Improving relativistic energy density functionals with tensor couplings

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The main aim of the present work is the development of new parameterisations of relativistic Energy Density Functional (EDFs) with tensor couplings, denoted by 'DDT' in the following, in addition to the usual standard minimal couplings of the mesons to the nucleons, denoted by DD3. The medium dependence of the interaction is taken into account with a density dependence of the minimal couplings using the functional forms introduced in [1]. The actual values of the model parameters are determined by fitting selected observables of finite nuclei that are sensitive to different contributions in the EDF and are obtained more-or-less directly from experiment: 1. the binding energy B; 2. the charge radius r_c; 3. the diffraction radius r_d; 4. the surface thickness σ; 5. the root-mean-square radius r_n of a single valence neutron level above a shell closure; 6. the spin-orbit splitting ΔE_{so} for two levels of a nucleon in states with the same principal quantum number, n, and orbital angular momentum, l, but different total angular momentum, $j = l \pm 1/2$, and; 7. the constraint isoscalar giant monopole giant resonance energy E_{mono}. A comparison to these data was performed after the model parameters have been determined.

We note that in this work, we neglect the Coulomb exchange term (which include also the self-energy term). A more detailed consideration of the contributions to the energy of a nucleus reveals, however, that it is admissible to neglect the exchange part in the Coulomb energy, which includes the self-energy, and use only the direct Coulomb term, which include the self-energy term, accounting for the missing contributions of charge symmetry breaking and long-range correlations, as done in DDT and DD3 parametrization, see subparagraph IIA in [2]. To study the effect of this modification, two variations, DDTC and DD3C, of the original DDT and DD3 parameterisations were also developed, by including the factor (Z-1)/Z in the direct Coulomb term, to remove the self-energy contribution. As seen from Table I, a better

Table I. Experimental binding energy differences in MeV of mirror nuclei in comparison to theoretical values from different parameterizations of the relativistic EDF. The numbers in brackets are the differences to the experimental value.

pair of mirror nuclei	experiment	DDT	DDTC	DD3	DD3C
^{41}Ca - ^{41}Sc	7.278	7.641 (0.363)	7.321 (0.043)	7.489 (0.211)	7.183 (-0.095)
^{34}Si - ^{34}Ca	39.528	40.240 (0.712)	38.251 (−1.277)	40.576 (1.048)	38.562 (−0.966)
^{48}Ca - ^{48}Ni	68.673	69.699 (1.026)	67.117 (-1.556)	68.639 (-0.034)	66.168 (-2.505)

agreement with the experimental data for pairs of mirror nuclei is obtained for the calculated results of DDT and DD3 relativistic EDFs. Other calculated results for properties of nuclei, nuclear matter and neutron stars will be published.

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