The Relativistic Spin-Orbit Force Near the Neutron-Drip Line

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The relativistic spin-orbit force and its dependence on neutron excess are studied using the $\sigma - \omega - \varrho$ model. By working within the schematic model of asymmetric semi-infinite nuclear matter we are able to isolate the spin-orbit potential and to investigate the following aspects: (i) the influence of the spin-orbit force on nuclear surface properties as a function of neutron excess, (ii) the local variation of the spin-orbit strength at various asymmetries, and (iii) the dependence of the spin-orbit force on the nucleonic isospin. Calculations have been performed for the currently used parameter sets NL1 and NL-SH up to the corresponding neutron-drip line. We conclude that with increasing neutron excess the spin-orbit strength drastically decreases while its impact on nuclear surface properties depends only slightly on asymmetry. The isospin dependence of the relativistic spin-orbit force is negligible.

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Groundstate and Thermonuclear Properties of Finite Nuclei in the Relativistic Semiclassical Approach

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The Wigner-Kirkwood semiclassical expansion of the relativistic nuclear Hartree–Fock theory is utilized to derive self–consistent relativistic extensions of the Thomas–Fermi approach, which are used to describe ground–state and thermostatic properties of nuclear systems [1–3].

Semiclassical expansions for Green function, self–energy, phase–space density and density are given and discussed [2,3]. The many–body problem is treated in the relativistic Hartree–Fock approximation with a Lagrangian with a standard one–boson–exchange potential structure including the possibility of space–dependent couplings [4]. The expansions are obtained by formulating the many–body problem in the mixed position–momentum (Wigner) representation and application of the Wigner–Kirkwood $\hbar$–expansion scheme.

The resulting self–consistency problems for the first three orders are formulated and the self–consistent relativistic extended Thomas–Fermi and extended Thomas–Fermi–Fock approaches are derived and used to describe the ground–state properties of finite nuclei. The resulting equations are solved numerically for several one–boson–exchange Lagrangians and the results are discussed and compared with the outcome of full quantal Hartree and Hartree–Fock calculations, other semiclassical treatments, and experimental data [5–7].

The relativistic density–dependent Hartree approach is adjusted to the outcome of the relativistic Brueckner–Hartree–Fock nuclear matter treatments with realistic one–boson–exchange Lagrangians and the density–dependent coupling constants are then used in the frame of the relativistic extended Thomas–Fermi approximation to determine the properties of finite nuclei. The results of this parameter–free treatment are studied for different one–boson–exchange potentials and compared with experiment [4].

The Wigner–Kirkwood semiclassical expansion is then generalized for finite temperatures by utilizing the spectral representation of the Green function for non–zero temperatures. The expansion is described in detail up to second order and the thermostatic properties of nuclear systems are discussed in the same order [7]. For finite nuclear systems static Hartree–Fock calculations at finite temperature describe a hot nucleus in equilibrium with an external vapour. A subtraction scheme is needed to extract the properties of the hot nucleus from those of the system "gas + hot nucleus". In the spectral representation method this is achieved by subtracting the parts of the occupation propabilities, which are related solely to the external gas (vapour phase).

Thermostatic properties and Coulomb instability of highly excited nuclei are discussed and calculated in a relativistic Thomas–Fermi approach using density–dependent coupling constants, and, for the purpose of comparison, density–independent coupling constants [8].

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