IWARA
From Quarks to Cosmos

IWARA2020, September 6 -12, 2020

THE ROLE OF QUARK MATTER SURFACE TENSION IN DENSE COMPACT STAR MATTER

A. G. GRUNFELD (CONICET, CNEA, ARGENTINA) AND G. LUGONES (UFABC, BRAZIL)

ag.grunfeld@gmail.com

german.lugones@ufabc.edu.br

ABSTRACT

Quark matter surface tension plays a key role in the understanding of neutron star (NS) interiors. We focus on the thermodynamic conditions prevailing in NSs, hot lepton-rich protoneutron stars and binary NS mergers. We explore the role of temperature, baryon number density, trapped neutrinos, droplet size, and magnetic fields within the multiple reflection expansion formalism, assuming that astrophysical quark matter can be described as a mixture of free Fermi gases composed of quarks *u*, *d*, *s*, electrons, and neutrinos, in chemical equilibrium under weak interactions. We discuss some astrophysical consequences of our results

Problem treated - approach

Finite-size effects are extremely relevant for understanding NS physics.

Quark matter surface tension plays (ST) a key role in the understanding of NS interiors.

- A crucial role in quark matter nucleation during the formation of compact stellar objects
- Determinant in the formation of mixed phases at the core of hybrid stars which may arise only if the ST is smaller than a critical value of the order of tens of MeV/fm^2.
- The most external layers of a strange star may have a crust with strangelets if the ST is below few MeV/fm^2.

+ High magnetic fields:

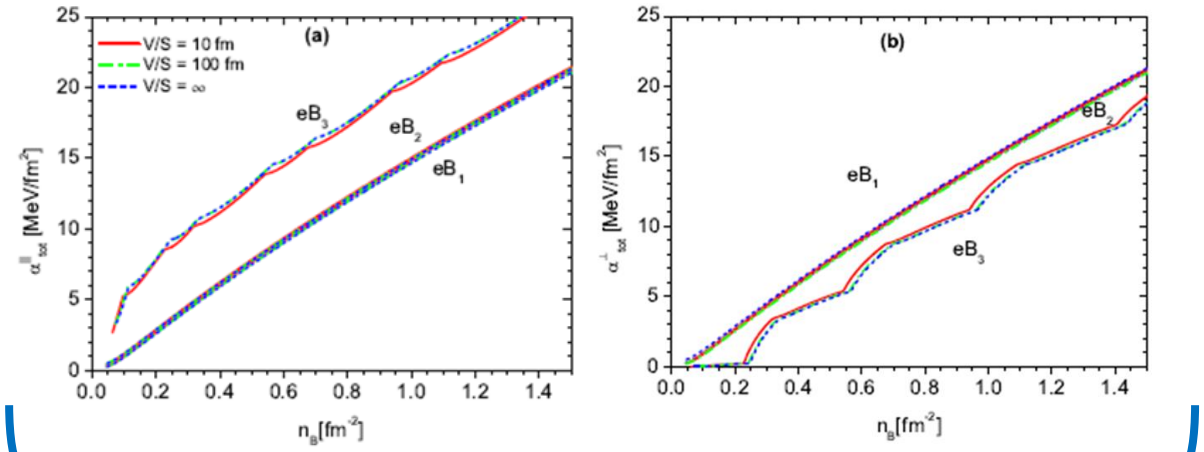
- Magnetars with large magnetic fields in the core, (up to 10^{19} G?). Then, it is interesting to study the behavior of ST of hot/cold, highly magnetized three-flavor quark matter droplets in NS, protoNS (PNS) and binary NS merger (NSM) scenario.

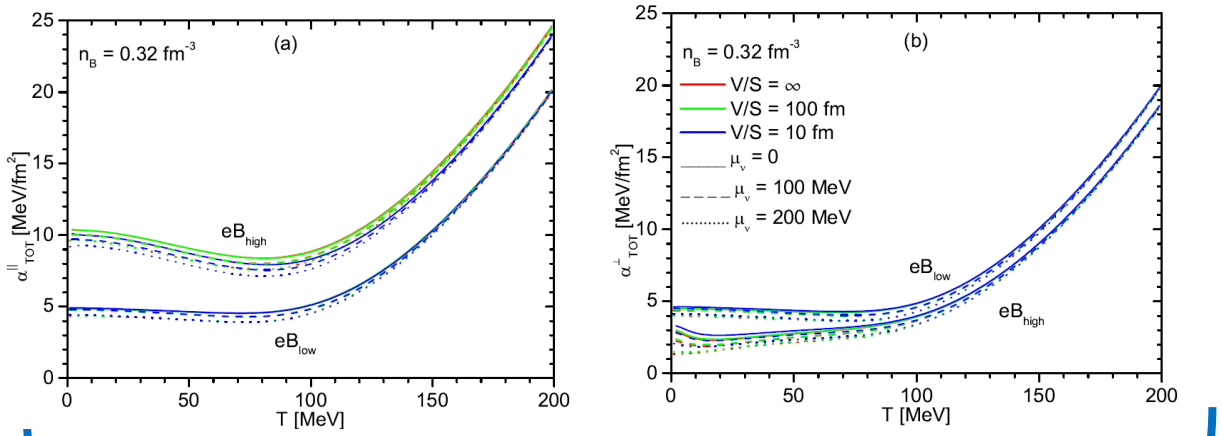
We combine/include in our work:

- Relativistic free gas (Fermi gas) for u, d, s quarks, at finite T and μ + electrons + neutrinos
- Magnetic field effects
- Pressure anisotropy
- Finite size drops of quarks throughout MRE
- Surface tension anisotropy
- Three astrophysical scenarios: PNS, NS, NSM

MRE + Fermi gas u, d, s + B + T + neutrinos
+ electric charge neutrality + chemical equil.
+ β decay

$$\frac{1}{(2\pi)^3}\int \cdots d^3k \longrightarrow \frac{|q_f eB|}{2\pi^2}\sum_{\nu=0}^{\nu_{max}} \alpha_\nu \int_{\Lambda_{f,\nu}}^{\infty} \cdots \rho_{MRE} dk_z$$





T = 0, μ_ν = 0

T, μ_ν

CONCLUSIONS

- For n_B from 2 to 10 n_{sat}, the surface tension α = 2 – 25 MeV/fm^2.
- Hadron-quark interphase in a hybrid magnetar would be a mixed phase
- Strangelet crust would be favored to form in SQM stars
- QM nucleation more prone to occur in lepton rich objects than in cold deleptonized NSs

REFERENCES

G. Lugones, A.G. Grunfeld Phys.Rev. C95 (2017), 015804

G. Lugones, A.G. Grunfeld Phys.Rev. C99 (2019), 035804