PROTON LOCALIZATION AND MAGNETIC FIELD EVOLUTION IN DENSE NEUTRON STAR MATTER

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Abstract

Localized protons induce a ferromagnetic instability in the form of spin ordering. The magnetized phase in the core of neutron star generates a strong magnetic field. The density-dependent effective proton magnetic moment and magnetization change sign at some density. We discuss here the model of ferromagnetic origin of magnetic fields of neutron stars. The magnetic phase transition occurs soon after formation of the neutron star and the core magnetic field is fully screened at the beginning.

Assumptions and results

⇒ Ferromagnetic instability of neutron matter with localized protons: $M = \mu_N\,\delta s_N + \mu_P\,\delta s_P = \left[-\mu_N g^{pn} N_N/(1+G_0^{NN}) + \mu_P\right] n_P$

⇒ Model of localization of protons in neutron star matter (n.s.m.)

- protons as impurities in n.s.m. of a few percent abundance (Fig. 1)
- nuclear symmetry energy for many interactions (Fig. 2) induces localization of protons
- neutron background forms a potential well with neutron density distribution given by equation

$$\frac{d\mu_P\left(n_N\left(r\right)\right)}{dn_N\left(r\right)}\Psi_P^*\left(r\right)\Psi_P\left(r\right)+\mu_N\left(n_N\left(r\right)\right)+2B_N\frac{d^2n_N\left(r\right)}{dr^2}-\mu_N=0,$$

where $\mu_N\left(n_N\left(r\right)\right)=\frac{d\varepsilon(n_N(r))}{dn_N(r)}$. At Fig. 3 we show the proton probability distribution and induced neutron background shape

- the ferromagnetic shell for neutron stars with various central densities is shown at Fig. 4
- magnetic field as a function of mass for some equations of state. Particularly good agreement is for AV14+UVII EOS (Fig. 6)

Figures

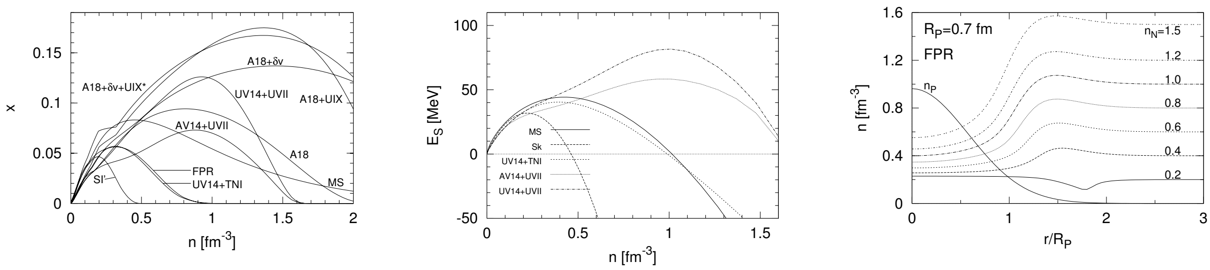

Fig. 1, 2 and 3. Proton fraction, the symmetry energy and neutron background density.

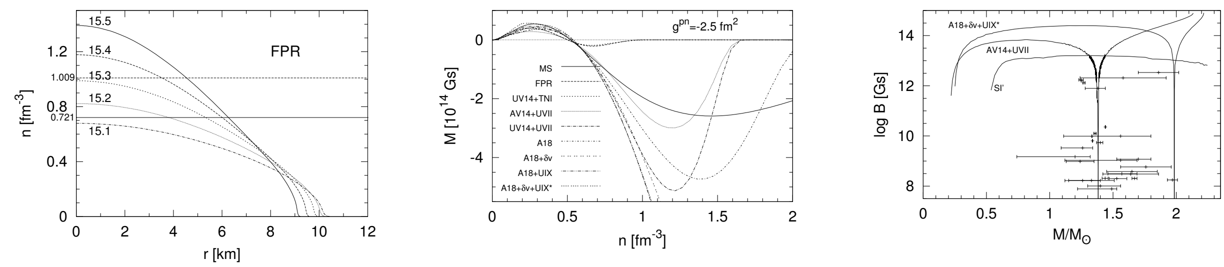

Fig. 4, 5 and 6. Baryon number density, the magnetization of nuclear matter and magnetic fields.

Conclusions

Ferromagnetic model seems to agree with data on magnetic fields and masses of pulsars.

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