Dense matter within RHF approaches

Presented by:

Mohamad CHAMSEDDINE

In collaboration with:

Jérôme MARGUERON, IP2I Lyon (PhD advisor)

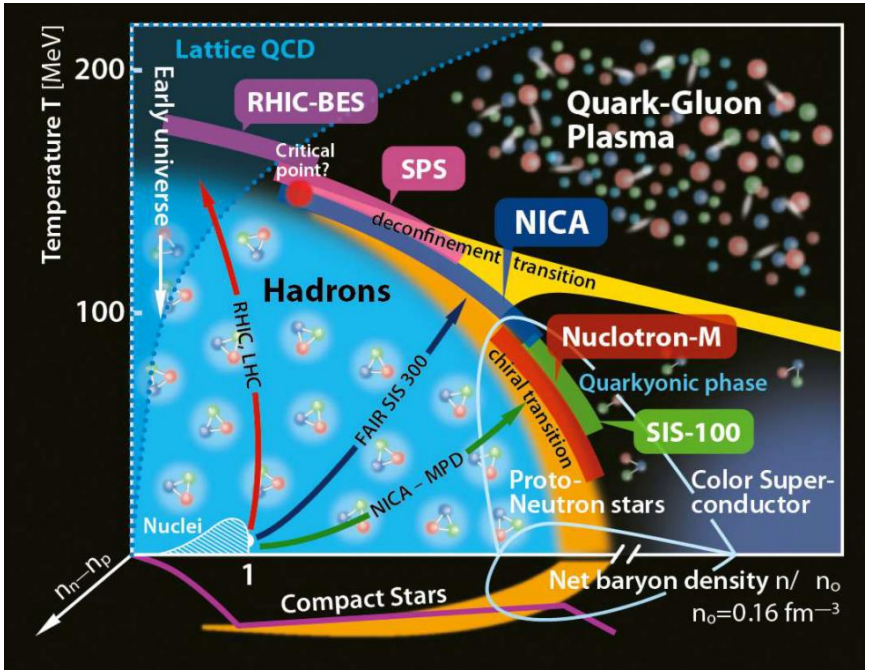
Guy CHANFRAY, IP2I Lyon (co-PhD advisor)

Hubert HANSEN, IP2I Lyon

Rahul Somasundaram, LANL, New Mexico

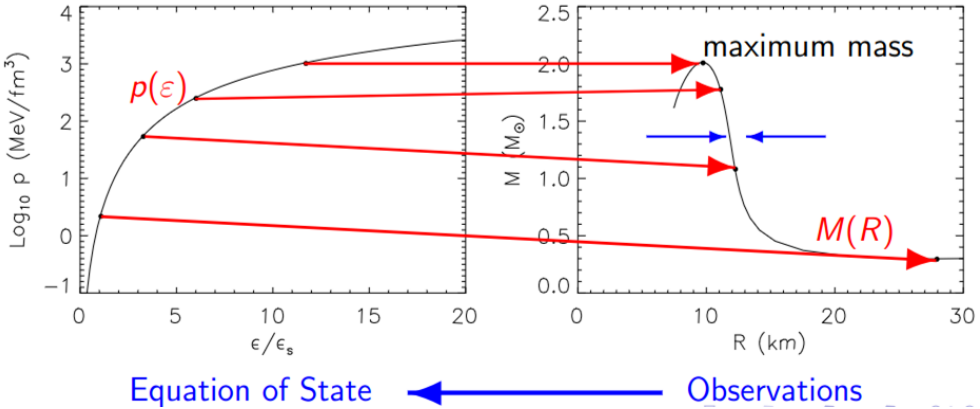
Phase diagram of QCD

- The state of matter at high densities remains a mystery (quark-gluon plasma, hyperons, color superconductivity, …)
- QCD is perturbative but at ~40n_{sat} !!
- No theory applies in the regime of low-T and large densities.



NS observables

- We solve the hydrostatic equations in GR for spherical and nonrotating stars (TOV equations)
- One-to-one correspondence between EoS and M-R curve
- We can extract tidal deformabilities from gravitational waves (LIGO/VIRGO) or compactness from X-ray measurements (e.g NICER)



Why relativistic mean field models ?

At high density, we need a **relativistic approach** since the sound speed in NS cores is expected to be larger than 10% of the light speed, as revealed by analyses of recent radio as well as X-ray observations from NICER of massive NSs.

- Can be extrapolated to high densities BUT no simple way to decide where the model breaks down in density

- We employ Bayesian statistics to explore the relation between observables uncertainties and the one in the model predictions

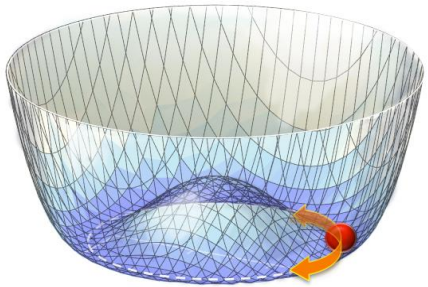
RHF with chiral symmetry and confinement (RHF-CC)

An effective model describing the nuclear interaction as an exchange of mesons and incorporates two main aspects of QCD:

1) Chiral symmetry

The radial component corresponds to the σ meson of Walecka, first identified by Chanfray (PRC 63 (2001)), and the phase component corresponds to the massless Goldstone boson, the pion

But since the quarks have a small mass, the symmetry is also explicitly broken and the pion acquires a small mass!



2) Confinement

Taken into account through the polarisation of the nucleon, i.e the nucleon mass response to the surrounding scalar field:

$$M_N \Longrightarrow M_N(s)$$

Form factors (FF) and Short Range Correlations (SRC)

- The model being an effective one, doesn't have a good resolution at short ranges ($q \sim M_N$)

- We use FF for nucleon finite size, and the Jastrow ansatz for SRC: the meson's propagator is convoluted with a correlation function forbidding the presence of 2 nucleons at the same point