Symmetry Energy in Nuclei

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Nuclear symmetry energy is an important ingredient in the equation of state of isospin asymmetric nuclear matter. It governs the structure of finite nuclei and of neutron stars. To advance understanding of the impact of the symmetry energy on nuclear properties, we perform Skyrme-Hartree Fock (SHF) calculations for nuclear systems and undertake qualitative considerations within Hohenberg-Kohn functional theory [1,2]. Two fundamental quantities - isoscalar and isovector densities, which are approximately independent of asymmetry, are introduced to characterize nucleon distributions. The two densities are approximately related to each other through the local value of the symmetry energy. Within our calculations for half-infinite nuclear matter, we arrive at symmetric surface and surface-symmetry characterizations for nearly all Skyrme parameterizations proposed in the literature. Strong correlations between the slope of symmetry energy with respect to density and the volume-to-surface symmetry-coefficient ratio, as well as the displacement of nuclear isovector relative to isoscalar surface, are observed. Utilizing data on mass dependence of the excitation energies to the isobaric analog states, corrected for microscopic effects and deformation, we determine the model-independent volume and surface symmetry coefficients [1-3]. Exploiting our calculations for half-infinite matter, we obtain constraints on the density-dependence of symmetry energy [1]. Firmer constraints could be achieved by comparing the SHF calculations for unrealistically large and realistic masses to expectations based on calculations for half-infinite matter. Some systematic deviations between those are found to be related to the instabilities associated with specific Skyrme parameterizations.

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