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Protoquark stars: stability windows and magnetic field effects

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The influence of strong magnetic fields on the QCD phase diagram covering the whole $T - \mu$ plane was investigated with the Nambu–Jona-Lasinio model [1]. It was shown that the first order segment of the transition line becomes longer as the field strength increases so that a larger coexistence region for hadronic and quark matter should be expected for strong magnetic fields. The location of the critical end point is also affected by the presence of magnetic fields which invariably increase the temperature value at which the first order line terminates. At low temperatures, the critical chemical potential displays an oscillation around the $B = 0$ value for magnetic fields within the $10^{17} - 10^{20}$ G range. These findings have non trivial consequences for the physics of magnetars.

Hence, we have calculated stability windows [2] at finite temperature for different models that are generally applied to describe quark stars: the MIT bag model and the Nambu-Jona-Lasinio model[3]. The quantity that has to be investigated in the search for stable strange matter at finite temperature is the free energy per baryon and we analyze stability windows up to temperatures of the order of 40 MeV. The effects of strong magnetic fields on the stability windows are then computed.

Next, we have chosen the MIT bag model and analyzed different stages of magnetized quark star evolution incorporating baryon number conservation and an anisotropic energy momentum tensor [4]. The first stages of the evolution are simulated through the inclusion of trapped neutrinos and fixed entropy per particle, while in the last stage the star is taken to be deleptonized and cold. We find that, although strong magnetic fields allow for more massive quark stars, the evolution of isolated stars needs to be constrained by fixed baryon number, which lowers the star masses. Moreover, magnetic field effects, measured by the difference between the parallel and perpendicular pressures, are more pronounced in the beginning of the star evolution when there is a larger number of charged leptons and up quarks. Within the model employed, large magnetic fields appear only at high densities, where the longitudinal matter pressure is large enough to partially compensate for the negative magnetic field longitudinal pressure.

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