Vacuum condensates, baryons and chiral symmetry in clustered hadronic matter

G. Krein, R. Marques de Carvalho and P.K. Panda

Instituto de Física Teórica, Universidade Estadual Paulista, Rua Pamplona 145, 01405-900 São Paulo, SP - Brazil

Chiral symmetry restoration at finite baryon density is usually discussed in the context of quark matter, i.e. a system of deconfined quarks. For many systems like stable nuclei and neutron stars, quarks are confined within nucleons and it would be interesting to investigate the effects of baryon density on chiral symmetry in such systems. Here we consider a high density system of nucleons, in which quarks are confined within clusters of three quarks. For the dynamics of the system we consider a QCD Coulomb gauge model Hamiltonian which includes confinement and asymptotic freedom. The vacuum is constructed as a condensate of quark-antiquark pairs. The vacuum gap equation for the condensate function is obtained minimizing the vacuum expectation value of the Hamiltonian [1]. The Coulomb-type potential gives rise to ultraviolate divergences which are nonperturbatively renormalized by adding appropriate counterterms to the Hamiltonian [2]. Nucleons are obtained as three quarks bound states using a variational calculation [3]. The energy density of the system of nucleons is obtained in the Hartree-Fock approximation and the gap equation for the in-medium condensate function is obtained by minimizing the Hartree-Fock energy density. This gives rise to an intricate self-consistent problem since the nucleon states used to construct the many-nucleon system depend on the condensate function. Numerical results are presented for the equation of state of nucleon matter and the density dependence of the quark condensate. The results are compared with traditional quark-matter calculations within this class of model [4].

References

[1] A. Amer, A. Le Yaouanc, L. Oliver, O. Pene and J.C. Raynal, Phys. Rev. Lett. **50** (1983) 87; Phys. Rev. D **28** (1983) 1530; P.J.A Bicudo and J.E. Ribeiro, Phys. Rev. D **42** (1990) 1611, 1625, 1635.

[2] S.L. Adler and A.C. Davis, Nucl. Phys. B **244** (1984) 469; R. Alkofer and P. A. Amundsen, Nucl. Phys. B **306** (1988) 305.

[3] P.J.A Bicudo, G. Krein, and J.E.F.T. Ribeiro, Phys. Rev. C **64** (2001) 025202; Phys. Rev D **45** (1992) 1673.

[4] A. Kocić, Phys. Rev. D **33** (1986) 1785.