Differences Among Ground-State-Equivalent Effective Nuclear Interactions

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We obtain a correlation between the incompressibility K_v and the anharmonicity K' of nuclear saturation curves for current Lagrangians and Skyrme-Gogny effective forces – all practically equivalent for the description of binding energies and radii of nuclei. We illustrate explicitly why a change in K_v can be compensated by modifying K' and/or the surface thickness t of large nuclei. A realistic value of $t = 2.3\,\mathrm{fm}$ fixes K_v to a value of about (210±30) MeV, consistent with recent breathing-mode analyses.

Mass Formula Coefficients from Fits to Calculated Masses and from Direct Microscopic Calculations

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We used the relativistic Thomas-Fermi approximation together with the NL1 nuclear effective Lagrangian in order to get energies of a series of finite isospin symmetric model nuclei (with A ranging from 10 up to a fictitious value of 60000). We then fitted coefficients of mass formula expressions with volume, surface and also $A^{1/3}$ and A^0 terms to these data. It is found that neglecting the A^0 term results in a $A^{1/3}$-coefficient a_3 much to small compared to the directly calculated coefficient using quantities from semi-infinite nuclear matter. This circumstance could explain the so-called curvature energy puzzle, where $a_3 \equiv 0$ seems to be consistent with results from experimental energy fits, whereas all direct calculations of a_3 with realistic interactions yield values in the order of 10 MeV. In particular it seems to be essential to take the A^0 term into account (and even desaturation terms exponential in $-A^{1/3}$) in the mass formula ansatz.

Relativistic Thomas-Fermi (RTF) Scaling Calculations of Compressed Nuclei

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Starting from RTF equilibrium ground states obtained from an effective NL1 Lagrangian we have calculated compressed nuclei for scaled densities

$$\rho_{\mathrm{sc}}(r) = \frac{1}{\lambda^3}\,\rho_{\mathrm{g.s.}}(r/\lambda)\,.$$

The compressibility modulus K_{A} of a nucleus with mass number A is extracted through

$$K_{\mathrm{A}} \equiv 9\,\rho_{\mathrm{c}}^2\;\left.\frac{\mathrm{d}^2(E/A)}{\mathrm{d}\rho_{\mathrm{c}}^2}\right|_{\rho_{\mathrm{c}}=\rho_o}\,,$$

with the central compressed density ρ_{c}, and the equilibrium central density ρ_o. Comparison of the calculated values for K_{A} is made with liquid drop type expansions where the coefficients are obtained from infinite and semi-infinite nuclear matter quantities. It is found that the more sophisticated expression derived in ref. [1], that includes higher order terms as e.g. curvature and surface symmetry contributions, does not appreciably improve upon the expression with only basic terms. The calculated K_{A}-values are in reasonable agreement with the values from experimental breathing-mode energies E_{br} extracted via the scaling-model formula

$$K_{\mathrm{A}} = \frac{M}{\hbar^2}\,\langle r^2\rangle E_{\mathrm{br}}^2\,.$$

The Coulomb contribution to K_{A} is in the order of -20 MeV, around 15% smaller than the liquid drop expression.

References

[1] R. C. Nayak, J. M. Pearson, M. Farine, P. Gleissl, and M. Brack, Nucl.Phys. **A516** (1990) 62