^{68}Seの変形混合とその回転による抑制

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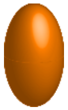
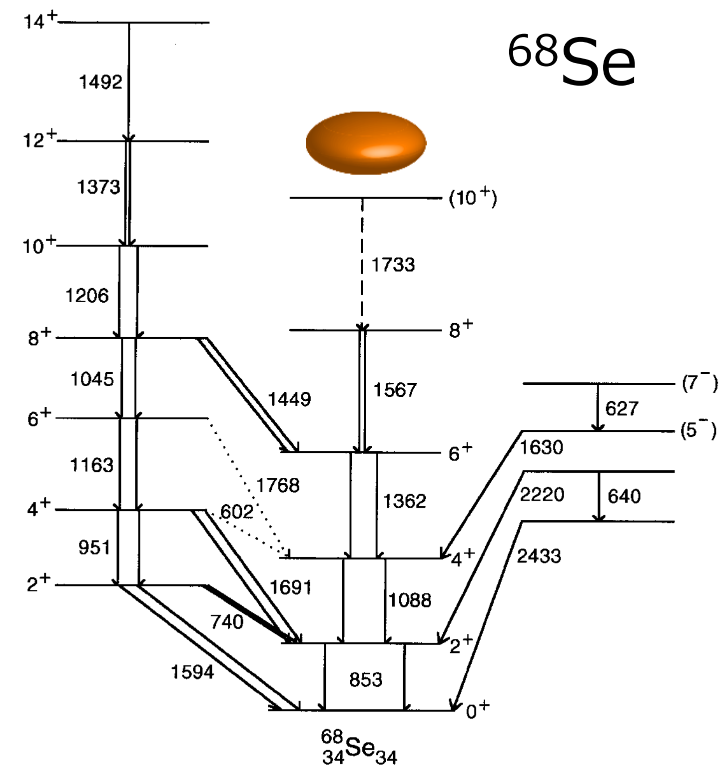
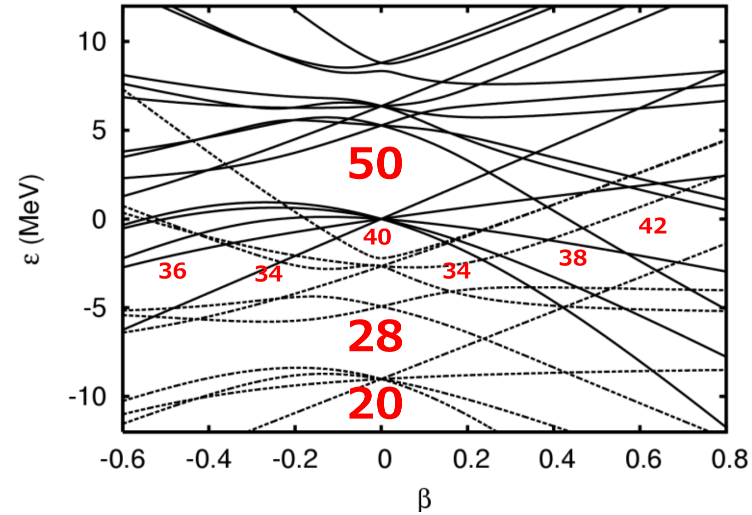
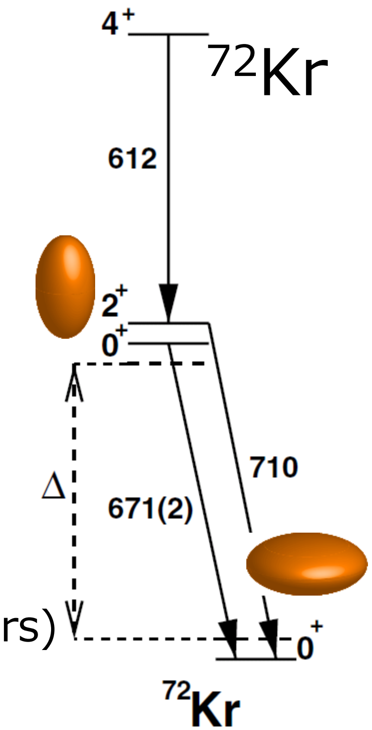
Shape coexistence in N~Z~40 region





neutron single particle energy

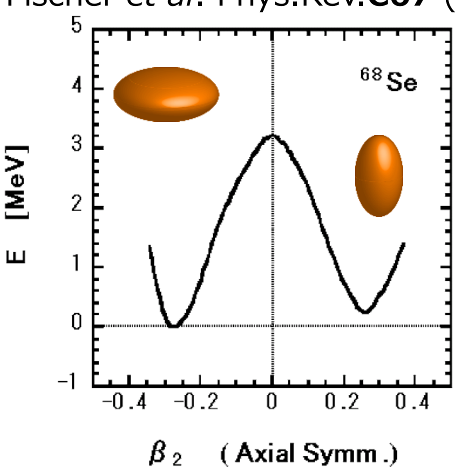




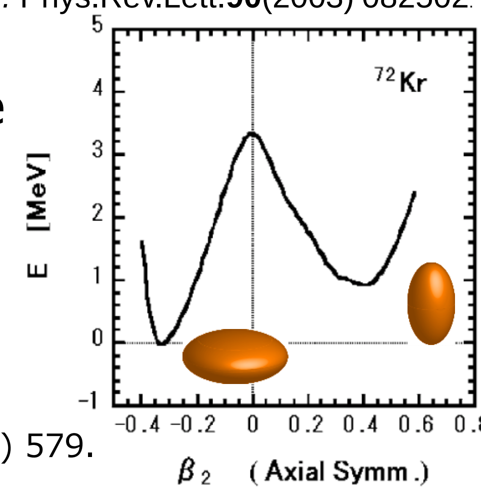
Z,N = 34,36 (oblate magic numbers)
Z,N = 38 (prolate magic number)

Fischer *et al*. Phys.Rev.**C67** (2003) 064318.

Bouchez *et al.* Phys.Rev.Lett.**90**(2003) 082502.



- oblate-prolate shape coexistence
- oblate ground state
- shape coexistence/mixing



Skyrme-HFB: Yamagami *et al.* Nucl.Phys.**A693** (2001) 579.

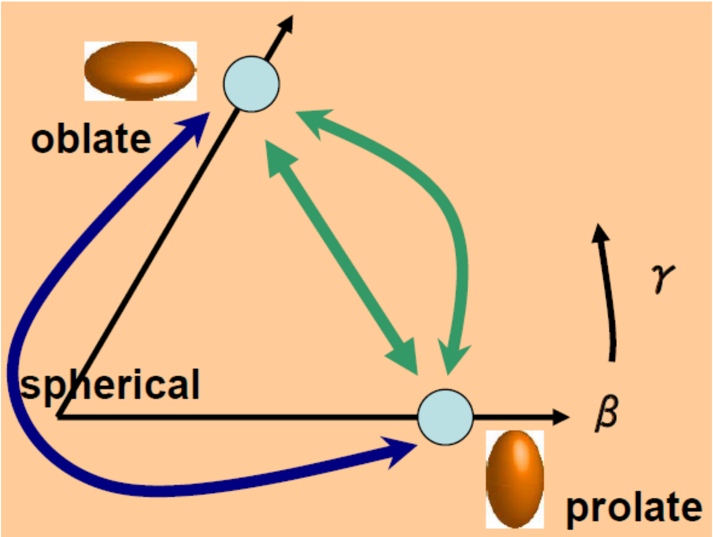
Questions:

- How strong do the oblate and prolate shapes mix?

- **Along which degrees of freedom do the oblate and prolate shapes mix?**

  - **Axial symmetric deformation?**

  - **Triaxial deformation?**

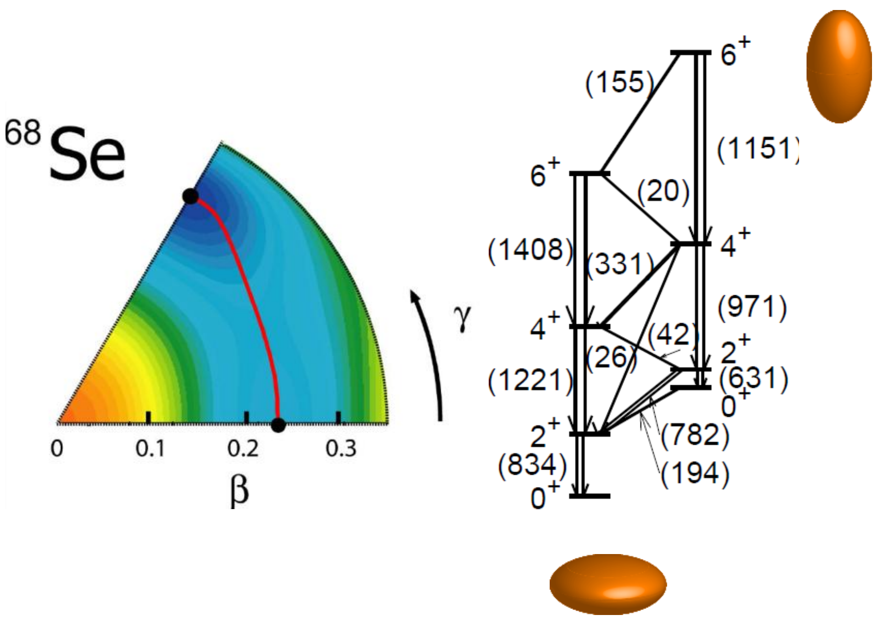


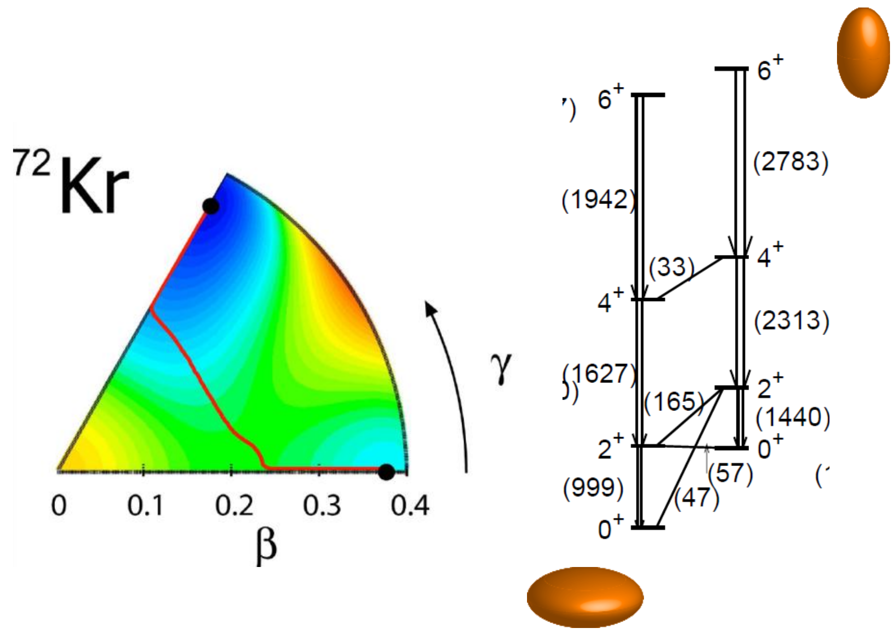
Need to determine the essential degrees of freedom of the collective dynamics without assumption

Local minimum on the potential energy surface

Collective paths obtained by means of the ASCC method

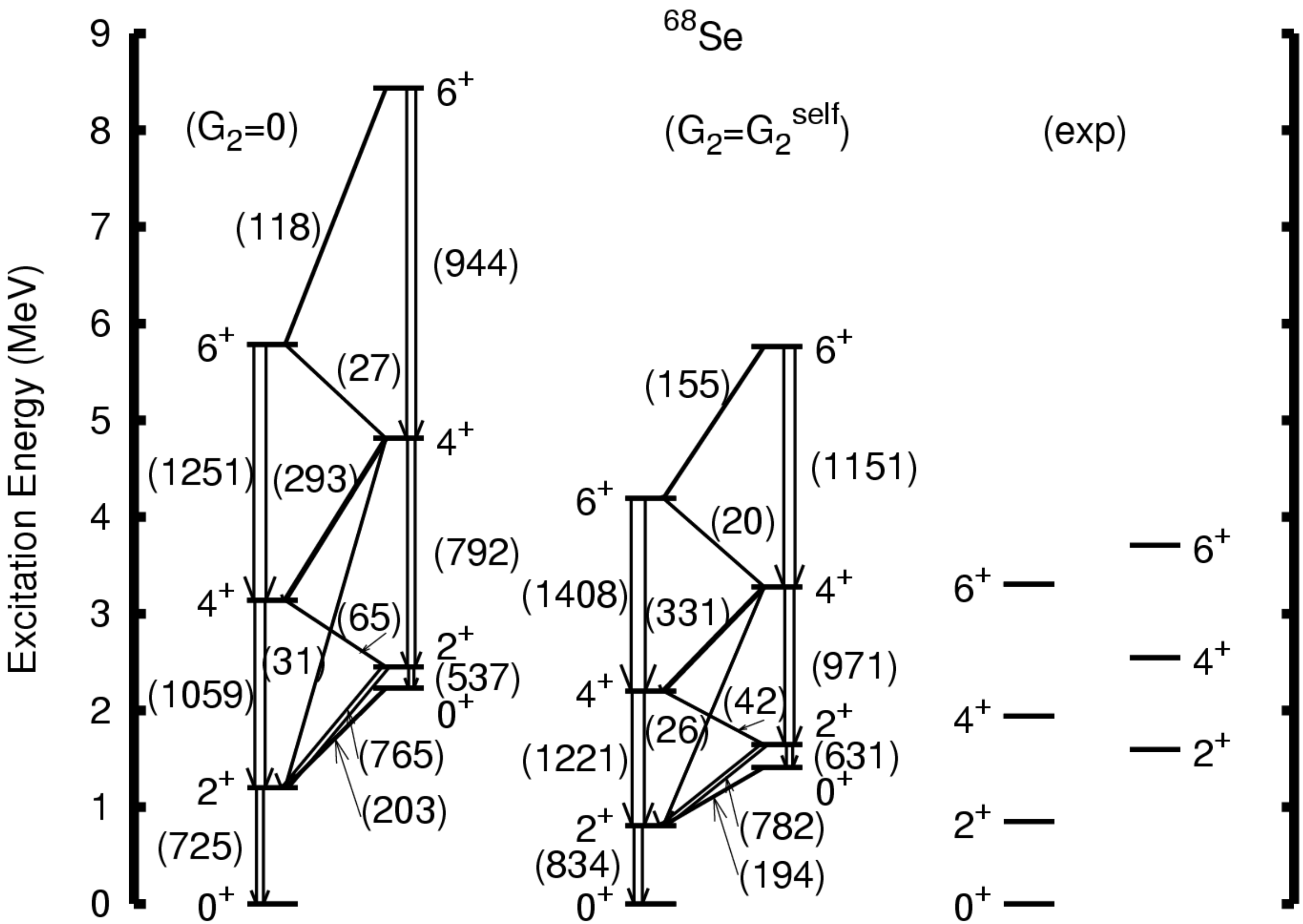
Recently, Hinohara et al. extracted the one-dimensional collective degree of freedom (collective path) for the shape mixing in 68Se and 72Kr and evaluated energy spectra, B(E2) values, and spectroscopic quadrupole moments by means of the Adiabatic SCC (ASCC) method.





The result indicates that the oblate and prolate shapes are strongly mixed at I=0, but the mixing rapidly decreases with increasing angular momentum.

Excitation spectra of ^{68}Se



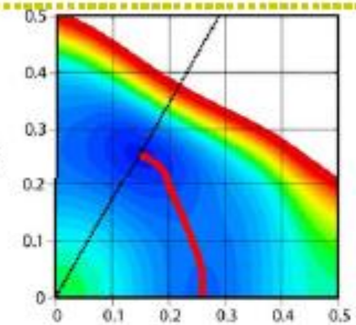
- ☐ **two rotational bands**
- ☐ **0_2^+ state**
- ☐ **quadrupole pairing lowers ex.energy**

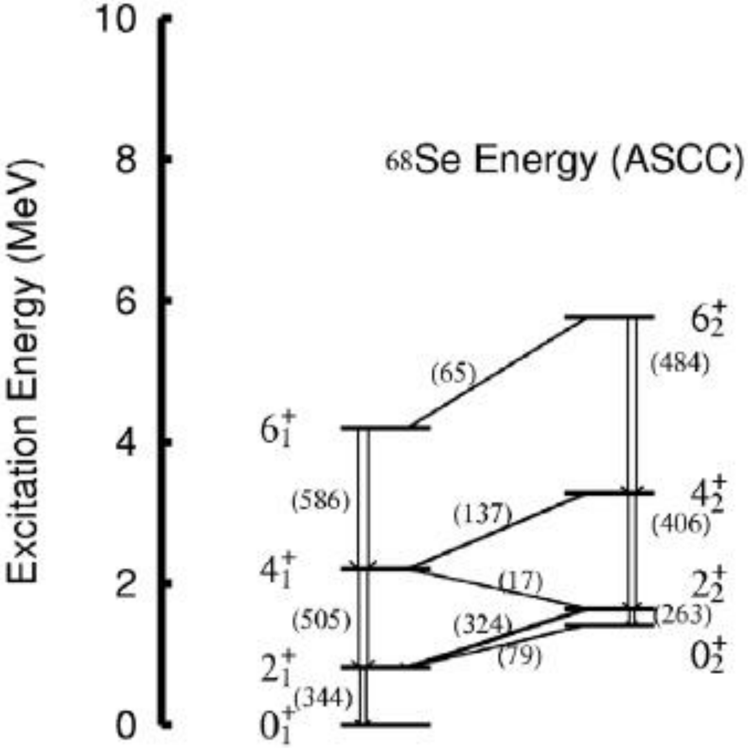
( ) …B(E2) e^2 fm^4

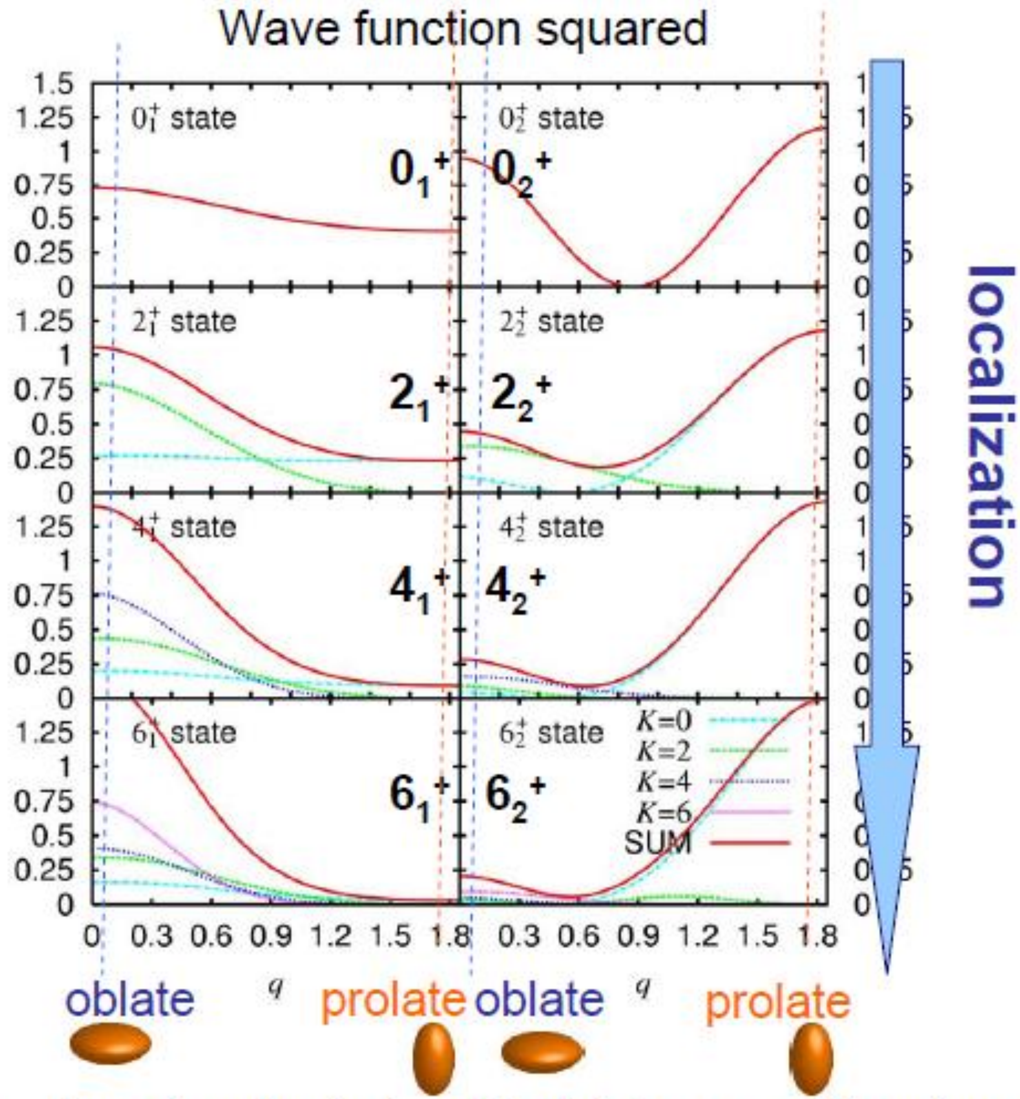
effective charge: e_{pol} = 0.904

EXP：Fischer et al., Phys.Rev.**C67** (2003) 064318.

Collective Wavefunctions of ^{68}Se

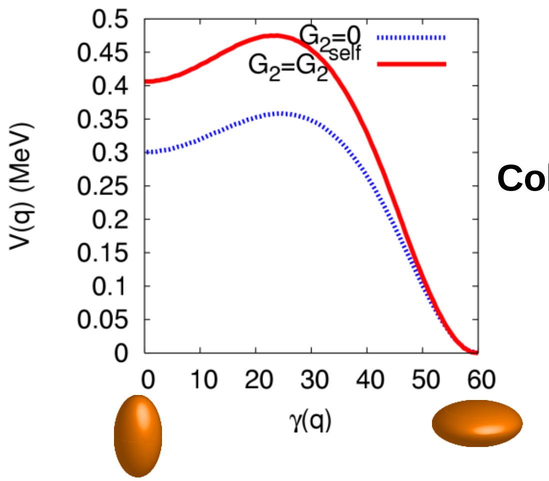




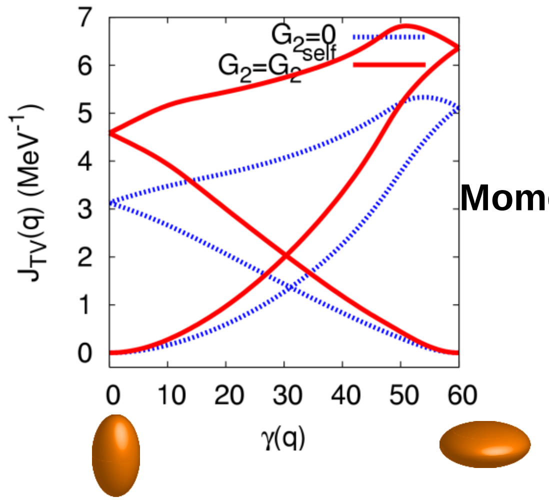


- I = 0: oblate and prolate shapes are strongly mixed via a triaxial degree of freedom
- ground band: mixing of different K states、excited band: K=0 dominant
- oblate-prolate mixing: strong in 0^+ states, reduced as angular momentum increases

What causes this rapid decrease in the mixing?



Collective potential



Moment of inertia

In this study, we investigate the low-lying states in 68Se by use of a simple model based on Bohr's Hamiltonian to understand what is essential for the rotational hindrance to shape mixing.

Bohr Hamiltonian

$$\{\hat{T} + V(\beta,\gamma)\}\Psi_k(\beta,\gamma,\Omega) = E_k\Psi_k(\beta,\gamma,\Omega)$$

with

$$\hat{T} = -\frac{\hbar^2}{2B}\left[\frac{1}{\beta^4}\frac{\partial}{\partial\beta}\beta^4\frac{\partial}{\partial\beta} + \frac{1}{\beta^2 \sin 3\gamma}\frac{\partial}{\partial\gamma}\sin 3\gamma\frac{\partial}{\partial\gamma}\right] + \sum_i \frac{\hat{I}_i^2}{2\mathcal{J}_i}$$

Bohr Hamiltonian

$$\{\hat{T} + V(\beta,\gamma)\}\Psi_k(\beta,\gamma,\Omega) = E_k\Psi_k(\beta,\gamma,\Omega)$$

with
$$\hat{T} = -\frac{\hbar^2}{2B}\left[\frac{1}{\beta^4}\frac{\partial}{\partial\beta}\beta^4\frac{\partial}{\partial\beta} + \frac{1}{\beta^2\sin 3\gamma}\frac{\partial}{\partial\gamma}\sin 3\gamma\frac{\partial}{\partial\gamma}\right] + \sum_i \frac{\hat{I}_i^2}{2\mathcal{J}_i}$$

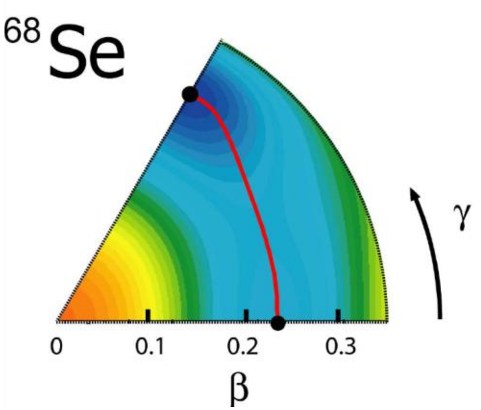
vibrational energy

rotational energy

$$\Psi_{IMk}(\beta,\gamma,\Omega) = \sum_{K=0}^{I}\Phi_{IKk}(\beta,\gamma)\langle\Omega|IMK\rangle$$

We assume that the w. f. is localized around $\beta = \beta_0$

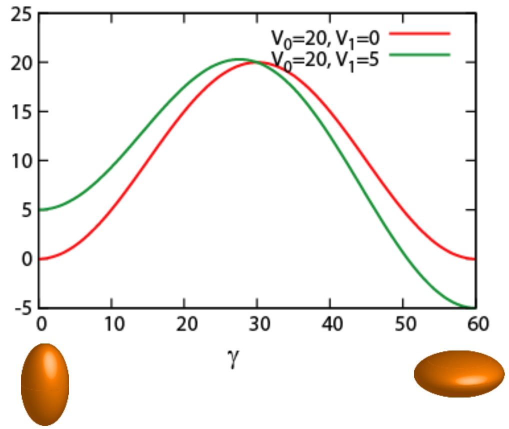
$$\Phi_{IKk}(\beta,\gamma) = f_k(\beta)\,g_{IKk}(\gamma)$$



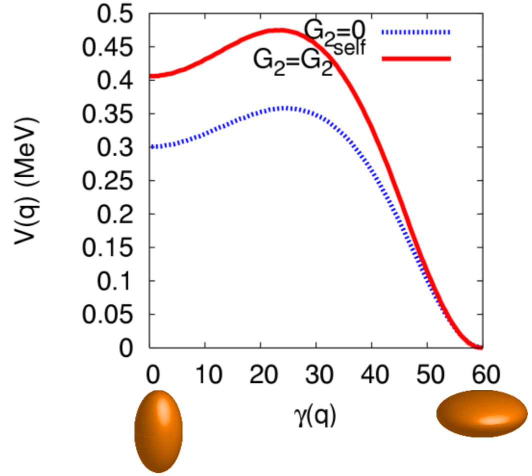
$$\boxed{\left(-\frac{\partial^2}{\partial\gamma^2} - 3\cot 3\gamma\frac{\partial}{\partial\gamma}\right)g_{IKk}(\gamma) - \sum_{K'=0}^{I}\sum_i \frac{\langle IMK|\hat{I}_i^2|IMK'\rangle}{2\tilde{\mathcal{J}}_i}g_{IK'k}(\gamma) + V_\gamma g_{IKk}(\gamma) = \Lambda_{IKk}g_{IKk}(\gamma)}$$

Collective potential

$$V_\gamma = \frac{V_0}{2}(1-\cos(6\gamma)) + V_1\cos(3\gamma)$$



ASCC

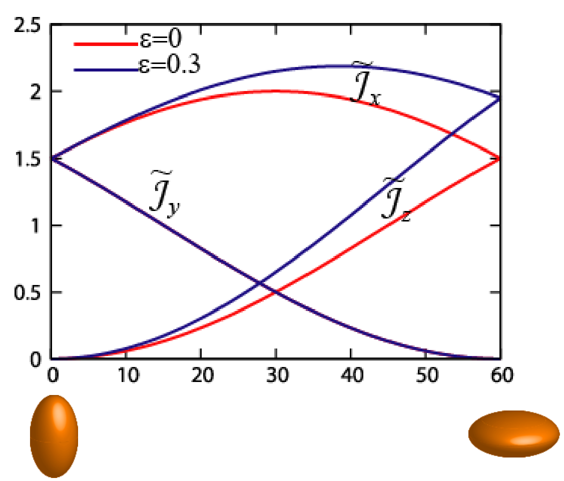


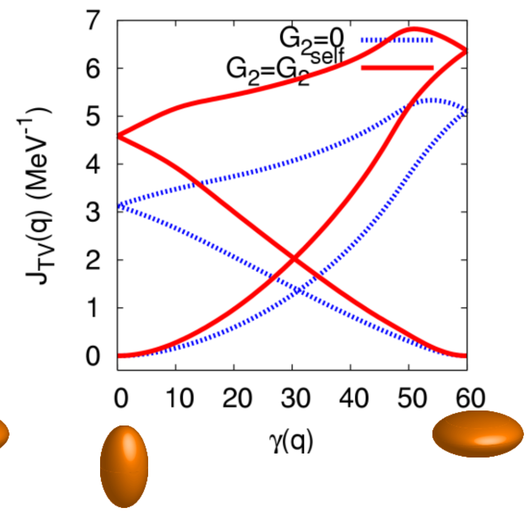
Moment of Inertia

$$\tilde{\mathcal{J}}_x = 2c\sin^2(\gamma - \frac{2}{3}\pi) + 2c\epsilon\sin^2\gamma$$

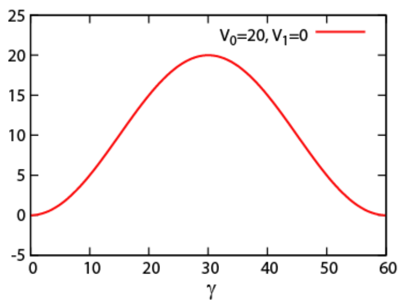
$$\tilde{\mathcal{J}}_y = 2c\sin^2(\gamma - \frac{4}{3}\pi)$$

$$\tilde{\mathcal{J}}_z = 2c(1+\epsilon)\sin^2\gamma$$

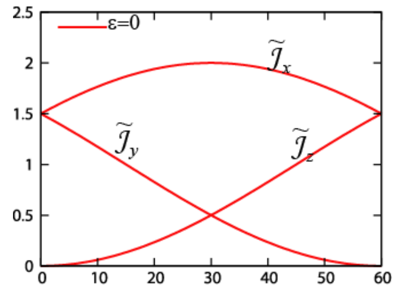




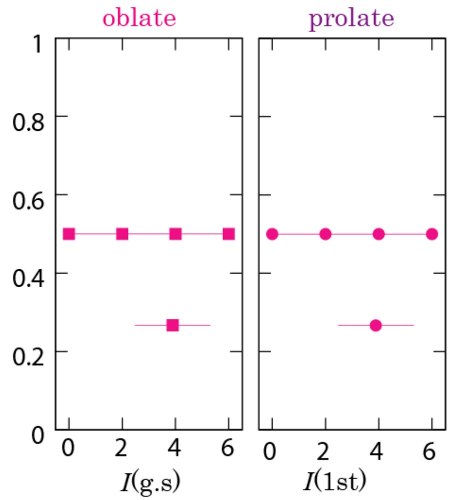
(A) Symmetric case $V_0 = 20, \quad V_1 = 0, \quad \varepsilon = 0, \quad c = 1.0$



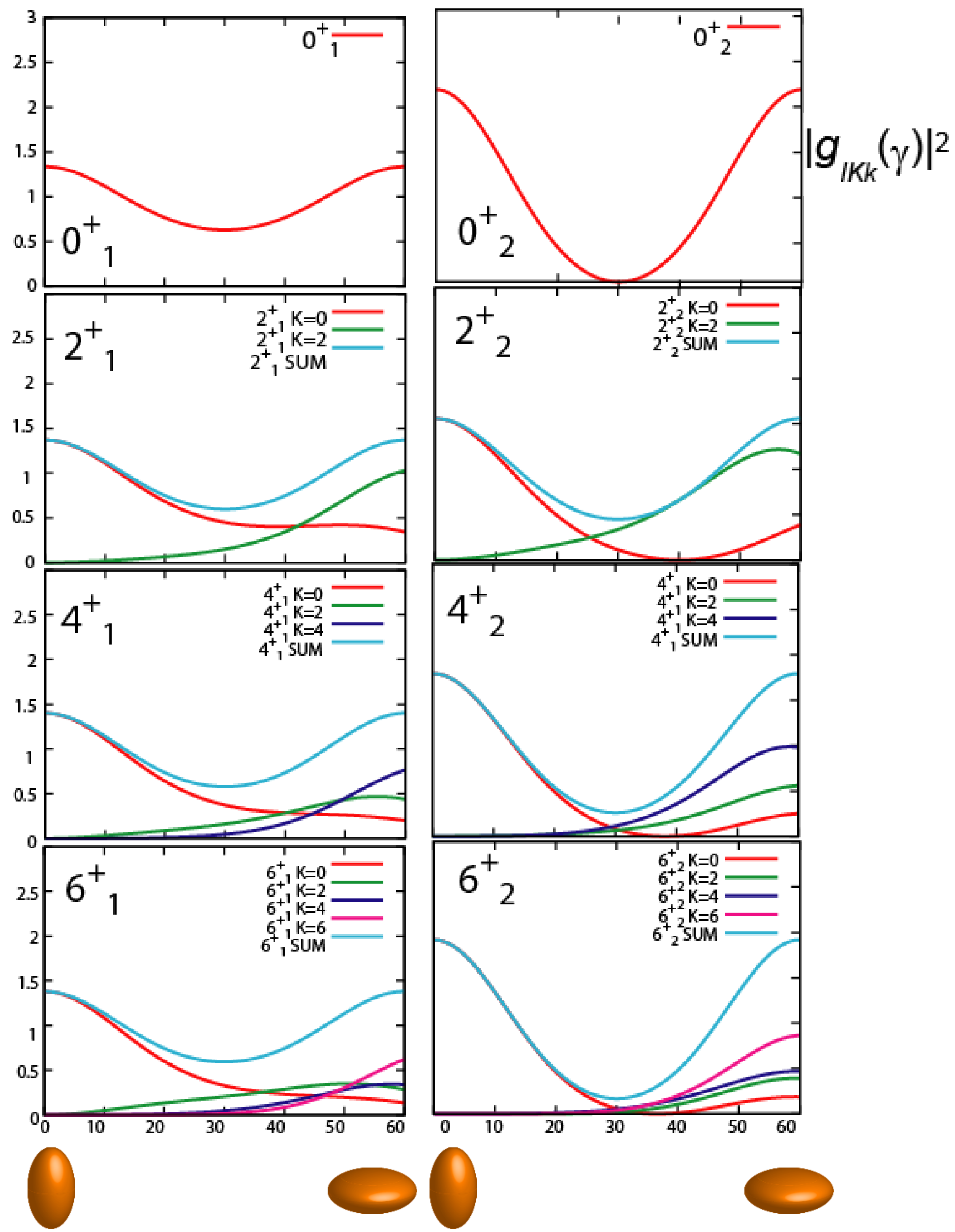
Collective potential



Moment of inertia

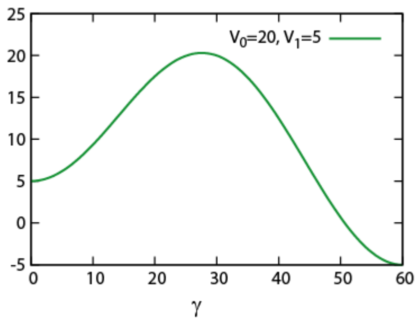


Oblate and prolate probabilities

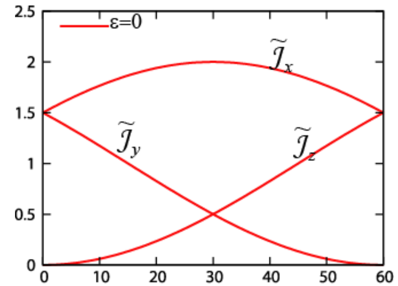


No localization

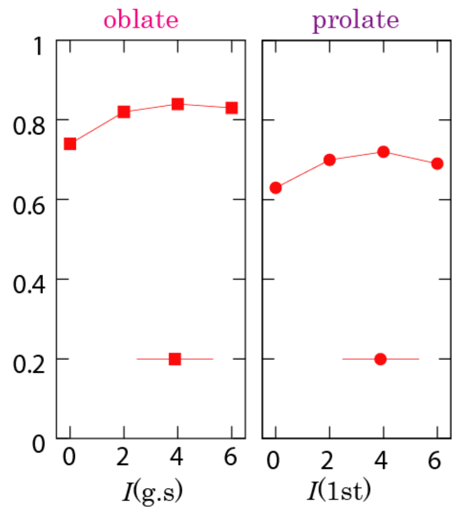
(B) Asymmetric potential $V_0 = 20, \quad V_1 = 5, \quad \varepsilon = 0, \quad c = 1.0$



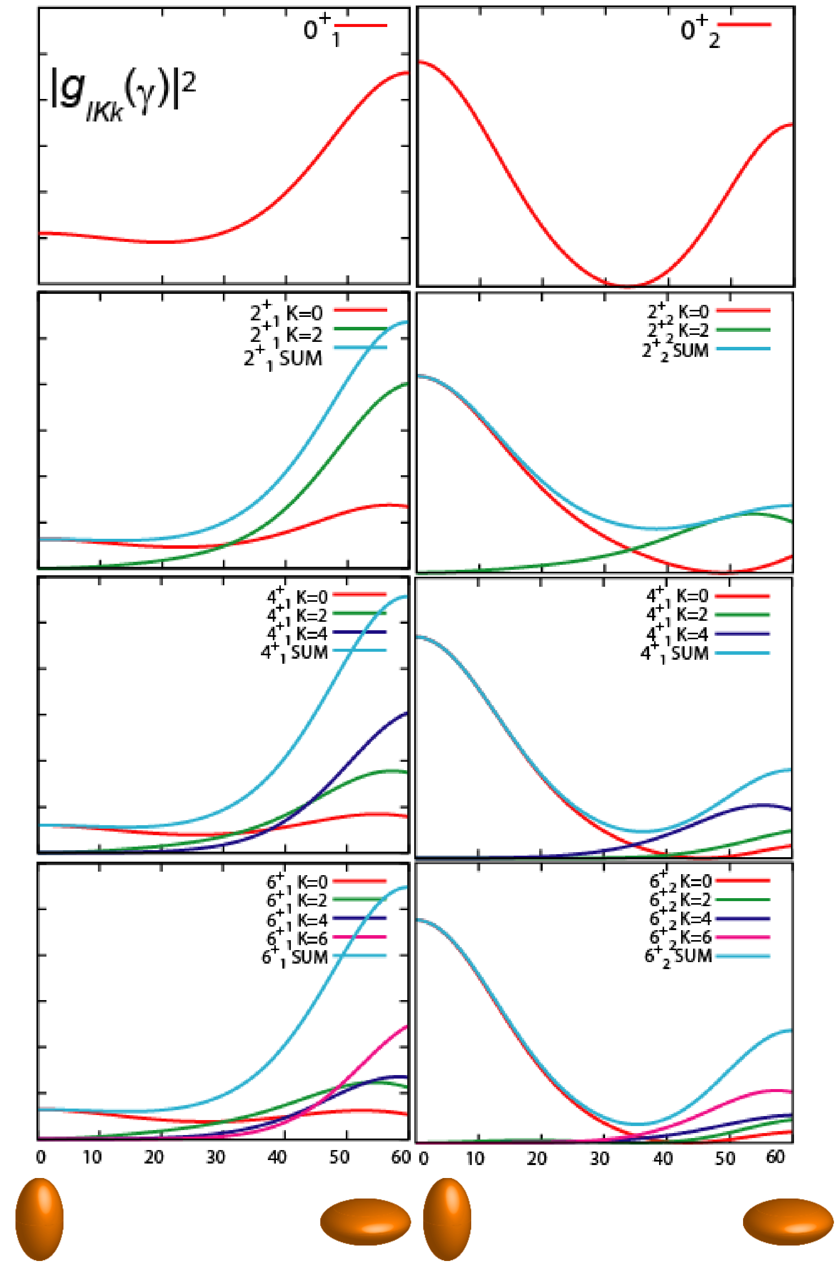
Collective potential



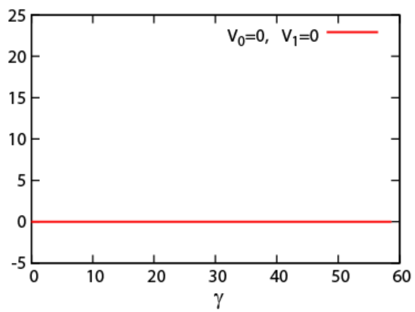
Moment of inertia



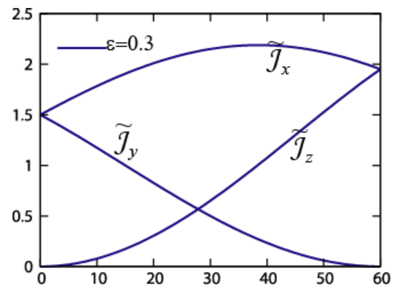
Oblate and Prolate probabilities



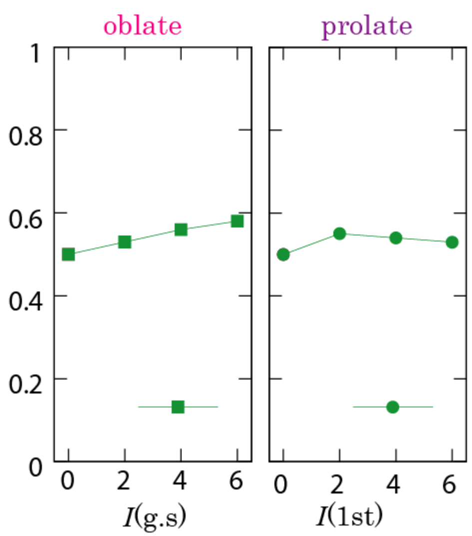
(C) Asymmetric MoI $\quad V_0 = 0\ ,\quad V_1 = 0,\quad \varepsilon = 0.3,\ \ c = 1.0$



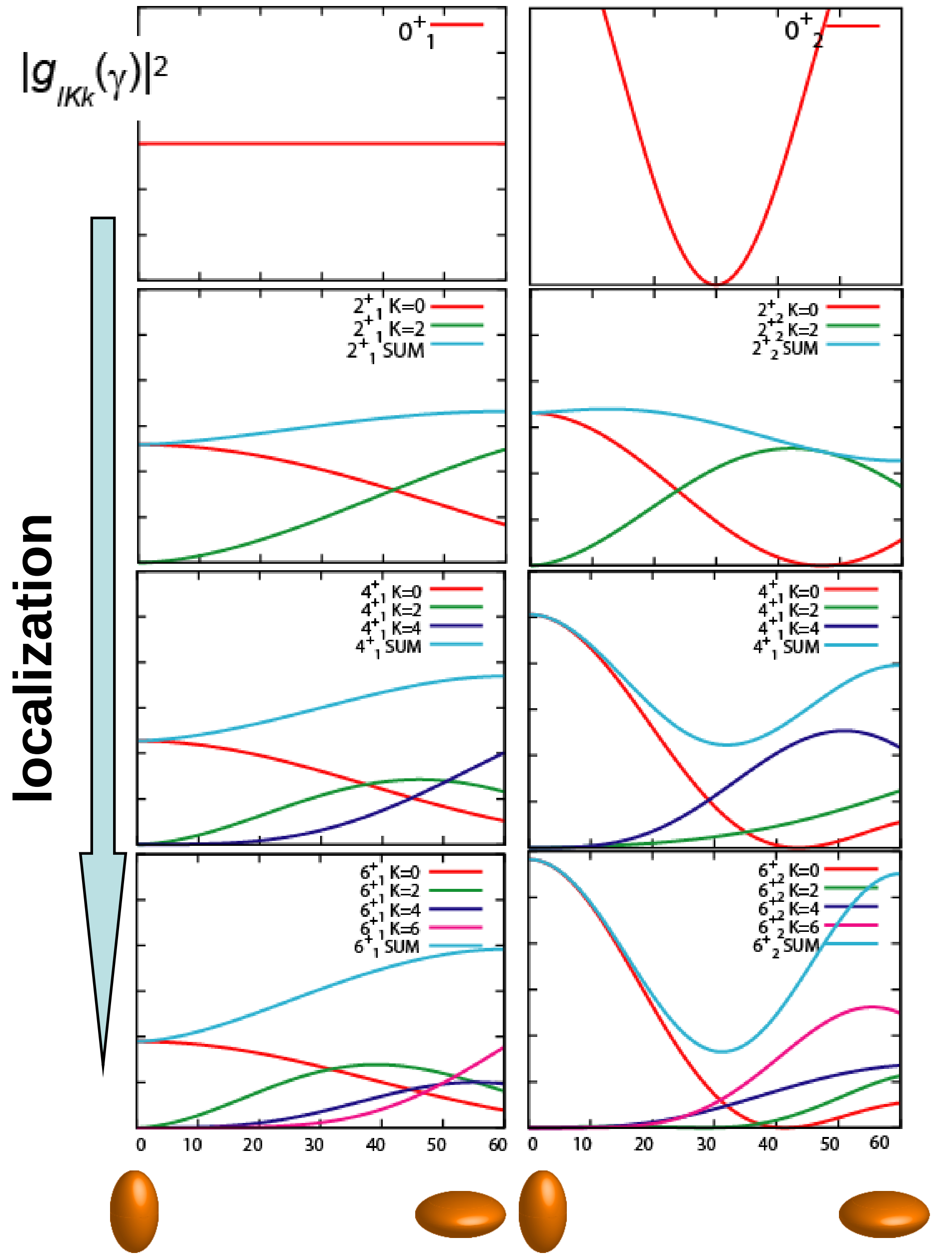
Collective potential



Moment of inertia

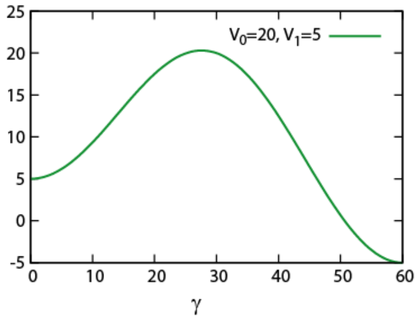


Oblate and Prolate probabilities

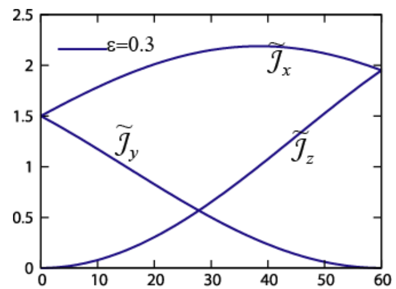


(D) Asymmetric potential & MoI

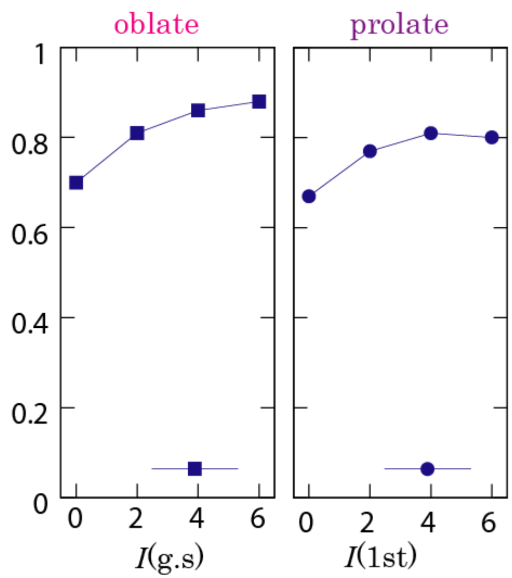
$$V_0 = 20, \quad V_1 = 5, \quad \varepsilon = 0.3, \quad c = 0.4$$



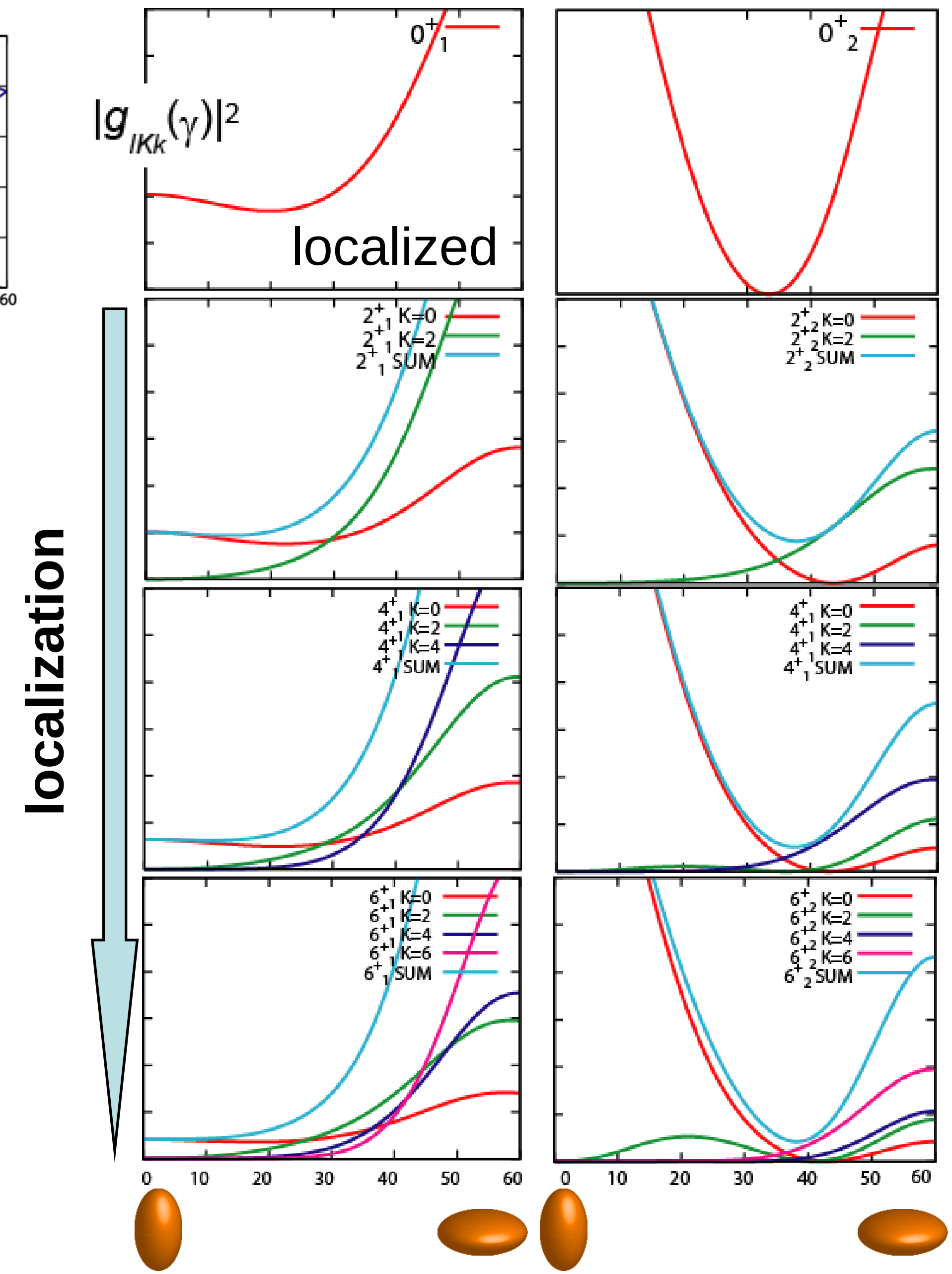
Collective potential

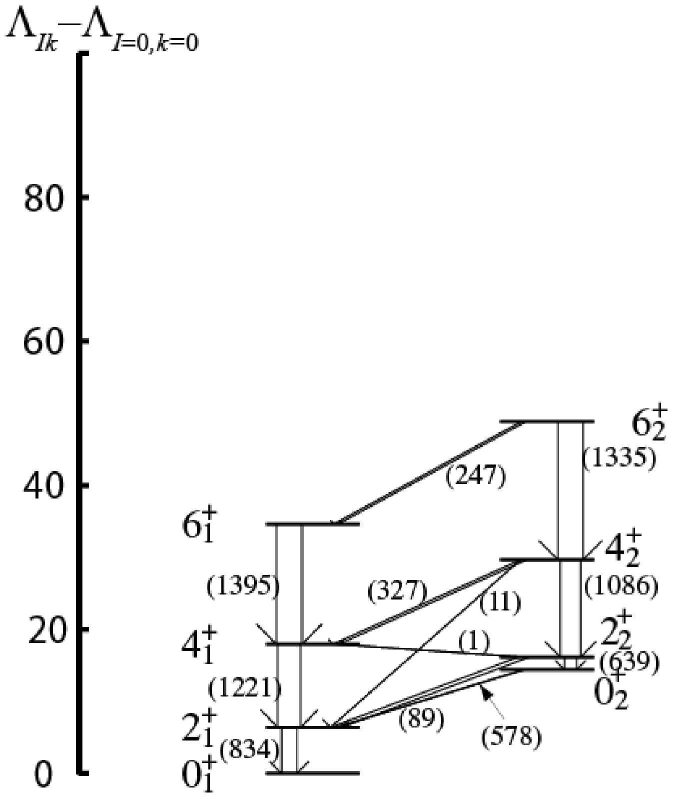


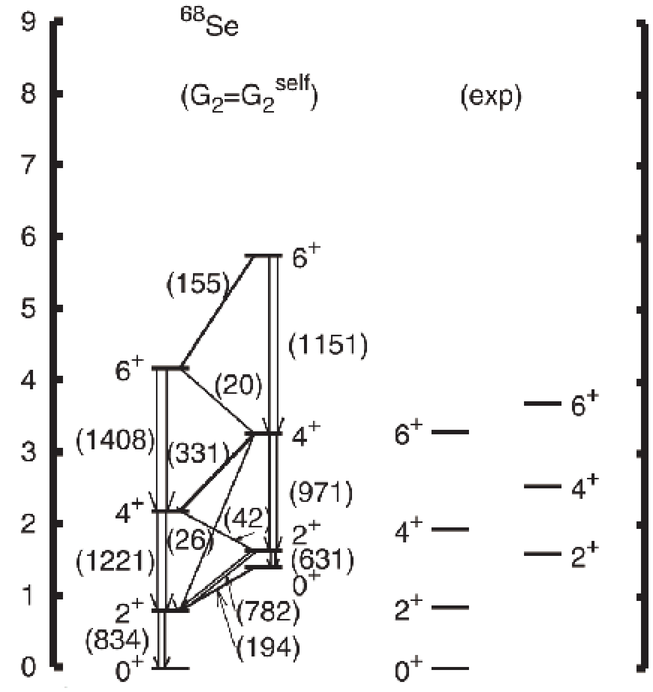
Moment of inertia



Oblate and Prolate probabilities







Summary

- The results for 68Se by the ASCC are reproduced qualitatively by a simple model based on Bohr’s Hamiltonian.
- Either the collective potential or the moments of inertia can localize the wave functions.
- The asymmetry in the moment of inertia is essential for the rotational hindrance to shape mixing