Density Dependent Hadron Field Theory ◇

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A fully covariant approach to a density dependent hadron field theory is presented. The relation between in-medium NN interactions and field-theoretical meson-nucleon vertices is discussed. The medium dependence of nuclear interactions is described by a functional dependence of the meson-nucleon vertices on the baryon field operators. As a consequence, the Euler-Lagrange equations lead to baryon rearrangement self-energies which are not obtained when only a parametric dependence of the vertices on the density is assumed. It is shown that the approach is energy-momentum conserving and thermodynamically consistent. Solutions of the field equations are studied in the mean-field approximation. Descriptions of the medium dependence in terms of the baryon scalar and vector density are investigated. Applications to infinite nuclear matter and finite nuclei are discussed. Density dependent coupling constants obtained from Dirac-Brueckner calculations with the Bonn NN potentials are used. Results from Hartree calculations for energy spectra, binding energies, and charge density distributions of ^{16}O, ^{40,48}Ca, and ^{208}Pb are presented. Comparisons to data strongly support the importance of rearrangement in a relativistic density dependent field theory. Most striking is the simultaneous improvement of charge radii, charge densities, and binding energies. The results indicate the appearance of a new "Coester line" in the nuclear matter equation of state.

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Nuclear Structure Calculations with "Free" One-Boson-Exchange Potentials

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Since neither the relativistic Hartree (RH)- nor the Hartree-Fock-approximation (RHF) give bound systems for realistic OBE-potentials, one has to introduce – at least – dynamical two-body correlations, for instance, the relativistic Brückner-Hartree-Fock approximation (RBHF), which are difficult to perform for finite systems. A simple connection to infinite nuclear matter results (INM) of RBHF-calculations was proposed by Brockmann and Toki [1] and extended by Lenske and Fuchs [2], who included rearrangement, by parametrizing the density-dependence of the self-energy and using these parametrizations in a RH-scheme. We used the parametrizations resulting from a INM-calculation in the full Dirac space [3] for three different OBE-potentials (A,B,C) – which differ in the tensor strength – constructed by Brockmann and Machleidt.

It turns out that one reproduces in this simple paramterfree approach the properties of finite systems surprisingly well [4]. The results for the potentials A and B differ not very much. Since the outcome for symmetric and asymmetric INM agrees very well with the semiempirical values of the mass formula, one can consider the results for the finite nuclei as a further step towards a unified microscopic scheme in the description of nuclear systems in the relativistic approach.

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