Structural Change of Cooper Pairs and Momentum-dependent Gap in Color Superconductivity

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The two-flavor color superconductivity is studied over a wide range of baryon density with a single model[1]. We pay a special attention to the *spatial*-momentum dependence of the gap and to the *spatial*-structure of Cooper pairs. At extremely high baryon density ($\sim \mathcal{O}(10^{10}\rho_0)$ with ρ_0 being the normal nuclear matter density), our model becomes equivalent to the usual perturbative QCD treatment[2,3] and the gap is shown to have a sharp peak near the Fermi surface due to the weak-coupling nature of QCD. On the other hand, the gap is a smooth function of the momentum at lower densities ($\sim \mathcal{O}(10\rho_0)$) due to strong color magnetic and electric interactions. To study the structural change of Cooper pairs from high density to lower density, quark correlation in the color superconductor is studied both in the momentum space and in the coordinate space. The gap at the Fermi surface shows the behaviour expected by the weak-coupling analytical solution in extremely high density region.[Figure 1:(a)] The size of the Cooper pair is shown to become comparable to the averaged inter-quark distance at low densities.[Figure 1:(b)] Also, effects of the momentum-dependent running coupling and the antiquark pairing, which are both small at high density, are shown to be non-negligible at low densities. These features are highly contrasted to the standard BCS superconductivity in metals.

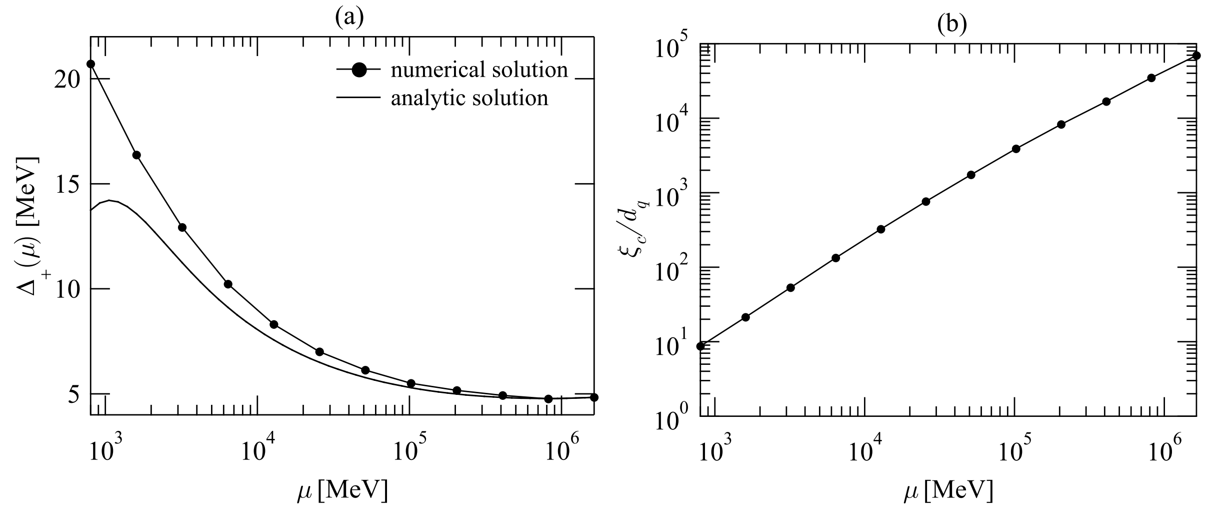

Figure 1: (a) Chemical potential dependence of the gap $\Delta_+(k = \mu)$ in the full calculation compared with the analytic result which is normalized at the highest density $\mu = 2^{12}\Lambda(\Lambda = 400\text{MeV})$. (b) Ratio of the coherence length ξ_c and the average inter quark distance d_q as a function of the chemical potential.

References

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