EoS and compact objects : status quo and open problems

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with : M. Baldo, H.-J. Schulze, H. Chen, K. Fukukawa, G. Taranto

Brainstorming on
Compact objects, their equation of state,
related explosive events, and their nucleosynthesis
Basel, 29 Sept-1 Oct, 2016

Phenomenological vs. ab initio approaches

Phenomenological approaches

Based on effective density-dependent NN force with parameters fitted on nuclei properties.

- Liquid Drop models
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  - ✧ BBP Baym et al., *NPA* ***175,*** *225 (1971)*
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  - ✧ DH Douchin&Haensel, *A&A* ***380,*** *151 (2001)*
- TF + RMF
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- ETFSI + Eff. Skyrme force
  - ✧ BSk Goriely et al.,*PRC* ***82****, 035804 (2010)*
- Hartree-Fock
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Ab initio approaches

The nuclear problem is solved starting from the two- and three-body realistic nucleon interaction.

- Diagrammatic
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- Variational
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  - ✧ FHNC Fantoni&Rosati, *Nuovo Cimento A****20****, 179 (1974)*
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  - ✧ LOCV Owen et al., *NPA* ***277****, 45 (1978)*
- Monte Carlo
  - ✧ VMC Wiringa, *PRC****43****, 1585 (1991)*
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NM saturation point and TBF's

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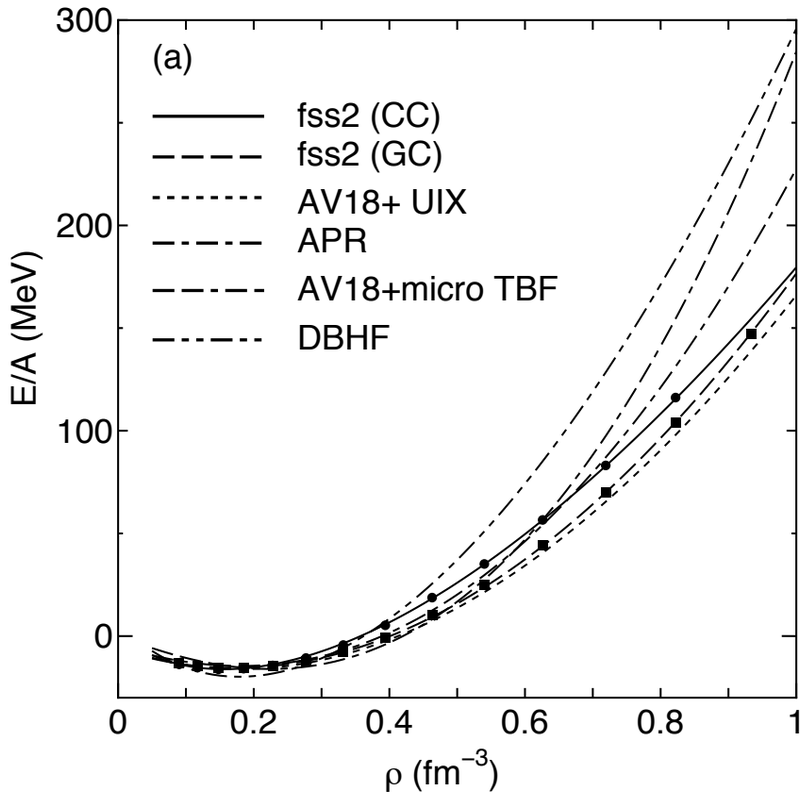

BBG (Av18+micro TBF, Av18 + UIX, fss2)

* Microscopic vs. Phenomenological TBF's. Saturation point well fitted. Different density dependence at large density.

* fss2 built from quark degrees of freedom. Nucleons described as three-quarks clusters with confinement. NN potential from gluon and meson exchange between quarks.
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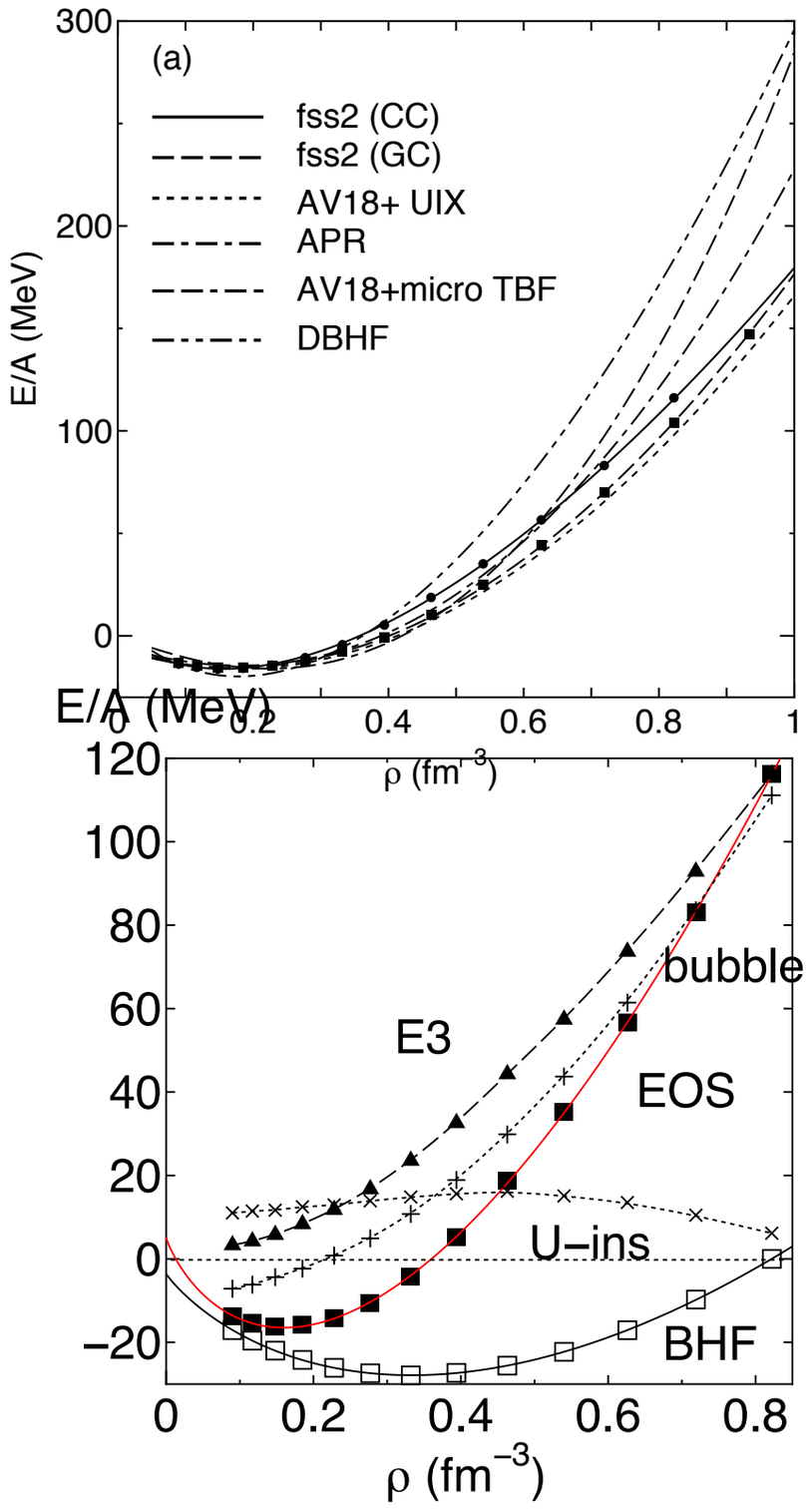

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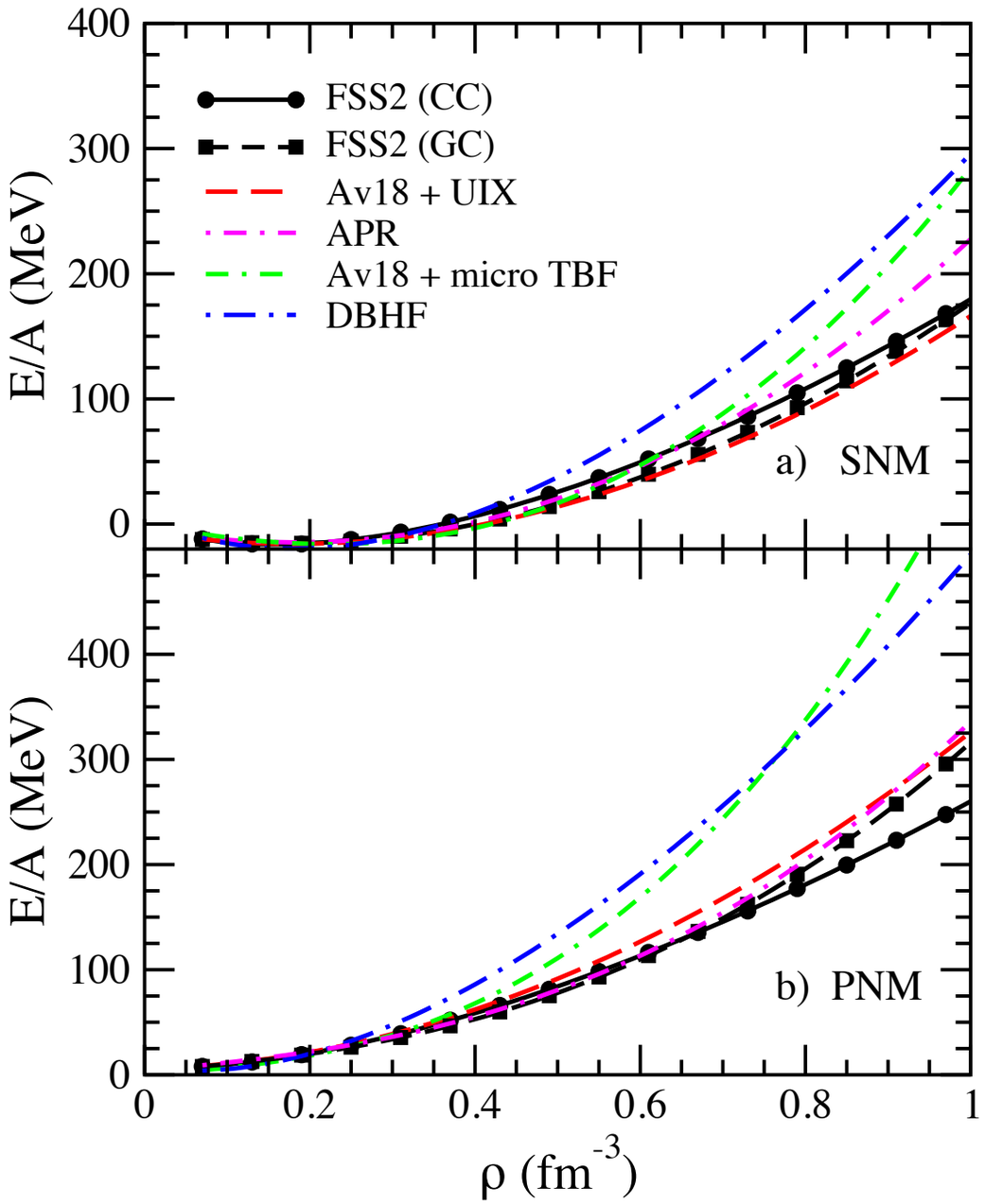
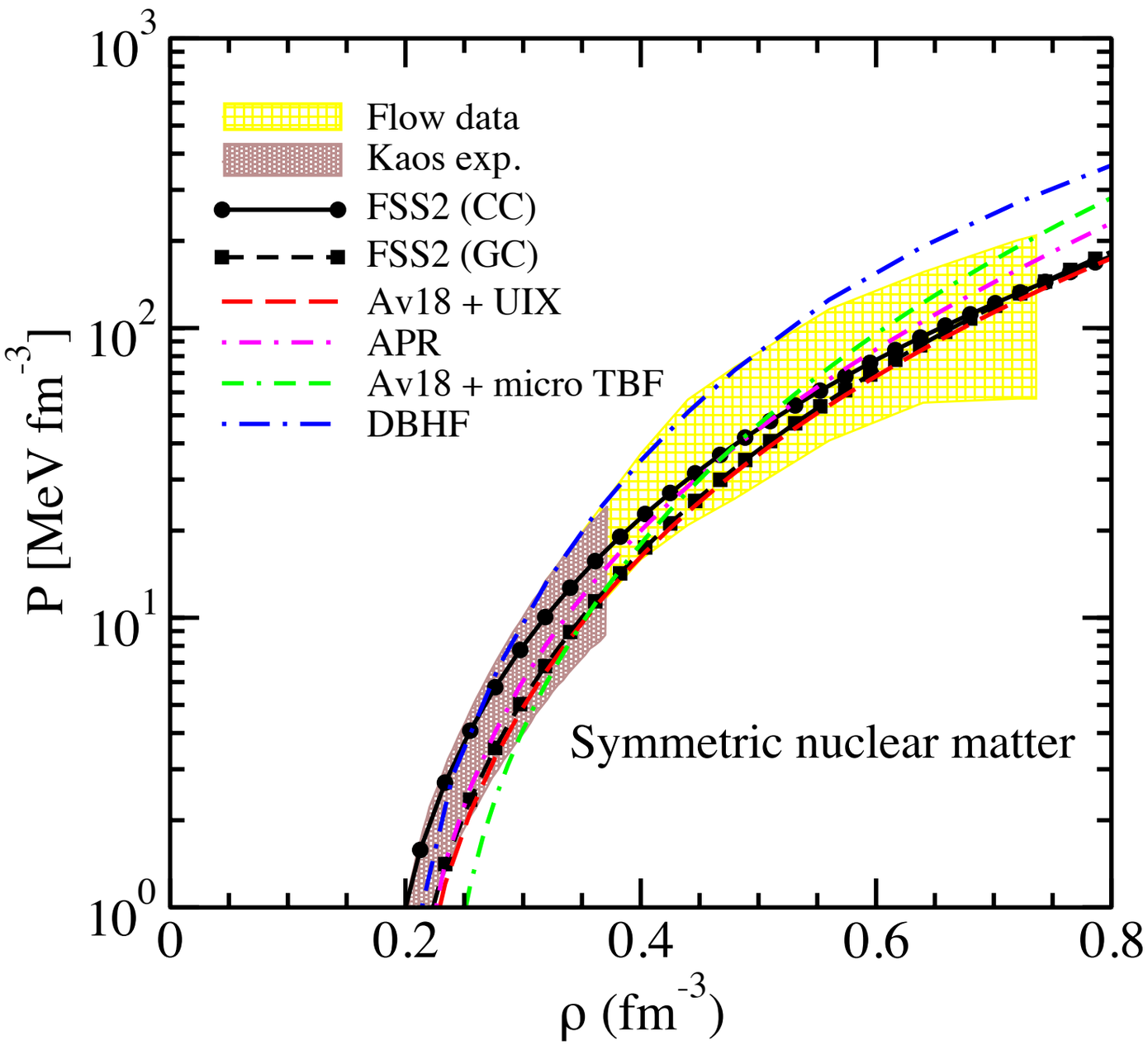
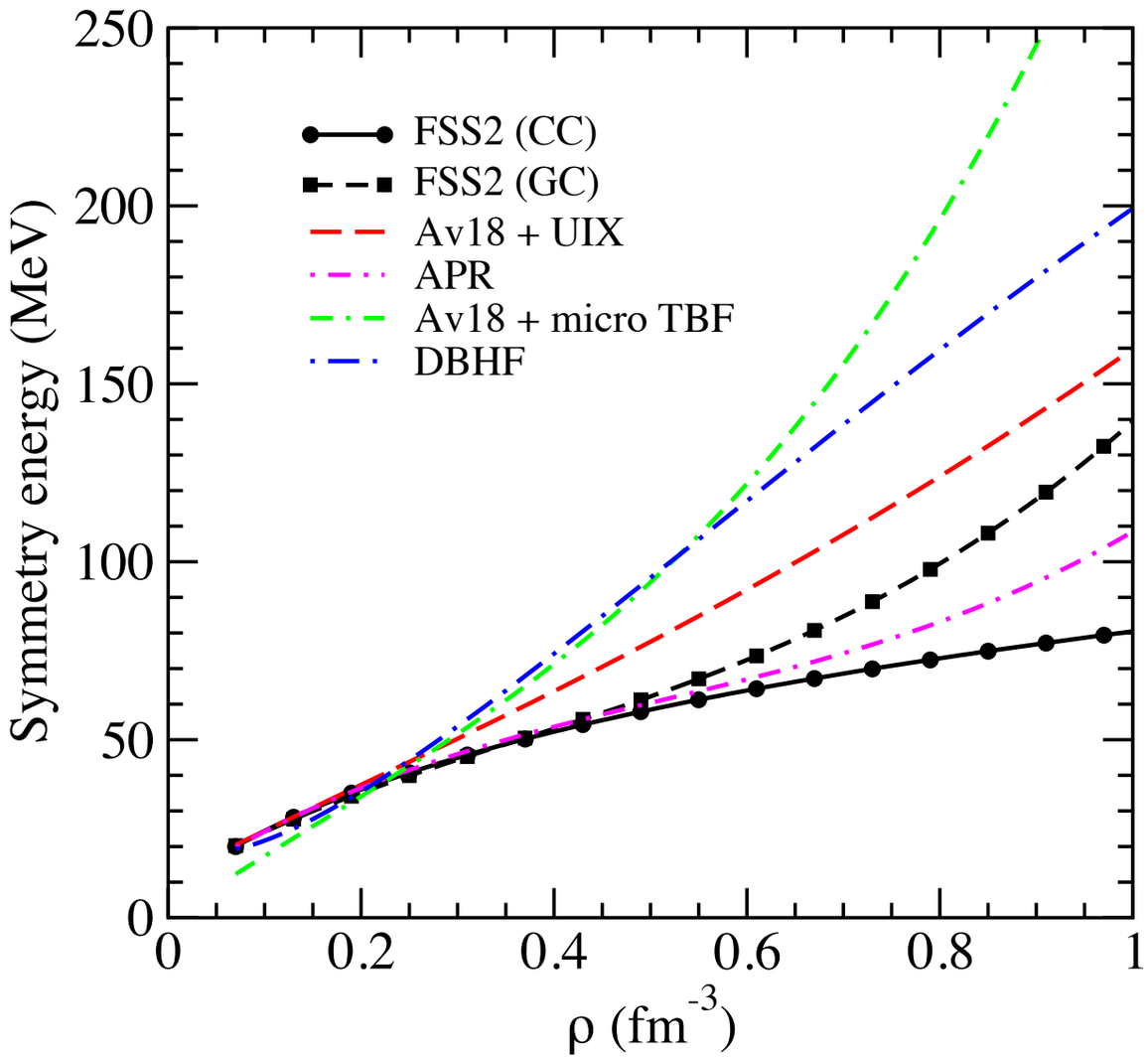
In fss2 the three hole-line contribution is relevant and produces a substantial saturation effect. No need of TBF's ....

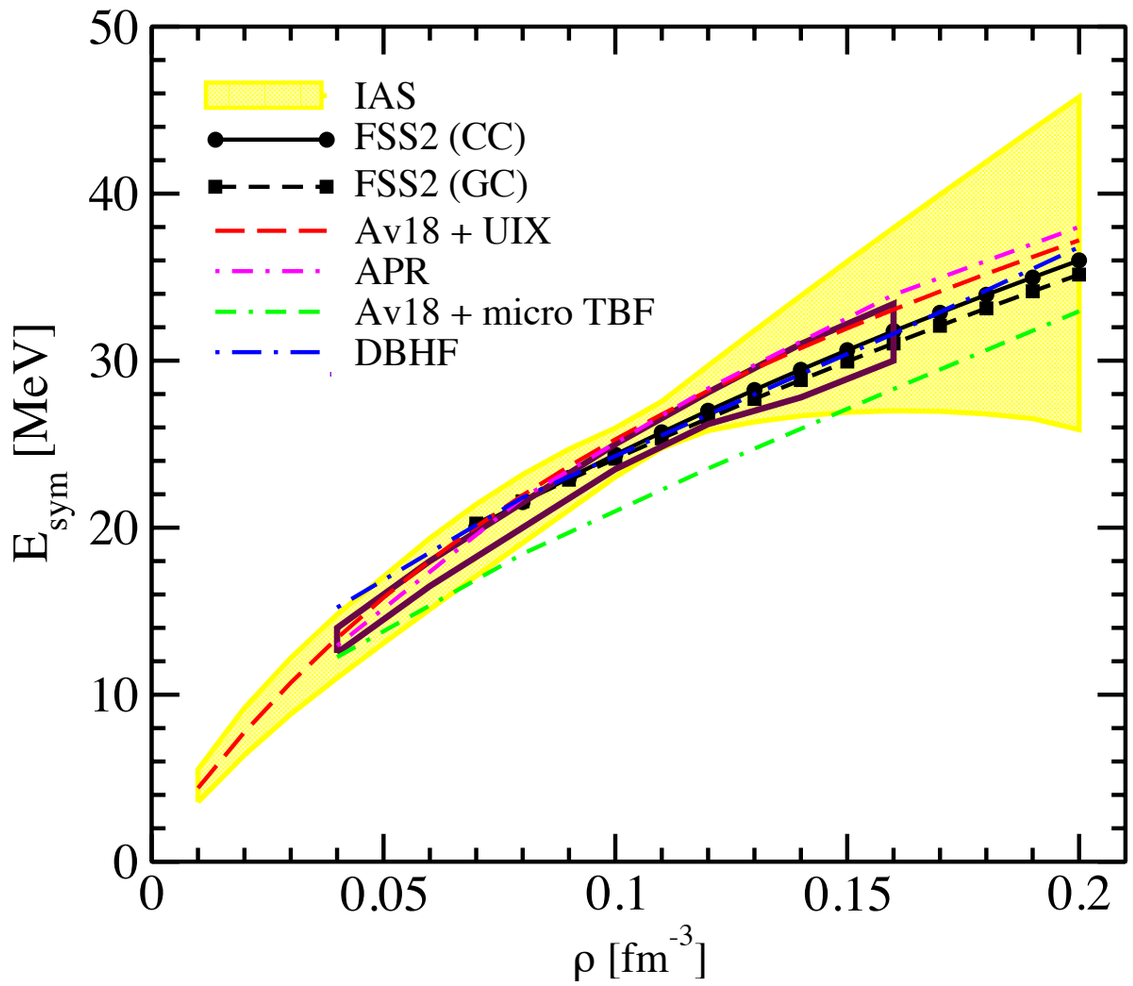
A comparison with HIC data



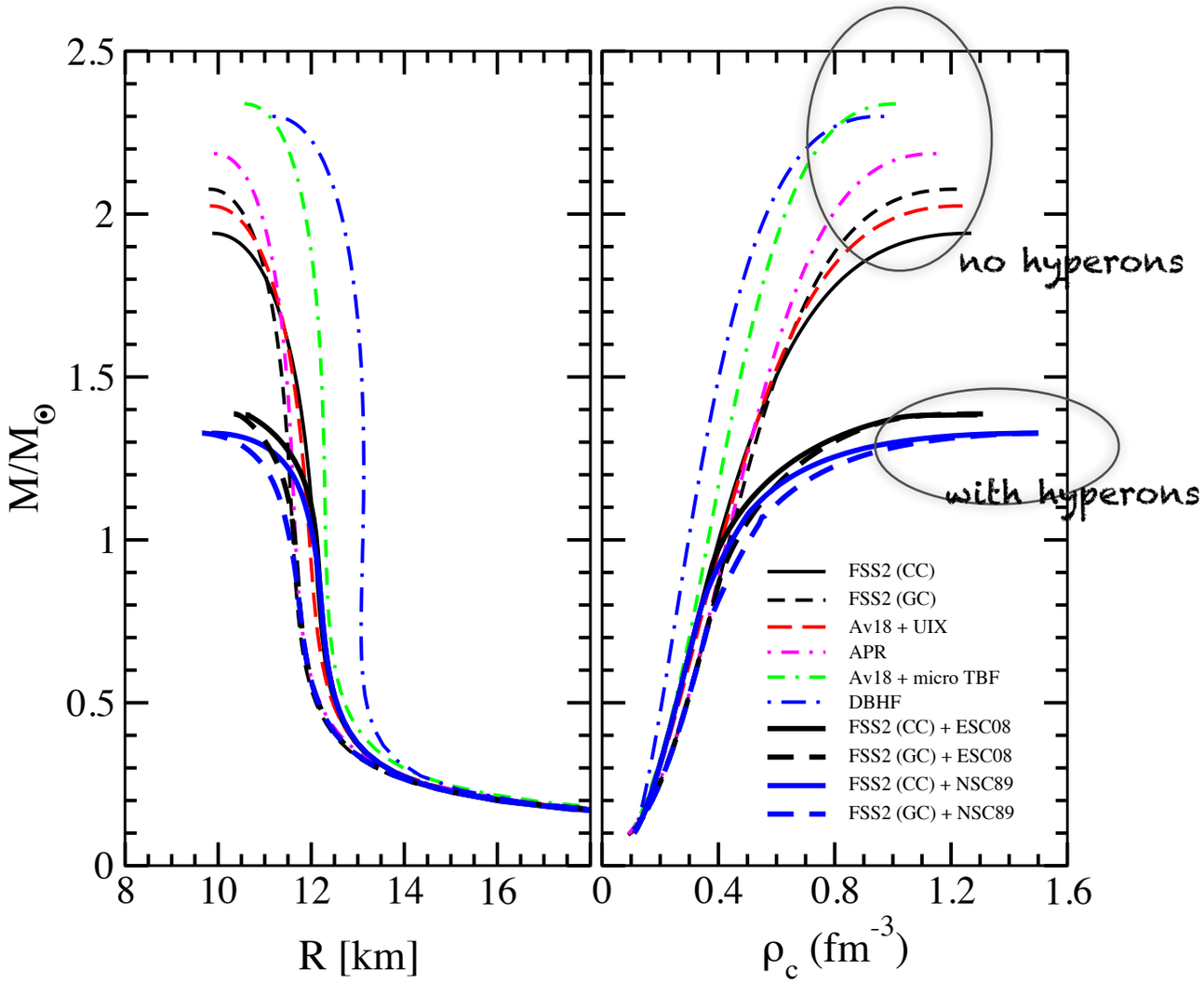


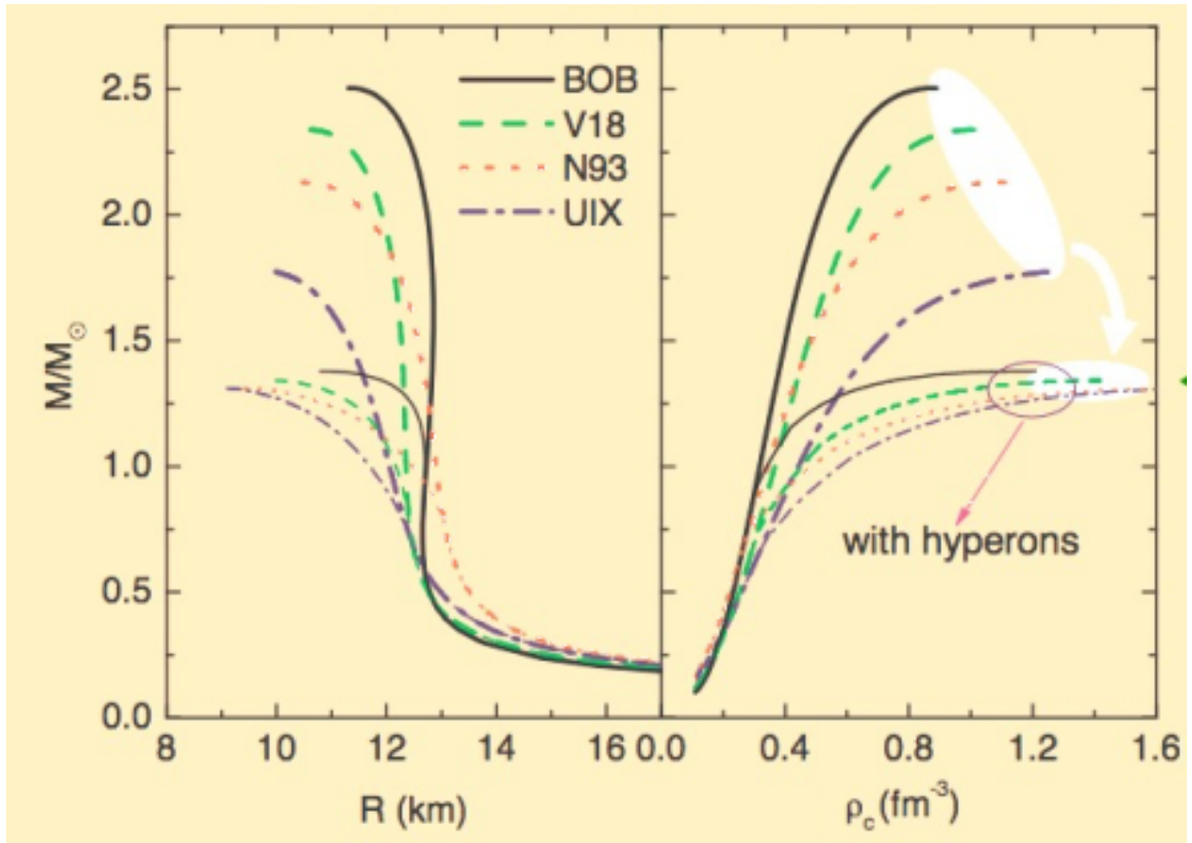
Symmetry energy





NS structure





The "Hyperon puzzle" :
Self-regulating softening due to hyperon appearance

Additional repulsion required !

Quark matter in NS

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Several models of Quark Matter

* MIT bag model
* Nambu-Jona-Lasinio model
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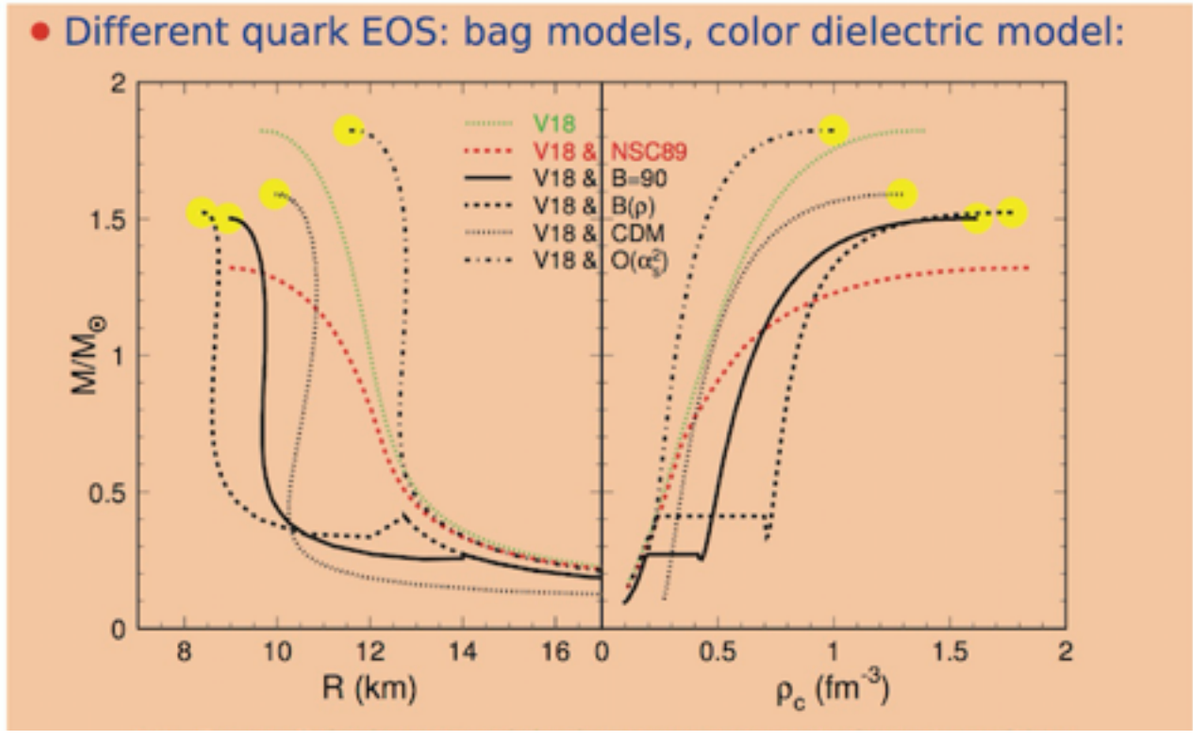

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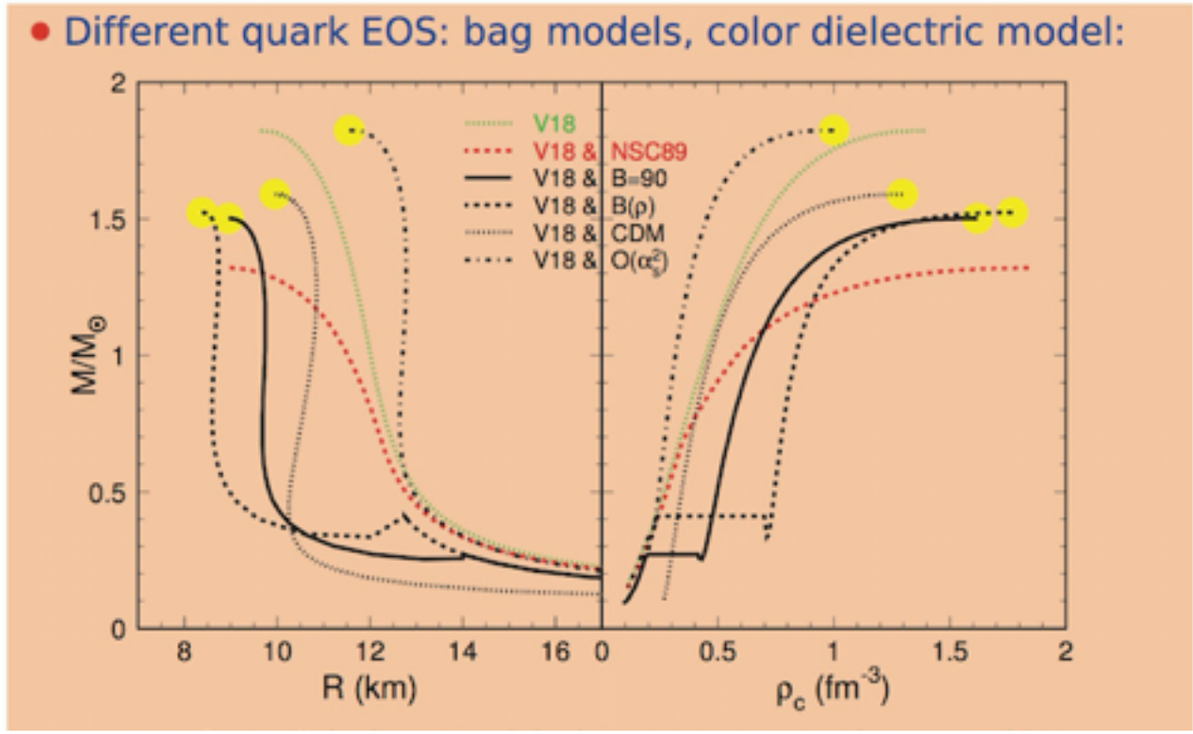

* When hyperons are present in the HP (MIT, pQCD, FCM), the limiting mass stays below 2 $M_\odot$. maximum masses : 1.5....1.9 $M_\odot$ with different radii !
* With NJL, DS models hyperons prevent the phase transition and the limiting mass can be larger than 2 $M_\odot$.

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Issue I : Relevance of TBF's.

fss2 potential based on quark d.o.f. does not need TBF's

True also for other cases ? Issue to be explored ...

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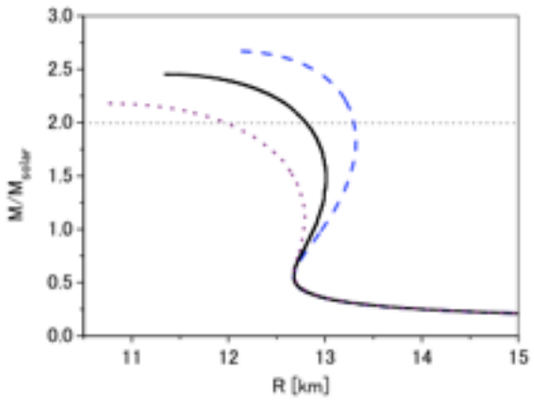
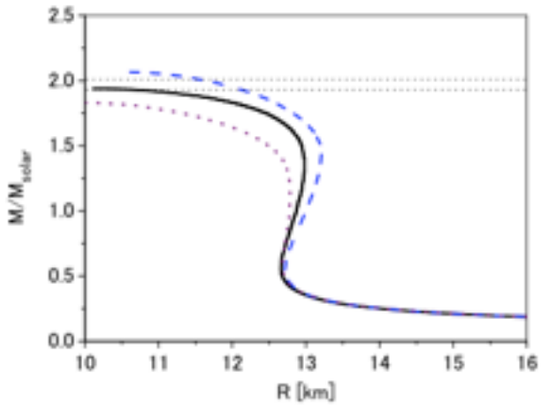
EoS based on multi-pomeron potential





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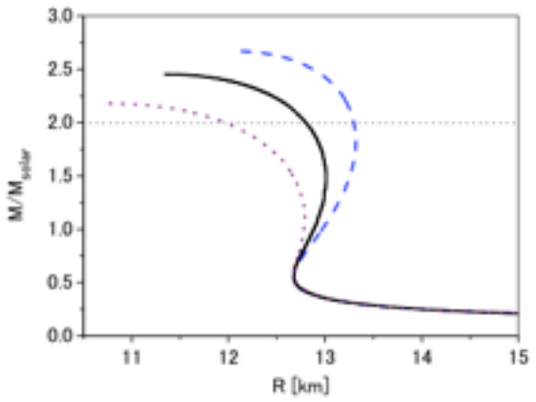

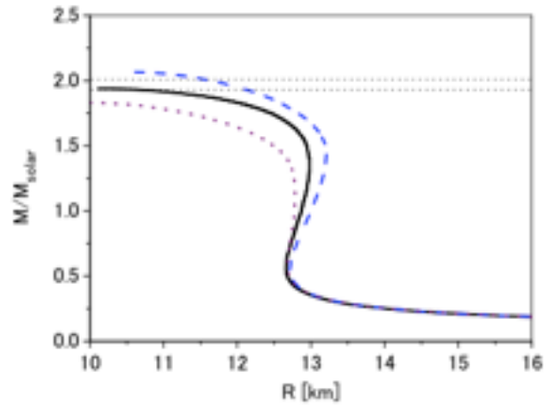

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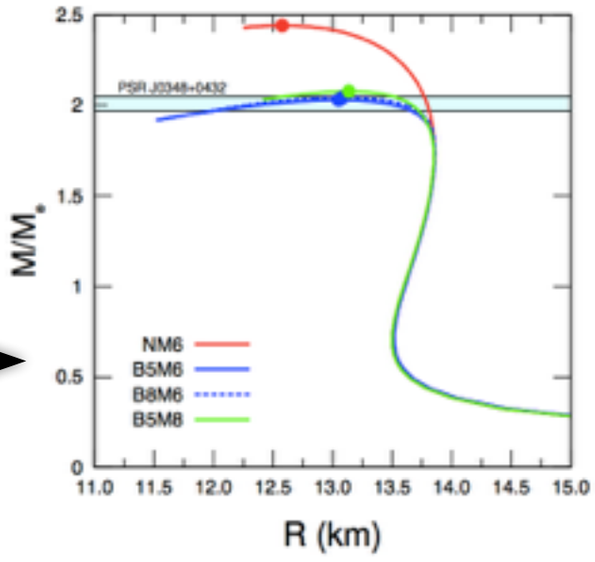

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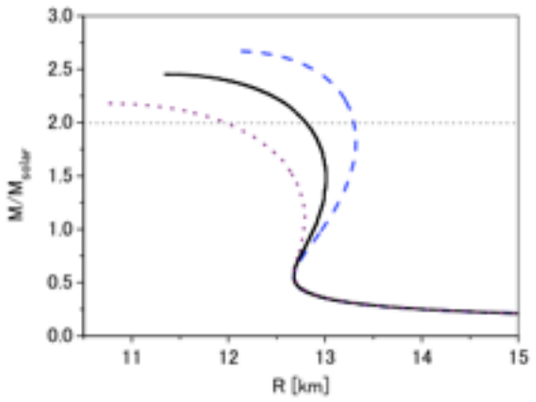

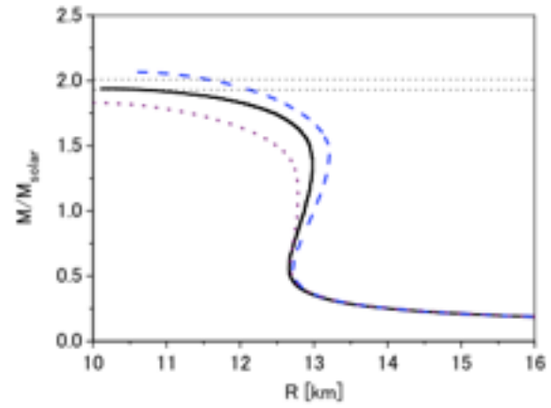

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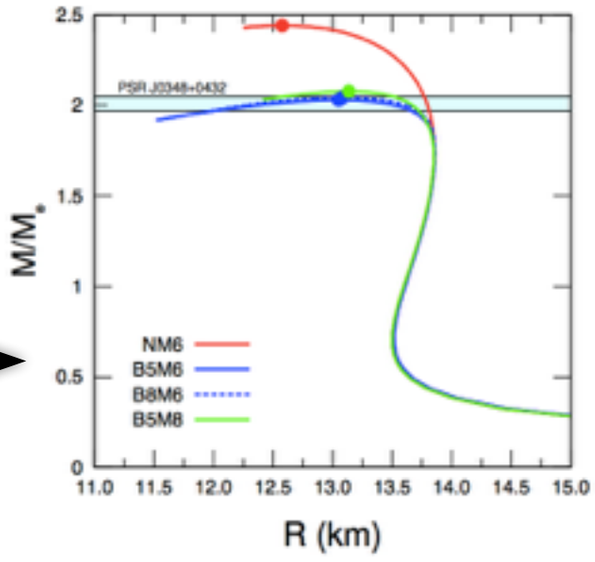

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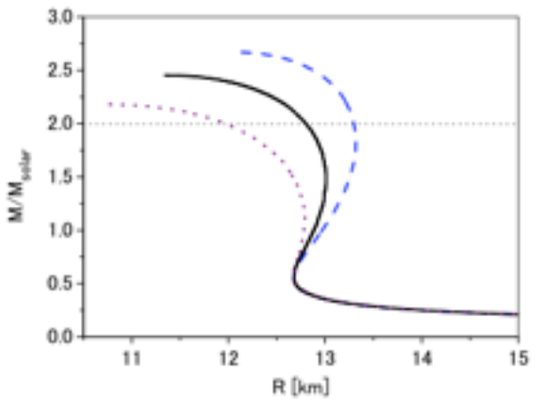

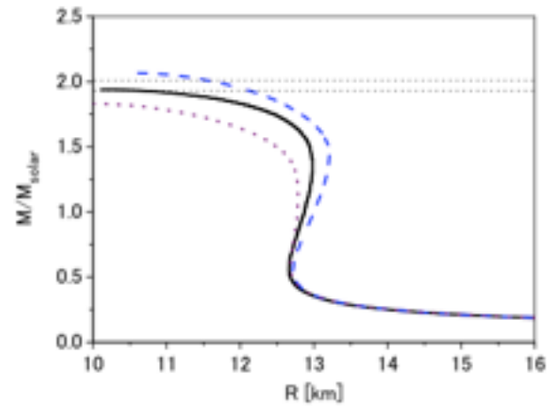

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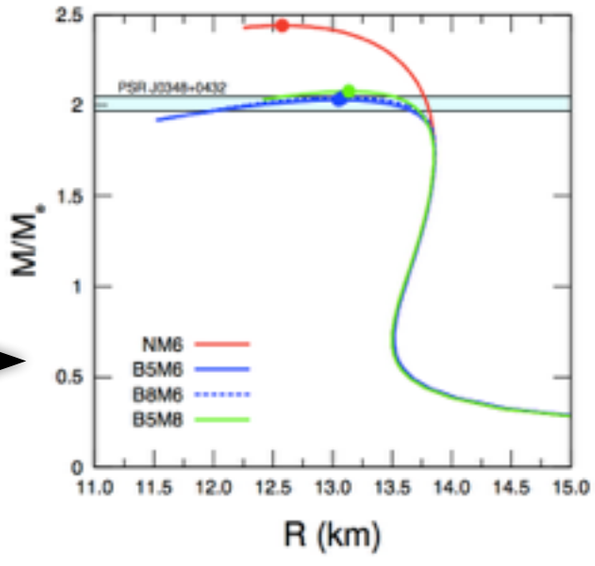

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Issue IV : EoS at finite T, $T>T_F$