A ferromagnetic phase of quark matter with color superconductivity

E.Nakano[a], T.Maruyama[b] and T.Tatsumi[c]

[a] *Department of Physics, Tokyo Metropolitan University, Hachioji, Tokyo 192-0397, Japan*

[b] *College of Bioresouce Sciences, Nihon University, Fujisawa, 252-8510, Japan*

[c] *Department of Physics, Kyoto University, Kyoto 606-8502, Japan*

We invetigate a coexistent phase of ferromagnetism with color superconductivity in high density quark matter with the mean-field approach based on the Hartree-Fock coupled with superconducting gap functions. Previosly one of the authors (T.T.) has shown that the one-gluon exchange force makes a spin-polarization in the quark matter with the pertubative calculation [1]. More details for the spin-polarization has been furthemore discussed in Ref. [2]. From that the axial vector interaction channel is known to be plays a role to cause a spin-polarization though there are has several channels such as scalar, vector and so on in the mean-field derived from the Hartree Fock calculation.

In this work we focus on the spin-polarization mechanism throgh the axial vector interaction channel. Along this purpose we introduce the zero-range approximation, and obtain the following the spin-dependent interaction energy as

$$\epsilon_{SD} = \frac{1}{2} G N_b^2 < \sigma_z/N >^2 \tag{1}$$

where N_b is the baryon density. The coupling G is obtained by the Fiertz transformation from original interactions. In the actual calculation the superconducting state is solved with the Hartree-Fock coupled with the gap equation using the above interaction. Please note that the s-wave coupling is avialable for the spin-aligned quark pair.

In Fig. 1 we show the expectation value of the quark spin as a density dependent function. We have found that a spin-polarized phase cooperatively exists with the superconductivity, and that the superconductivity largely enhances the spin-polarization.

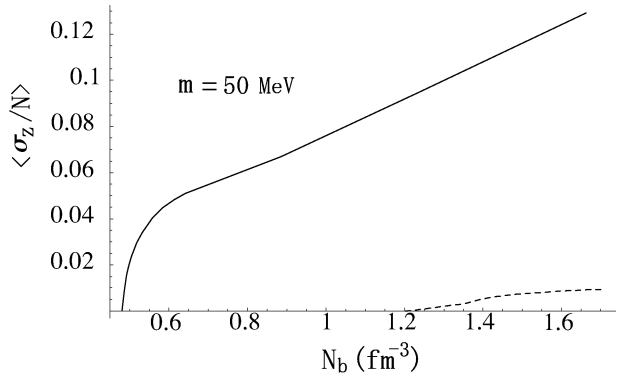

Figure 1: Spin expectation values as a function of baryon density N_b, solid line and dashed line for the superconductivity and normal states, repectively.

[1] T. Tatsumi, Phys. Lett., B489 (2000) 280.

[2] T. Maruyama, T. Tatsumi, Nucl. Phys., A693 (2001) 710.