$^3D_2$ Pairing in Asymmetric Nuclear Matter

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The superfluid $^3D_2$ pairing instability in isospin–asymmetric nuclear matter is studied, using the Paris nucleon–nucleon interaction as an input [1]. It is found that the critical temperature associated with the transition to the superfluid phase becomes strongly suppressed with increasing isospin asymmetry, and vanishes for asymmetry parameter values α $(\equiv (n_n - n_p)/(n_n + n_p))$ that are larger than several percent. It is shown that for neutron star models based on relativistic, field–theoretical equations of state, a large fraction of their interior may exist in a $^3D_2$–paired superfluid phase. The implications of such a $^3D_2$ superfluid in massive neutron stars is discussed with respect to observable pulsar phenomena. Another interesting phenomenon, discussed in the paper, concerns the numerical finding of two critical superfluid temperatures for a given density in the case of isospin–asymmetric matter. Using the BCS cut–off ansatz, a mathematical expression for the critical temperature is derived which confirms this finding analytically.

References

[1] Th. Alm, G. Röpke, A. Sedrakian, and F. Weber, "^{3}D$_2$ Pairing in Asymmetric Nuclear Matter", (preprint, September 1995), submitted for publication

Neutron Matter Calculations Performed for the Paris Nucleon-Nucleon Potential

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The rapid discovery pace of newly observed pulsars, which are interpreted as rotating neutron stars, has renewed considerable interest in the properties of neutron star matter (electrically charge neutral many-baryon matter in chemical equilibrium). The properties of such matter have been studied by numerous authors in the framework of non-relativistic Schroedinger theory as well as, in recent years, relativistic field-theoretical treatments.

In a first approximation, neutron star matter can be treated as consisting of only neutrons. The equation of state of neutron matter is considerably easier to determine. Naturally, it is of great relevance to explore to which extent different, competing many-body techniques as well as the model adopted for the nucleon-nucleon interaction influence the (theoretically determined) properties of neutron matter and the equation of state associated with it. This aspect will be investigated in this article.

The many-body technique employed here is the simplest version of the so-called ladder (Brueckner-Hartree-Fock type) approximation of the Green's function theory, the so-called Λ^{00} approximation. As demonstrated elsewhere, this approximation constitutes a many-body method which is capable of describing the properties of nuclear matter properly. One of the best non-relativistic nucleon-nucleon interactions presently available is the Paris potential. It includes the one-pion exchange, correlated and uncorrelated two-pion exchange, and ω–meson contributions, which give a fairly realistic description of the long and medium range part of the nucleon-nucleon force. The short-range repulsion is described phenomenologically by a soft-core.

The Paris potential is used here, together with – for the purpose of comparison – the phenomenological Reid soft-core potential, as an input to determine the properties of neutron matter [1]. The parameters of these potentials are adjusted to the free nucleon-nucleon scattering problem and the properties of the deuteron. Hence, at the level of the Λ^{00} approximation one is left with a parameter-free determination of the properties of neutron matter. The resulting equations of state are compared with those obtained from variational calculations and a recent Thomas-Fermi calculation.

References

[1] A. Kronawitter, F. Weber, and M. K. Weigel, "Neutron Matter Calculations with the Paris Nucleon-Nucleon Interaction", August 1995, (submitted for publication)