High-order effects on the incompressibility of isospin asymmetric nuclear matter

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We have derived the analytical expressions for the saturation density as well as the binding energy and incompressibility at the saturation density of asymmetric nuclear matter exactly up to 4th-order in the isospin asymmetry $\delta=(\rho_n-\rho_p)/(\rho_n+\rho_p)$ using 11 characteristic parameters defined at the normal nuclear density ρ_0 by the density derivatives of the binding energy per nucleon of symmetric nuclear matter, the symmetry energy $E_{sym}(\rho)$ and the 4th-order symmetry energy $E_{sym,4}(\rho)$ [1]. Using an isospin- and momentum-dependent modified Gogny (MDI) interaction and the Skyrme-Hartree-Fock (SHF) approach with 63 popular Skyrme interactions, we have systematically studied the isospin dependence of the saturation properties of asymmetric nuclear matter, particularly the incompressibility $K_{sat}(\delta)=K_0+K_{sat,2}\delta^2+K_{sat,4}\delta^4+O(\delta^6)$ at the saturation density. Our results show that the magnitude of the high-order $K_{sat,4}$ parameter is generally small compared to that of the $K_{sat,2}$ parameter. The latter essentially characterizes the isospin dependence of the incompressibility of asymmetry nuclear matter at the saturation density and can be expressed as $K_{sat,2}=K_{sym}-6L-(J_0/K_0)L$, where L and K_{sym} represent, respectively, the slope and curvature parameters of the symmetry energy at ρ_0 while J_0 is the third-order derivative parameter of symmetric nuclear matter at ρ_0. Furthermore, we have constructed a phenomenological modified Skyrme-like (MSL) model which can reasonably describe the general properties of symmetric nuclear matter and the symmetry energy predicted by both the MDI model and the SHF approach. The results indicate that the high-order J_0 contribution to $K_{sat,2}$ generally cannot be neglected. In addition, it is found that there exists a nicely linear correlation between K_{sym} and L as well as between J_0/K_0 and K_0. These correlations together with the empirical constraints on K_0, L, $E_{sym}(\rho_0)$ and the nucleon effective mass lead to an estimated value of $K_{sat,2} = -370 \pm 120$ MeV.

[1] L. W. Chen, B. J. Cai, C. M. Ko, B. A. Li, C. Shen, and J. Xu, arXiv:0905.4323; Phys. Rev. C (submitted).