The dipole polarizability of the doubly-magic nuclei

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The dipole polarizability

- Nuclear electric dipole polarizability αD represents a viable tool to constrain the EOS of nuclear matter and the physics of neutron stars.
- This parameter provides information on the symmetry energy of EOS.

Calculations

The starting point of the method is the HF calculations with Skyrme interaction of the ground state, where spherical symmetry is assumed for the ground states.

Hartree-Fock equations for spherical nuclei:

$$-\vec{\nabla}\cdot\frac{\hbar^2}{2m_q^*(\vec{r})}\vec{\nabla}\phi_i+\left(U_q+W_q\vec{l}\cdot\vec{\sigma}\right)\phi_i=E\phi_i$$

Skyrme potential:

$$V=\sum_{i<j}v_{ij}^{(2)}+\sum_{i<j<k}v_{ijk}^{(3)}$$

D. Vautherin and D. M. Brink Phys. Rev. C **5**, 626 (1972)

RPA equations

X, Y amplitudes are the eigenvectors of the RPA secular matrix:

$$\begin{pmatrix} A & B \\ -B & -A \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix} = \omega \begin{pmatrix} X \\ Y \end{pmatrix}$$

Solutions of this set of linear equations yield the excitation energies ω of RPA And the amplitudes X, Y of the excited states.

Using them, we obtain the energies of the excited states of the nucleus.

Electric dipole polarizability

Equation of electric dipole polarizability:

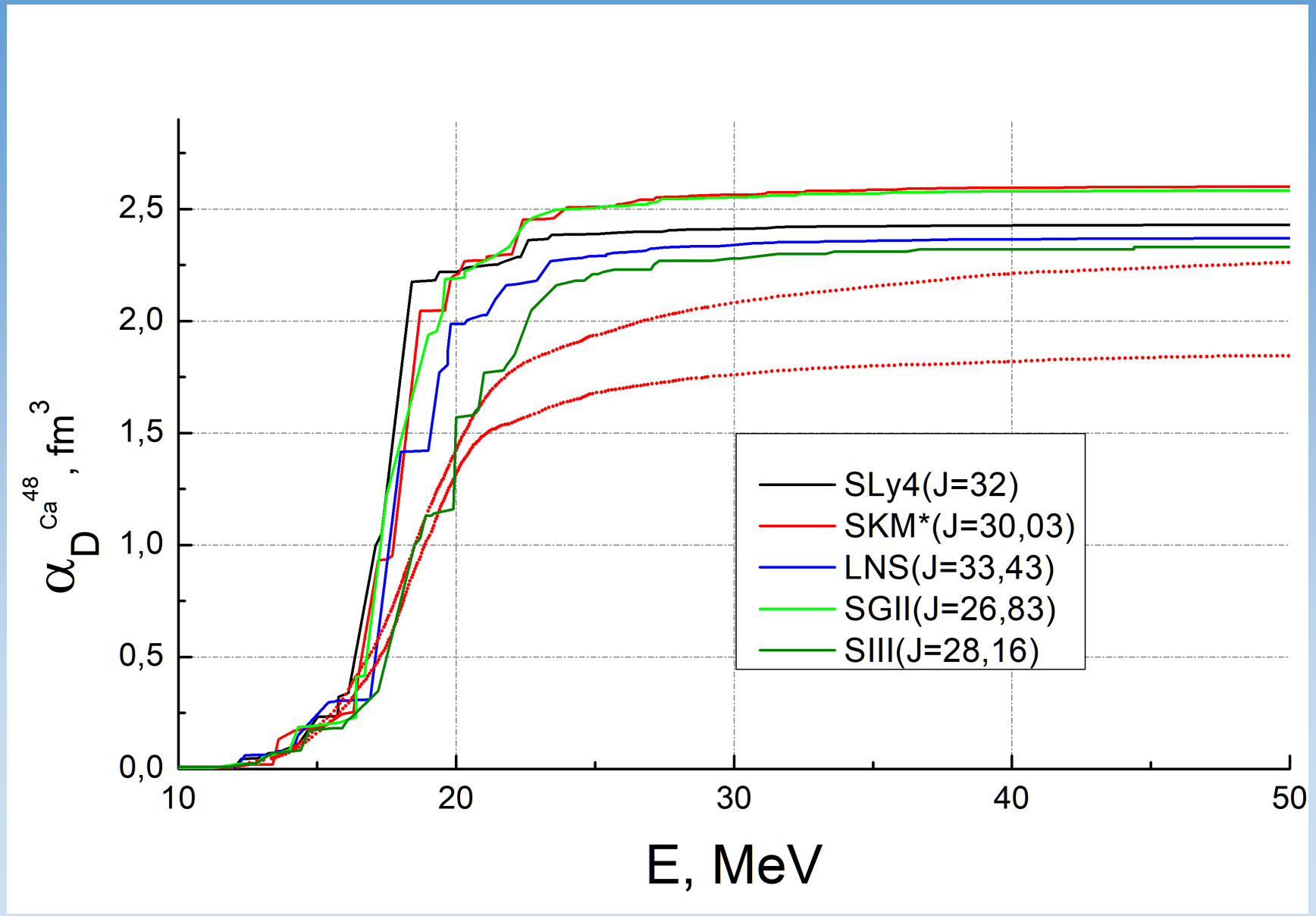
$$\alpha_D \approx \frac{\pi e^2}{54}\frac{A\langle r^2\rangle}{J}\left[1+\frac{5}{3}\frac{9J}{4Q}A^{-\frac{1}{3}}\right]$$

Equation to determine α_D by single-particle matrix elements:

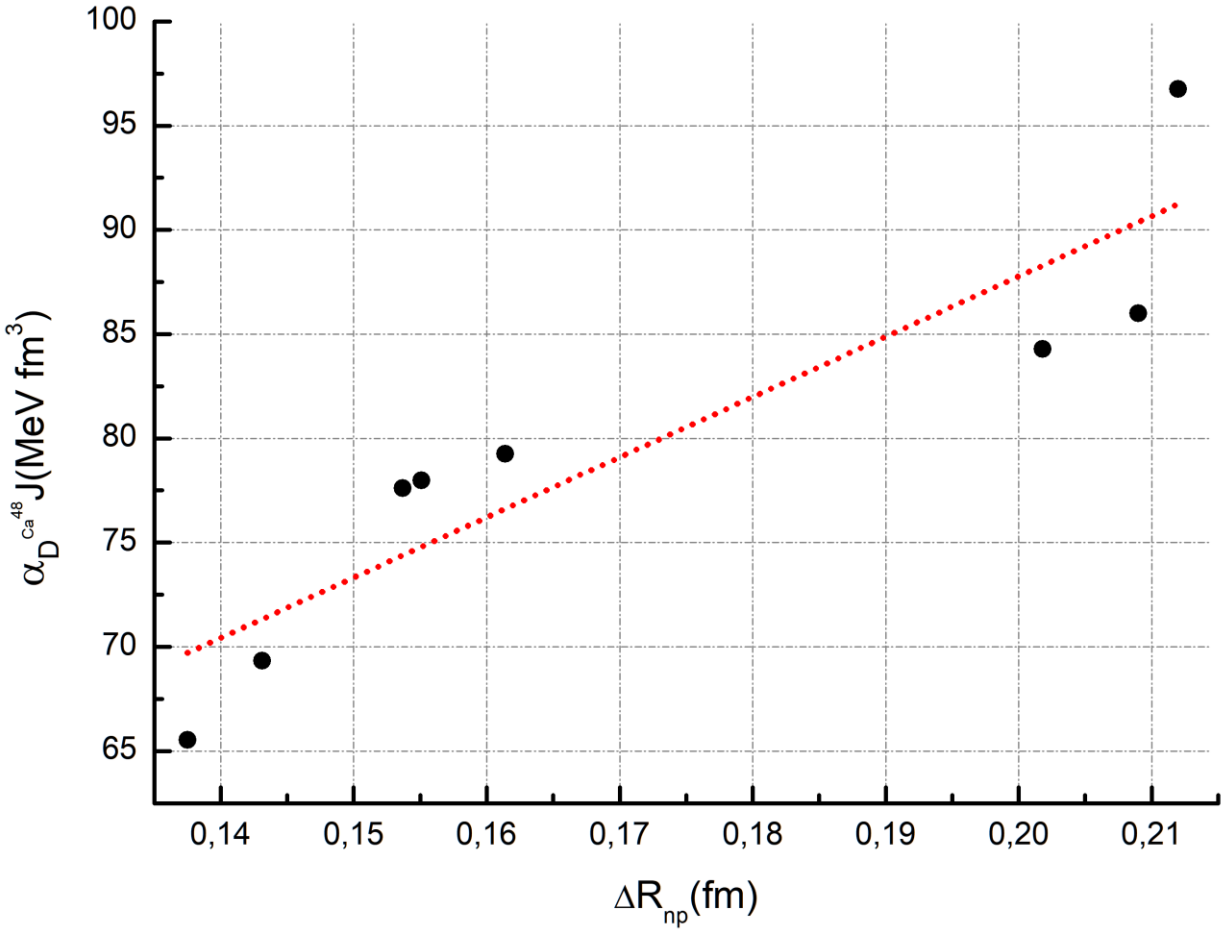
$$\alpha_D = \frac{\hbar c}{2\pi^2}\int\frac{\sigma_\gamma(E_x)}{E_x^2}dE_x = \frac{8\pi}{9}\int\frac{B(E1,E_x)}{E_x}dE_x$$

X. Roca-Maza *et al.* Phys. Rev. C **92**, 064304 (2015)

The dipole polarizability α_D of 48Ca

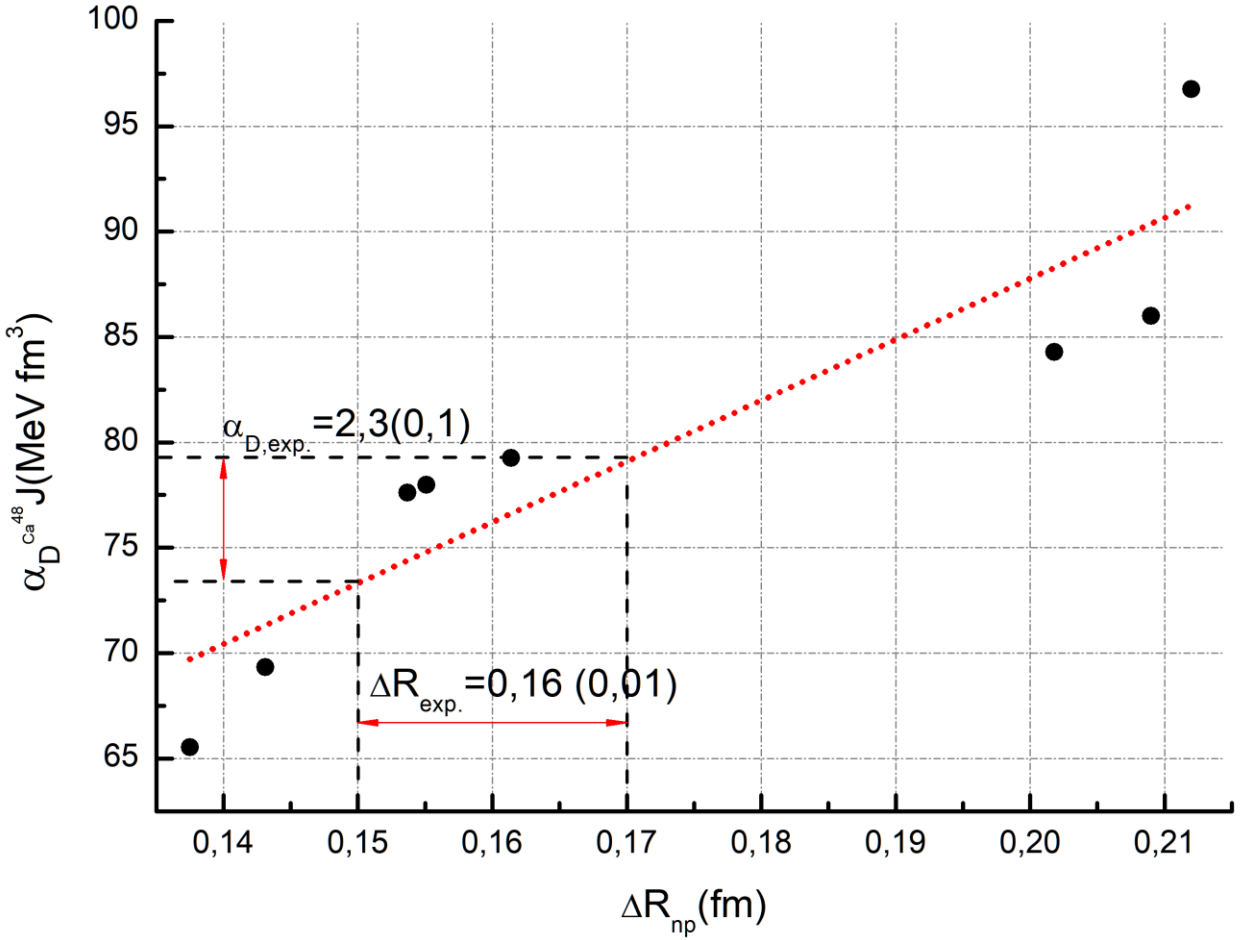


Determination of symmetry energy of 48Ca



Skyrme parameters: SLy4, SKM*, LNS, SGII, SIII, SK255, SKI2, SKI3

Determination symmetry energy of 48Ca

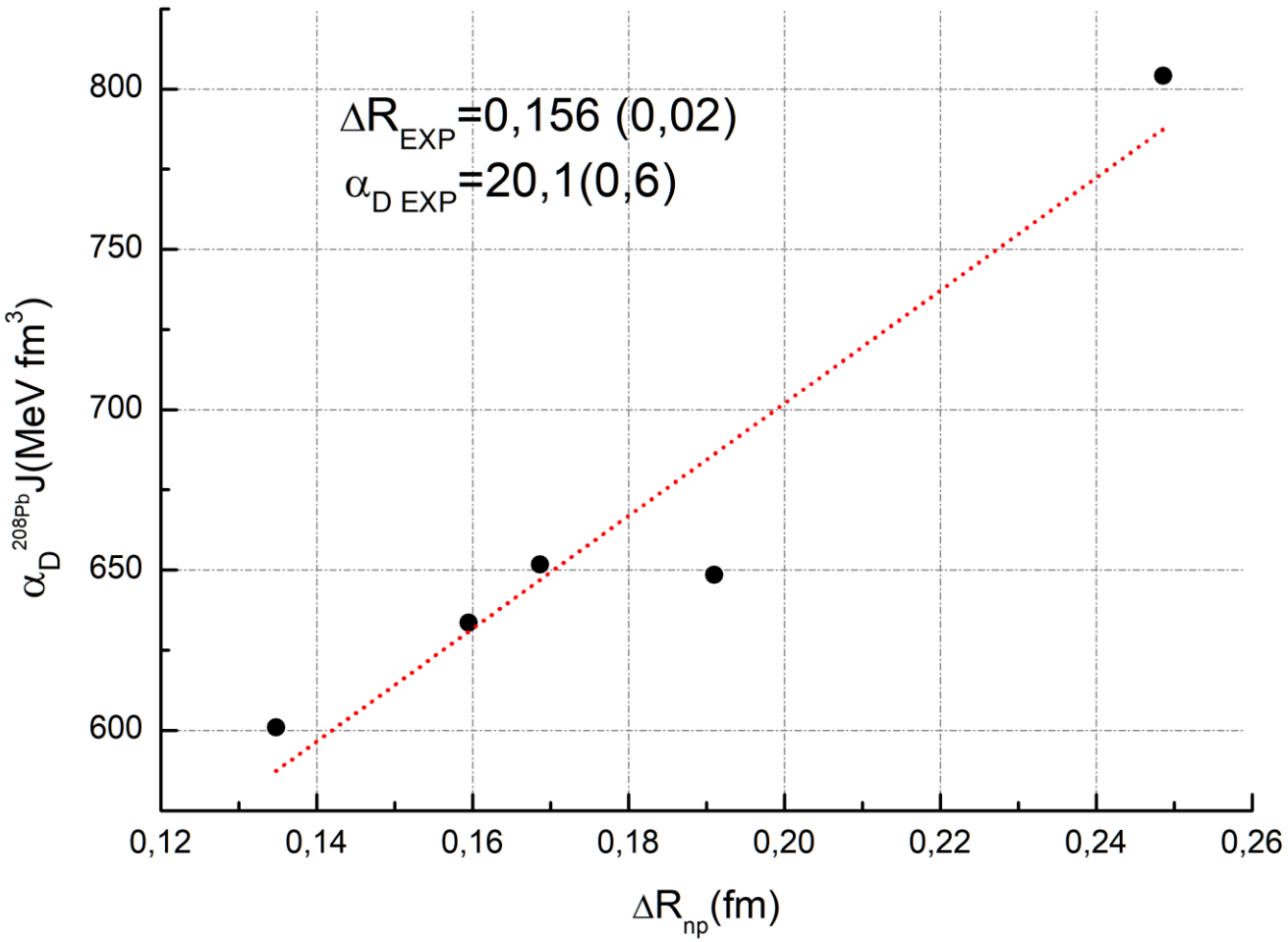


With such a calculation, we obtained the following estimate for the symmetry energy of ^{48}Ca:

$$J = 33{,}7 \pm 10{,}5 MeV$$

X. Roca-Maza *et al.* Phys. Rev. C **92**, 064304 (2015)

Determination symmetry energy of 208Pb



For this calculation, the following Skyrme potentials were chosen: SLy4, LNS, SKM*, SGII, SK255.

Symmetry energy of ^{208}Pb, which was calculated using experimental data:

$J = 31{,}6 \pm 7{,}6\ MeV$

A. Tamii, PRL 107, 062502 (2011)

Conclusions

In this work, it was shown that sets of the Skyrme parameters (SLy4, SKM*, LNS, SGII, SIII, SK255, SKI2, SKI3) give a qualitative description of dipole polarizability α_D. The dependences of α_D on the size of the neutron skin were obtained, and the symmetry energies of some nuclei were also calculated. In the near future, it is planned to study the dipole magnetic susceptibility.

Thanks for your attention!