HYBRID QUARK STARS WITH STRONG MAGNETIC FIELD

Toshitaka Tatsumi[1], Hajime Sotani[2]
[1] Department of Physics, Kyoto University, Kyoto 606-8502, Japan
[2] Division of Theoretical Astronomy, National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

Discovery of huge magnetic field in magnetars has stimulated a renewed interest about the magnetic field and physics of compact stars, where microphysics such as QED or QCD may play active parts. Here we discuss the equation of state (EOS) of quark matter in the core of compact stars by taking into account the strong magnetic field. We show that quark EOS becomes very stiff in the presence of the strong magnetic field, and becomes stiffest under the causality condition beyond the threshold strength of $B_c \sim O(10^{19})$ G. This is because quarks make the Landau levels with the level spacing of $\Delta E^2 \sim 2eB$ in the presence of the magnetic field and thereby only several Landau levels are occupied for the strong magnetic field; only the lowest Landau level is occupied in the extreme case beyond B_c. Thus quarks can freely move along the magnetic field with localization in the perpendicular plane, which resembles the quasi-one dimensional systems and gives rise to a stiff EOS. Assuming the density dependence of the magnetic field inside stars, we figure out some interesting features of the effects of the magnetic field: it may easily produce high-mass stars beyond two solar mass.

As another interesting possibility, we discuss the appearance of the third family of compact stars, succeeding white dwarfs and neutron stars, before collapsing into black holes. We demonstrate an example, which is specified by a discontinuous increase of the adiabatic index at the hadron-quark phase transition. Such new family may affect the supernova explosions or the gravitational wave emitted from the neutron star mergers.