Differences Among Ground-State-Equivalent Effective Nuclear Interactions

W. Stocker and T. v. Chossy

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 $t = 2.3$ fm fixes K_{v} to a value of about (210 ± 30) MeV, consistent with recent breathing-mode analyses. We refer to previous nonrelativistic Thomas-Fermi approaches that came to the same conclusion.

published in: Phys. Rev. **C58** (1998) 2777

Maxwell Construction and Phase Transitions in Fermi Fluids

J. M. Pearson [a] and W. Stocker
[a] Université de Montréal, Canada

We apply elementary thermodynamics to Fermi fluids with a view to establishing the conditions for liquid-gas phase transitions at absolute zero. Particular attention is paid to the case of single-component nuclear matter (both charge-symmetric and pure neutronic cases).

to be published in: Zeitschrift f. Naturforschung **54a** (1999)

Relativistic Thomas-Fermi Studies of Exotically Large Nuclei

T. v. Chossy and W. Stocker

The relativistic Thomas-Fermi approximation (RTF) reproduces satisfactorily well nuclear energies and densities obtained by relativistic Hartree calculations. Higher order corrections to RTF do not improve apparently upon the lowest order. Therefore RTF methods are suitable for extensive exploratory studies of average nuclear properties in the (N,Z)-plane up to nuclei far beyond the experimentally known region.

We examined the properties of nuclei within the RTF framework for several effective Lagrangians in current use. For fixed neutron excess $I = (N - Z)/(N + Z)$ systematic calculations were performed for many values of A in the order of several thousands up to the boundary, where the binding energies of nuclei vanish.

In the first series of calculations the nucleon number A was increased gradually, the iterative RTF procedure beeing initialized with meson fields and densities obtained from respective previous calculations. For A larger than some critical value a bubble nucleus emerged as a RTF solution, which is characterized by a density distribution that is concentrated completely in the surface region. Even starting with a liquid drop type density did not yield a compact-nucleus solution after convergence.

This supports the intuitive picture that the protons tend towards the surface due to some sort of Faraday cup effect, thus lowering the Coulomb contribution to the total energy. In order to reduce the asymmetry energy the neutrons would follow the protons closely, thereby, however, creating a second surface with expenditure of energy. The interplay of these competing effects determines whether the bubble structure is energetically favoured.

In a second approach we started from the bubble-nucleus region, and reduced the value of A step by step. Now, bubble solutions appeared even for A smaller than the critical value. Thus metastability is obvious in our RTF simulations. The really stable of both solutions is characterized by a lower energy. Bubble nuclei are favoured energetically for A-values larger than a so called cavitation value A_{cav}, which depends on the neutron excess I.

For the NL1-Lagrangian the bubble-nucleus region could be roughly marked in the (N,Z)-plane. Bubble nuclei that are proton as well as neutron stable were found only in a limited region between $I \approx 0.35$ and 0.4 and $A \approx 700$ and 1200. For $I \approx 0.4$ and $A \approx A_{cav}$ nuclear configurations appeared where there is a neutron gas inside an external bubble.

We found the calculated rms radii of bubble nuclei approximately proportional to $A^{0.84 \pm 0.05}$, in contrast to liquid-drop nuclei with an exponent of about 1/3.

Our RTF investigations are in qualitative agreement with the earlier predictions of Refs. [1], where – on the basis of a generalized droplet model and phenomenological shell model potentials – metastable islands of nuclear bubbles were found for nuclei in the region of A=450 – 3000.

References

[1] K. Dietrich and K. Pomorski, Nucl.Phys. **A627** (1997) 175;
K. Dietrich and K. Pomorski, Phys.Rev.Lett. **80** (1998) 37.