A new Skyrme type energy density functional

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Energy density functional (EDF) theory is a powerful tool for the study of many-body problems. The problem in its implementation is to find the EDF itself. The quest for a new and more accurate EDF is one of the major problems in modern nuclear theory.

We aim to build a more effective EDF associated with the Skyrme effective nucleon-nucleon interaction that is able to correctly predict the properties of nuclei at and away from the valley of stability. We have used many different nuclear properties including binding energy, charge rms radii, spin-orbit splitting of single-particle orbits, rms radii for valence neutrons and centroid energies for the isoscalar giant monopole resonance (ISGMR) for many different nuclei ranging from very light ^{16}O to very heavy ^{208}Pb. Traditionally, it has been required that experimental data on the ground state be well reproduced by the mean-field theory. We have made our fit to modified experimental data [1], which takes into account correlation effects, i.e. to go beyond the mean-field.

We have used the simulated annealing method in addition to an advanced least square method to search the hyper-surface of the Skyrme parameter space for the global minima. We have developed a new Skyrme-based EDF, named KDEX. The new interaction better predicts the rms radii of ^{16}O and ^{208}Pb which has been a problem in most previous interactions. The values of the Skyrme parameters for the KDEX interaction are given in Table I together with those of the KDE0 [2] interaction.

TABLE I. Values of the parameters of the Skyrme type interactions.

	KDE0 (HF)	KDEX (HF+CORR)
t_0 (MeV fm^3)	-2526.51 (140.63)	-1419.83 (14.68)
t_1 (MeV fm^5)	430.94 (16.67)	309.14 (8.79)
t_2 (MeV fm^5)	-398.38 (27.31)	-172.96 (3.92)
t_3 (MeV fm$^{3(1+\alpha)}$)	14235.5 (680.73)	10465.4 (133.29)
x_0	0.7583 (0.0655)	0.14741 (0.00437)
x_1	-0.3087 (0.0165)	-0.08527 (0.0046)
x_2	-0.9495 (0.0179)	-0.6144 (0.0159)
x_3	1.1445 (0.0882)	0.02197 (0.00106)
W_0 (MeV fm^5)	128.96 (3.33)	98.90 (2.27)
α	0.1676 (0.0163)	0.4989 (0.0103)

Our future plans include:

i) Improve the fit between theoretical prediction and experimental results by modifying the density dependence of the Skyrme interaction.

ii) Include in the fit of the EDF ISGMR data for more nuclei, which is sensitive to the nuclear matter incompressibility coefficient. Also we would like to include higher multipole data, which is sensitive to symmetry energy density and the effective mass.

[1] P. Klüpfel, P.-G. Reinhard, T. J. Bürvenich, and J. A. Maruhn, arXiv:0804.3385v2 (2008).
[2] B. K. Agrawal, S. Shlomo, and V. Kim Au, Phys. Rev. C **72**, 014310 (2005).