(1) \[
\left( 1 - \frac{d V}{d \theta} \gamma - \frac{d \theta}{d \gamma} \frac{d V}{d \gamma} \right) \frac{d}{dx} = \frac{d}{d \theta} \frac{d V}{d \theta} + \frac{d}{d \gamma} \frac{d V}{d \gamma}
\]
(2) \[
\left( 1 - \frac{d V}{d \theta} \gamma + \frac{d \theta}{d \gamma} \frac{d V}{d \gamma} \right) \frac{d}{dx} = \frac{d}{d \theta} \frac{d V}{d \theta} - \frac{d}{d \gamma} \frac{d V}{d \gamma}
\]

\text{The results are presented in Figs. 1 to 3 for several different cases.}

\text{Parameterized by}

\text{Landau parameters of nuclear matter in the spin and spin-isospin channels}
where $N(0)$ is the level density at the Fermi surface. In Fig. 2 the two Landau parameters are plotted as a function of the density based on Eqs. (3) and (4). The Landau parameter $G'_0$ is the strength of the spin-isospin component $V_{\alpha\alpha} = G'_0 (\sigma_1 \cdot \sigma_2) / (\tau_1 \cdot \tau_2)$ of the residual interaction [1], which governs the Gamow-Teller (GT) giant resonance in nuclei [3]. Its value at the saturation point has been determined with high precision from the experimental excitation energy of the GT resonance on $^{58}$Ni [4]. The value reported is $1.182 < G'_0 < 1.188$ (we have multiply by a factor two according to the definition we adopted). More recent fit on $^{112}$Sn and $^{208}$Pb within a RPA calculation with Skyrme forces confirm such a prediction [5].

Our nuclear-matter prediction of $G'_0$ at the saturation density, which is about 1.22 including 3BF is in a pretty good agreement with the previous values. The value without 3BF of about 1.30 is in less agreement. Since the behaviour of $G'_0$ around the saturation point is very flat, there is no room for large uncertainties in the comparison. Such an agreement provides a support to the important role played by the microscopic 3BF as to reproducing all saturation properties of nuclear matter. Other predictions of $G'_0$ including 3BF are from phenomenological Skyrme forces, which unfortunately are scattered in wide range of values lower than the experimental one [6].

So far experimental information on $G'_0$ is not enough since spin resonances have only been observed with too small strength compared to other collective modes [7].

The prediction of $G_0$ and $G'_0$ for densities other than the nuclear density, which is reported in Fig. 2, is of great interest in the study of neutron stars. In connection with the strong magnetic fields observed in neutron stars some authors [8, 9, 10] studied the magnetic susceptibility $\chi$ in neutron matter and found that $G_0$ reduces the $\chi$ of degenerate neutron gas. This reduction is amplified at high density when including 3BF either in Brueckner calculations [11] and in Montecarlo many-body simulations [12].

Spin and spin-isospin excitations of nuclear matter are coupled to the weak interaction governing the neutrino emission of URCA processes as well as the neutrino transport in neutron stars. The high-density increase of $G_0$ and $G'_0$, driven by the 3BF, is expected to have important implications for the neutron star cooling because of the sizeable enhancement induced by the nuclear correlations on the neutrino mean free path [13].

In conclusion, in this note we reported on a BHF calculation of the Landau parameters $G_0$ and $G'_0$ as a function of baryonic density. The main scope was to point out the large effect of 3BF, especially at high densities. At the 2BF level, there is a wide disagreement with previous Brueckner calculations (see Ref. [14] and Refs. therein quoted) that has not yet clearly explained, since one can hardly control and compare the different approximations. On the other hand, our prediction for $G'_0$ has been found to be in very good agreement with the experimental value extracted from GT resonance when 3BF is included. The relevance of the spin Landau parameter for neutron stars has been also discussed in connection with magnetic susceptibility and neutrino mean free path.

This work is supported in part by the Chinese Academy of Science within the One Hundred Person Project and the NNSF of China under the contract Nos 10075078, 19935030 and 10047001.

References:


