Quark Matter in Compact Stars

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Pulsars are interpreted as rapidly rotating neutron stars. They contain matter in one of the densest forms we know of (up to 10^9 tons per cm^3). Because of the tremendous densities in the cores of neutron stars, the nuclear boundaries of neutrons, protons plus other constitutes in the centers of neutron stars may dissolve into their constituent quarks, creating the novel state of ultra-dense matter known as quark matter. In the first part of this presentation it will be shown that the existence of such matter in neutron stars could lead to a dramatic, observable anomaly in the timing structure of isolated pulsars [1]. This analysis has been extended to the spin evolution of neutron stars in binary systems (X-ray pulsars), which are being spun up by mass transfer from accretion disks. It is found that quark deconfinement in such pulsars, induced by the changing spin period, can lead to a dramatic saturation in the pulsar's spin frequency [2]. This finding provides a possible explanation for the anomalous spin frequency distribution of neutron stars in low-mass X-ray binaries, which all lie in a rather narrow band. In the second part of this presentation I shall discusses several striking astrophysical implications of the strange-matter hypothesis, according to which 3-flavor strange quark matter may constitute the absolute ground state of the strong interactions (instead of ^{56}Fe). If true, then almost certainly pulsars are compact strange stars. Such objects may have very strong electrostatic dipole layers on their surfaces that can support, out of contact, ordinary matter up to the neutron drip density. This give rise to the possible existence of new types of stars, which range from compact ones, analogous to neutron stars, to white dwarfs-like objects, to planetary-like configurations [3]. The properties of such objects will be discussed.

References

[1] N. K. Glendenning, S. Pei, and F. Weber, "Signal of Quark Deconfinement in the Timing Structure of Pulsar Spin-Down", Phys. Rev. Lett. **79** (1997) 1603.
[2] N. K. Glendenning and F. Weber, "Phase Transition and Spin Clustering of Neutron Stars in X-ray Binaries", Astrophysical J. **559** (2001) L119.
[3] G. J. Mathews, B. O'Gorman, , I.-S. Suh, and F. Weber, "Evidence for White Dwarfs with Strange-Matter Cores" (to be submitted for publication).