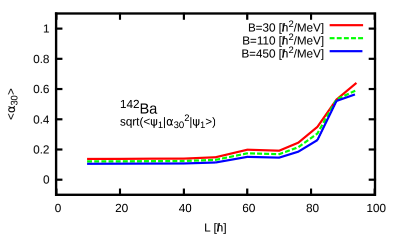
$\hbar\omega$ [MeV]	B [$\hbar^2$/MeV]	e_0 [MeV]
0.5	30	1.89
1.0	110	1.48
1.5	450	1.2



The mean values of the dynamical octupole deformation of

0 - state excitation - $\sqrt{\langle\psi_0|\alpha_{30}^2|\psi_0\rangle}$ 1 - state excitation - $\sqrt{\langle\psi_1|\alpha_{30}^2|\psi_1\rangle}$





Summary and Conclusions

- *Prediction, for the first time, of the Poincare shape transition in wide range of nuclear masses and spins.*
- *The new formula for the shape - dependent congruence energy is proposed and tested.*
- *The octupole vibrations in fast rotating nuclei are under investigation.*