Probing the QCD Phase Diagram with neutrino astrophysics

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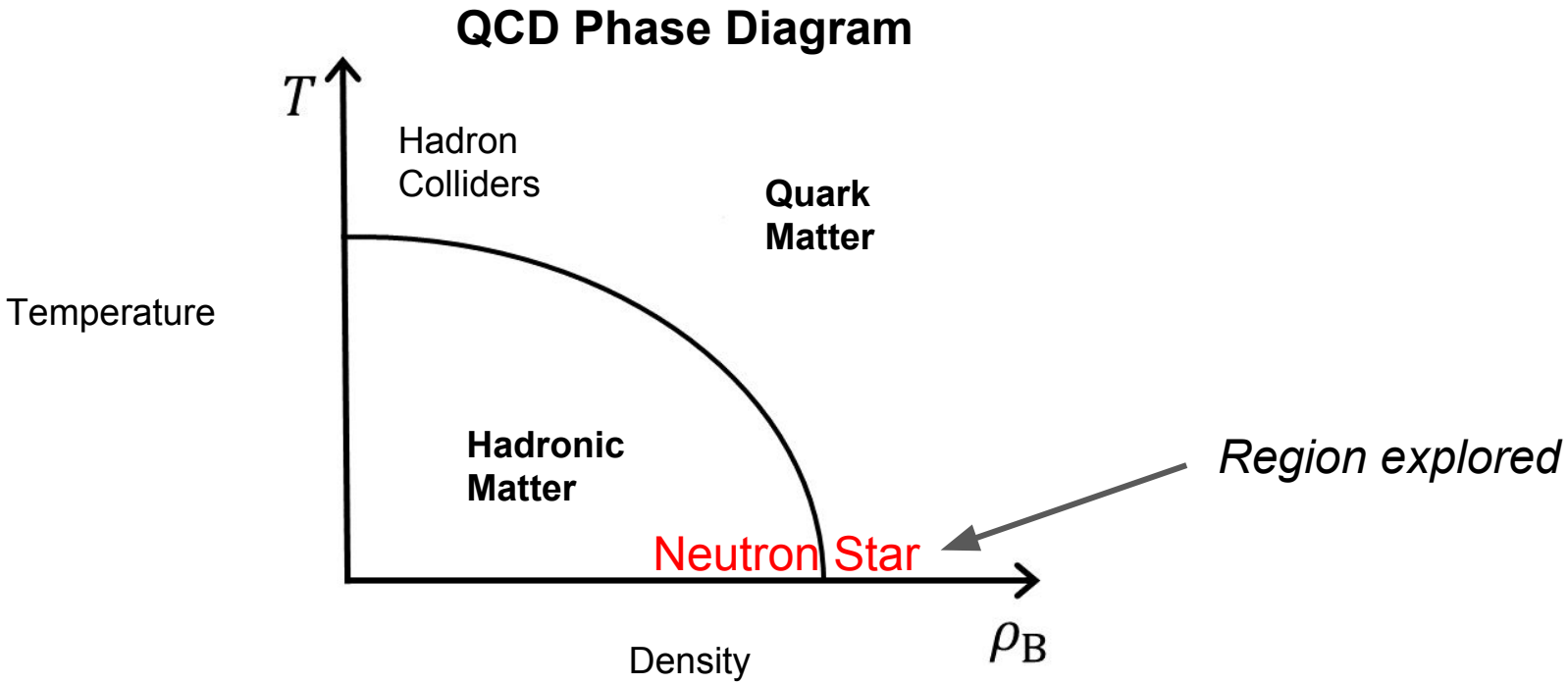
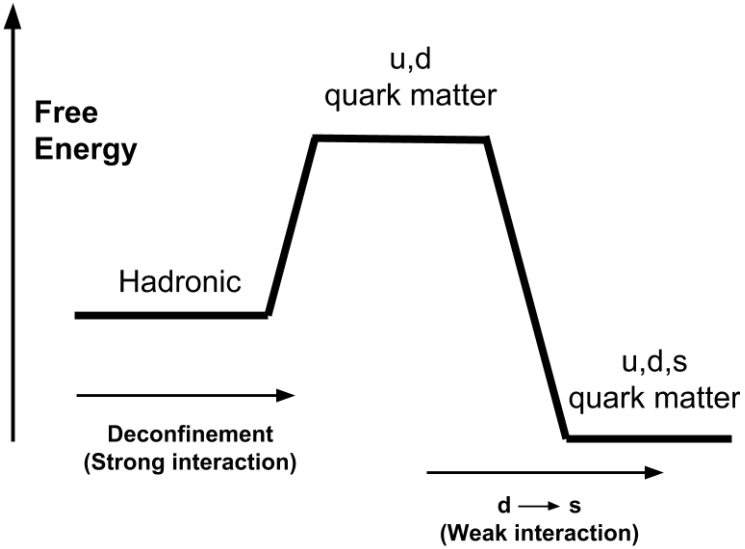
Presentation Outline

- **QCD Phase Diagram**
- **Hadron-quark phase transition**
- **Birth of a quark star (quark nova)**
- **Results and Observational signatures**
- **Conclusion**

Neutrinos could signal the onset of a **hadron-quark phase transition.**

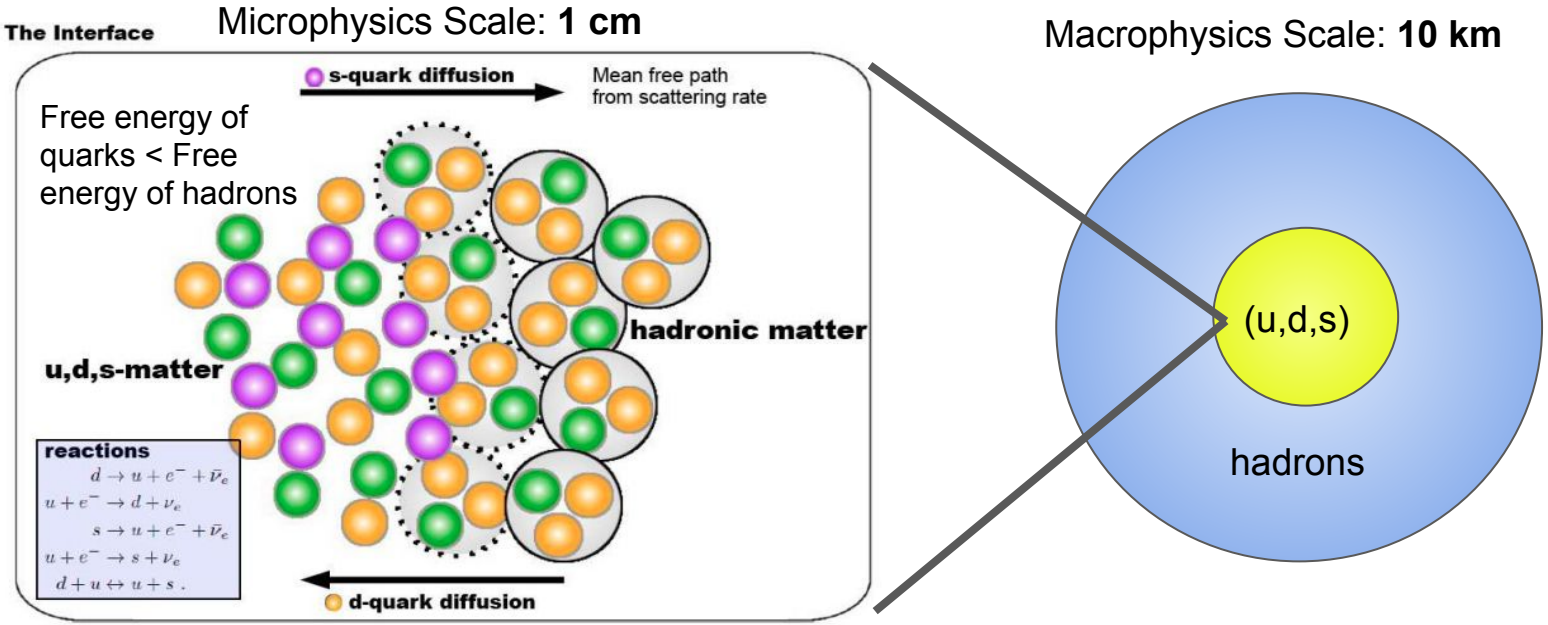


The hypothesis of stable quark matter can lead to ~100 MeV per hadron converted to u,d,s matter!



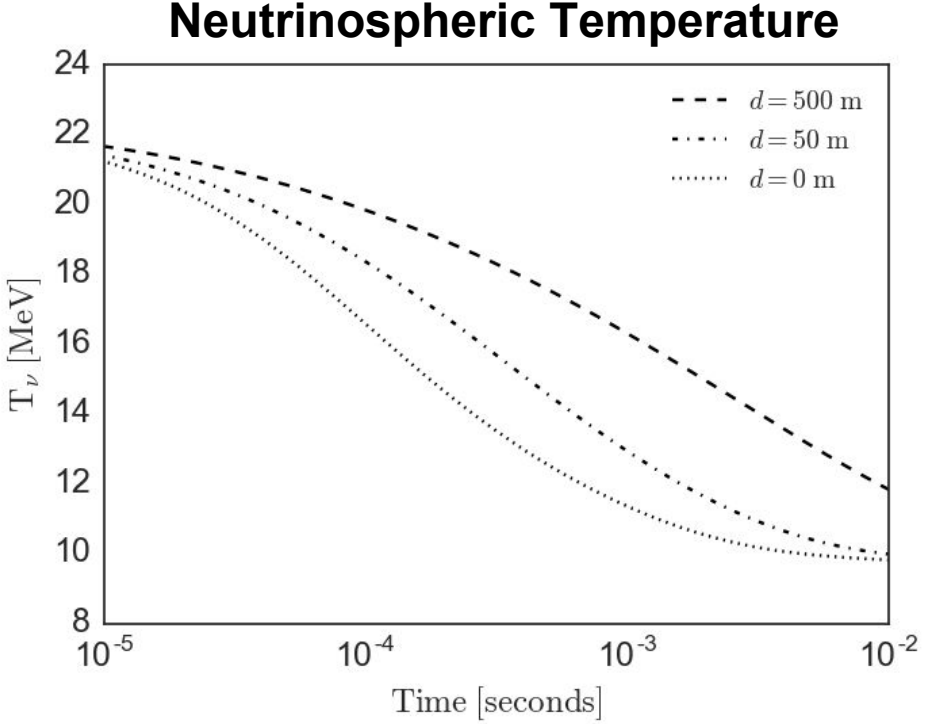
10^{57} baryons and 100 MeV per baryon leads to 10^{53} erg in energy!

How do neutrinos behave across scales (**Micro** and **Macro**)?



How does a nascent quark star look?

Results: Harder neutrino spectrum from PQS vs PNS



$$T_{\nu,\mathrm{PNS}} \propto 5 \text{ MeV}$$

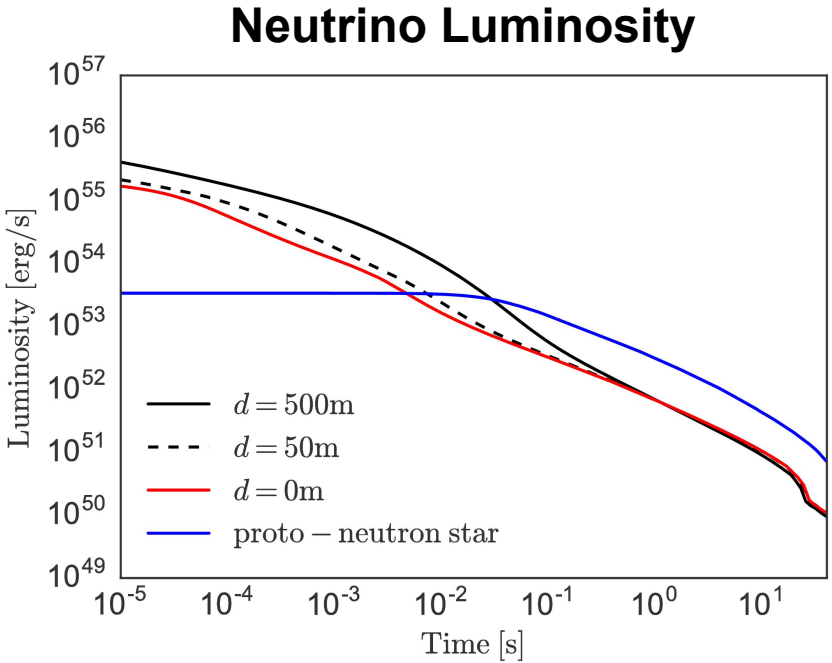
$$T_{\nu,\mathrm{PQS}} \propto 20 \text{ MeV}$$

$$L \propto T_\nu^4$$

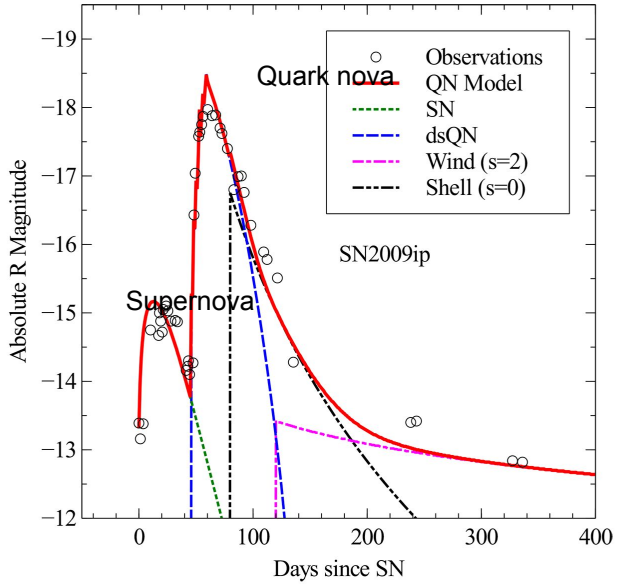
$$\frac{L_{PQS}}{L_{PNS}} \propto 4^4 \propto 10^2$$

Peak neutrino luminosity is >10^{55}erg/s. Neutrino luminosity is so high that 10^{52}erg of neutrino energy is deposited in the matter above the neutrinosphere.

Outer layers of NS ejected with 10^{52}erg (10 times supernova) in kinetic energy. ***Peak detector counts of PQS is 1000 times PNS.***



Nascent quark star leads to a second hump in the light cuve (quark-nova)



Neutrinos of T~20 MeV coupled with superluminous light curve becomes a signature for quark nova!

Conclusion

- Neutrino astrophysics can be used to probe the QCD Phase Diagram.
- According to some models, the conversion of a neutron star to a quark star can release 10^{53}erg in neutrinos.
- Simulations show that a nascent quark star would have a much harder neutrino spectrum that for proto neutron stars.
- Neutrinos induced mass ejection can lead to a superluminous light curve.
- Hard (T ~ 20 MeV) spectrum coupled with a double humped superluminous light curve is a signal for a hadron-quark phase transition.

Dr. Moazzen-Ahmadi, Dr. Ouyed, Dr. Knudsen,
Dr. Langill, Dr. Shi, and Dr. Weber...

THANK YOU

for your presence today!