Relativistic Calculations of Neutron Star Matter

Ha. Huber, F. Weber, and M. K. Weigel

We have calculated the porperties of neutron star matter in the relativistic Brueckner–Hartree–Fock approximation (RBHF) under the constraints of electric charge neutrality and generalized beta equilibrium. This treatment is "parameter–free" in the sense that the OBE potentials are adjusted to the two–nucleon data. For the OBE potentials we use the modern Brockmann–Machleidt potentials. Furthermore we tested the possibility to parametrize the outcome of these microscopic calculations in the framework of the relativistic Hartree–Fock theory (RHF). We emphasize that all former parametrizations of the EOS restricted themselves to reproducing the properties of symmetric nuclear matter only. The complicated extension to asymmetric nuclear matter, which obeys the additional constraints of electric charge neutrality and generalized beta equilibrium, was an open problem.

From our results it follows that the fits of asymmetric matter with fixed asymmetry are very good. Also the outcome of RBHF calculations of electrically charge neutral matter in generalized beta equilibrium (i.e. neutron star matter) is reproduced in the RHF scheme with sufficient accuracy. The origin of the remaining deviations is difficult to locate. They may be caused by the more complex OBE Lagrangian of the RBHF treatment in comparison with the RHF Lagrangian and/or the different energy dependence of the self–energies in both approximations.

References

[1] H. Huber, F. Weber, and M. K. Weigel, "Relativistic Calculations of Neutron Star Matter", June 1995, to appear in Nucl. Phys. **A**

Determination of the Relativistic Optical Potential

J. Ramschütz and M. K. Weigel

The topic of this work [1,2] is the investigation of optical potentials, which describe the elastic nucleon–nucleus–scattering, in the framework of the relativistic scattering theory. For the determination of the optical potential the atomic nucleus is described in local density approximation (LDA), with the density taken from empirical density distributions.

The properties of nuclear matter in LDA are determined in the framework of the relativistic quantum field theory for hadrons via quantumhadrodynamics (QHD), where the relativistic Hartree– and Hartree–Fock approximation are used. In this model the dynamics of the system are governed by a relativistic Lagrangian, which describes the nucleon–nucleon–interaction by the exchange of virtual mesons. The Lagrangian contains the fields of the free nucleons and mesons and the couplings between nucleons and mesons (σ-, ω-, ρ- and π-mesons). Because Hartree– and Hartree–Fock theory are phenomenological theories, the coupling constants and partly the meson masses must be fitted to the semi–empirical results for nuclear matter.

A detailed consideration of different Lagrangians, which is for example caused by the fact, that the semi–empirical nuclear matter parameters (incompressibility, saturation density etc.) can only be determined within certain bandwidths, shows, that the energy dependence is too weak, if one uses the relativistic Hartree–Fock approximation; good agreement with empirical results is only possible within certain energy windows. For comparison also results obtained by using the Hartree approximation, where the self–energy is not energy–dependent, are presented.

References

[1] J. Ramschütz, "Bestimmung des Optischen Potentials in der Quantenhadrodynamik", Ph.D. thesis, LMU München, 1995
[2] J. Ramschütz, M. K. Weigel, J. Phys. **G20** (1994) 1633