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A review of new data on compact stars from a Magnetar model of magnetised cores*

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Abstract. We have used the Magnetar model to identify some stars, in a sampling of a few high magnetic field pulsars, as magnetars. Thus this model throws up a lot of unexplored physics from the strongly interacting core to the plasma physics and the crustal solid state physics of huge magnetic fields.

Our understanding of neutron stars is at a crossroad. We have to understand many families of neutron stars, for example pulsars and magnetars, in one framework. This is what we have tried to do in this work.

Neutron stars are also the laboratory to understand the high density phase diagram for strong interactions. This work gives us a new understanding of the strong interactions that is linked intimately to astrophysical data.

Our Model Conclusions

In conclusion we enumerate some of the consequences of the model presented above:

i) Magnetars belong exclusively to the higher than pulsar mass population of neutron stars that are born with a high density magnetic core.

ii) The high density core is created by a strong interaction phase transition that aligns magnetic moments to create large dynamical $10^{16(17)}$ G magnetic fields at the surface of the core. Dynamical fields are 'permanent' unlike fields derived from currents.

iii) The core field is shielded by Lenz currents generated in the high conductivity plasma in and around it, but is gradually transported to the crust by ambipolar diffusion over a timescale of $\simeq 10^{5-6}$ years with interior temperatures of more than $\simeq 10^{8.5}$ K, - this results in a time delay before the field comes out to the surface. In old spun up binary neutron stars created by slow accretion (for example the large mass (almost 2 solar mass) binary neutron star, PSR J1614-2230), the lower interior temperatures inhibit transport of the core field to the crust.

iv) The strong magnetic field breaks through the crust as the shielding currents dissipate giving out a steady X-ray flux and several energetic flares.

v) This further implies that the surface field keeps increasing in magnitude till all shielding currents dissipate and the permanent dipolar core field is established.

* Talk delivered by V. Soni

vi) Neutron stars are also the laboratory to understand the high density phase diagram for strong interactions. The existence of the large mass (almost 2 solar mass) binary neutron star, PSR J1614-2230, very probably rules out soft equations of state, associated with quark matter (with/without condensate) cores.

We have found that all these phenomena are supported by extensive data and observations.

References

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