

The nuclear matter density functional under the nucleonic hypothesis

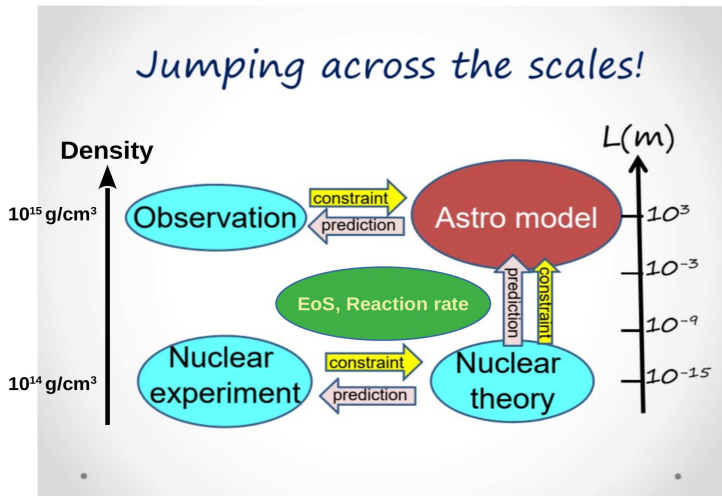
Chiranjib Mondal
Hoa Dinh Thi & Francesca Gulminelli



“XXIInd Colloque GANIL”
September 28, 2021

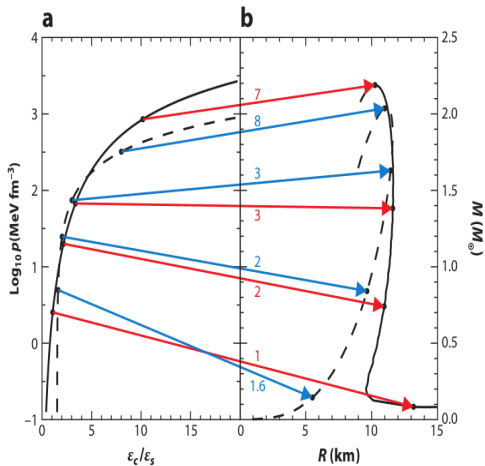
Theory and experiment/observation

Jumping across scales



Equation of State

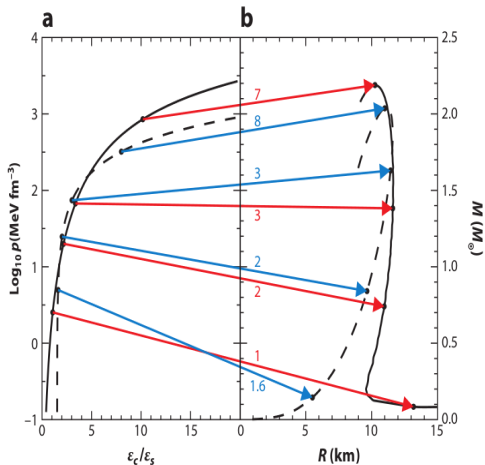
One-to-one correspondence



J. Lattimer, *Ann. Rev. Nucl. Part. Sci.* 62, 485–515 (2012)

Equation of State

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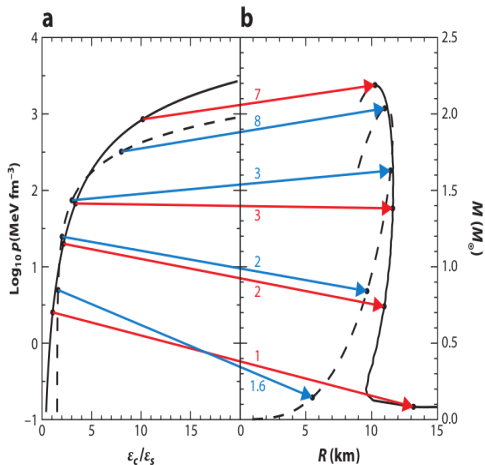


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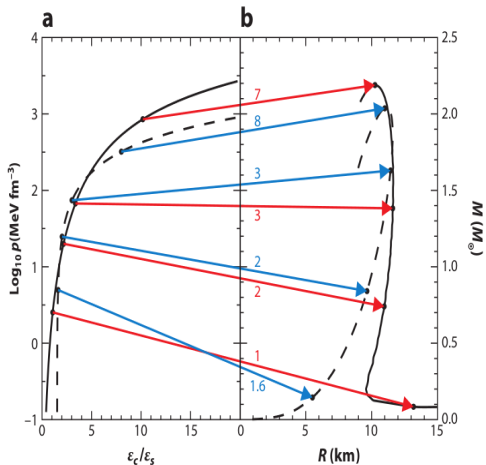


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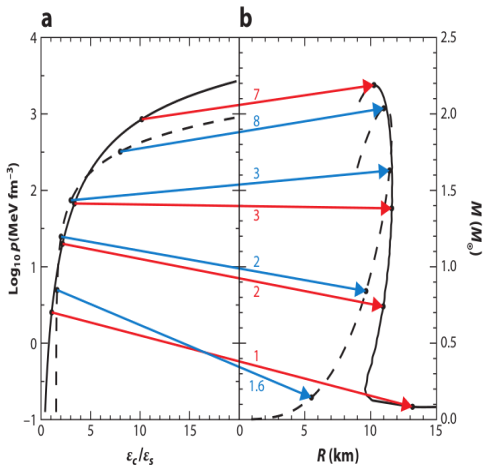


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- **What about composition? Hyperons? Quarks?**

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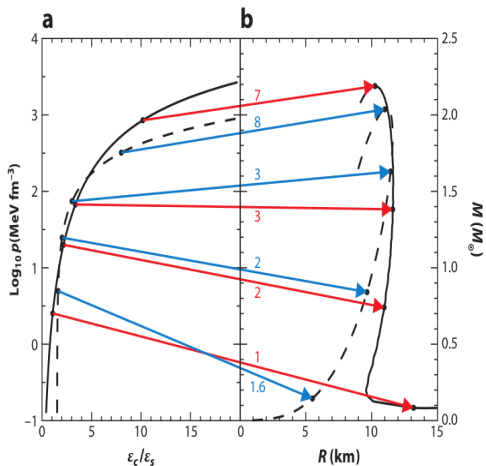


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- Reactions \Rightarrow nucleosynthesis \Rightarrow kilonova as well as cooling \Rightarrow X-ray spectra.

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- What about composition? Hyperons? Quarks?
- Reactions \Rightarrow nucleosynthesis \Rightarrow kilonova as well as cooling \Rightarrow X-ray spectra.
- Impact of new observations like $M(R)$ (NICER), $\Lambda(R)$ (LIGO/VIRGO).

Nucleonic meta-modelling

Founding aspects (Based on J. Margueron *et. al.*, PRC 97, 025805 (2018))

Features

- Flexible functional $e(\rho_n, \rho_p)$ able to reproduce existing effective nucleonic models and interpolate between them.
- Expansion in powers of the Fermi momentum or of the density.
- Expansion around saturation: Parameter space = emp. par. \vec{X} .
- **Beta-equilibrium!!!**

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- The energy per particle is given by ($x = \frac{n_b - n_{\text{sat}}}{3n_{\text{sat}}}$, $n_b = \rho_n + \rho_p$,
 $\delta = \frac{\rho_n - \rho_p}{n_b}$)

$$e(\rho_n, \rho_p) \simeq e_{\text{SNM}}(n_b, 0) + e_{\text{sym}}(n_b)\delta^2$$

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$$e_{\text{SNM}}(n_b) \simeq E_{\text{sat}} + \frac{1}{2}K_{\text{sat}}x^2 + \frac{1}{6}Q_{\text{sat}}x^3 + \frac{1}{24}Z_{\text{sat}}x^4$$

$$e_{\text{sym}}(n_b) \simeq J_{\text{sym}} + Lx + \frac{1}{2}K_{\text{sym}}x^2 + \frac{1}{6}Q_{\text{sym}}x^3 + \frac{1}{24}Z_{\text{sym}}x^4.$$

Impact of recent data on Meta-model

Obtaining the filters

Prior = Nuclear physics informed prior with AME2016 fit.

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Filters in Bayesian Analysis

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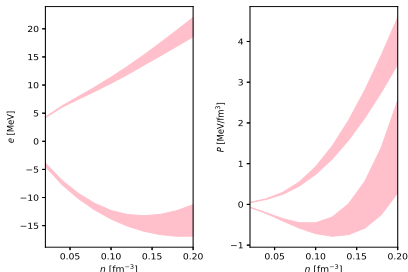
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EFT



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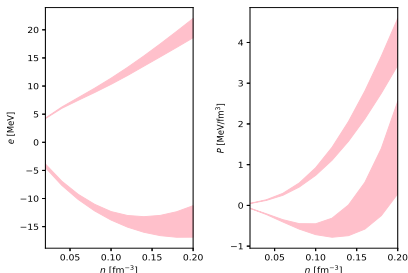
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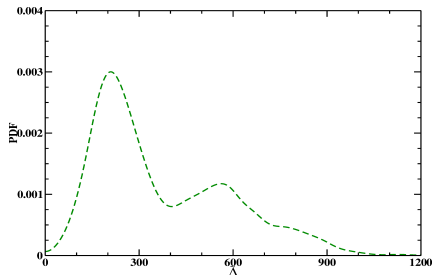
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EFT



LVC



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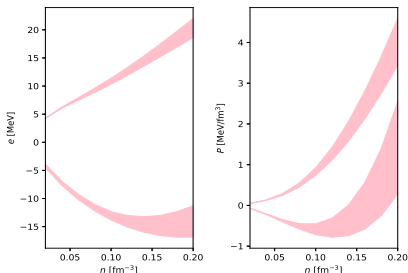
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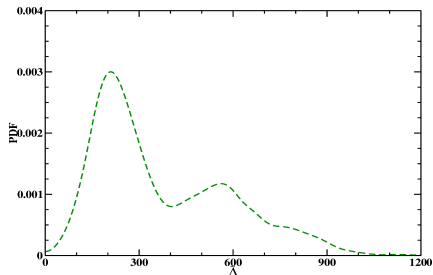
Filters in Bayesian Analysis

- **LD** = EFT energy band at low density.
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- **All** = EFT + HD + LVC + NICER.

EFT

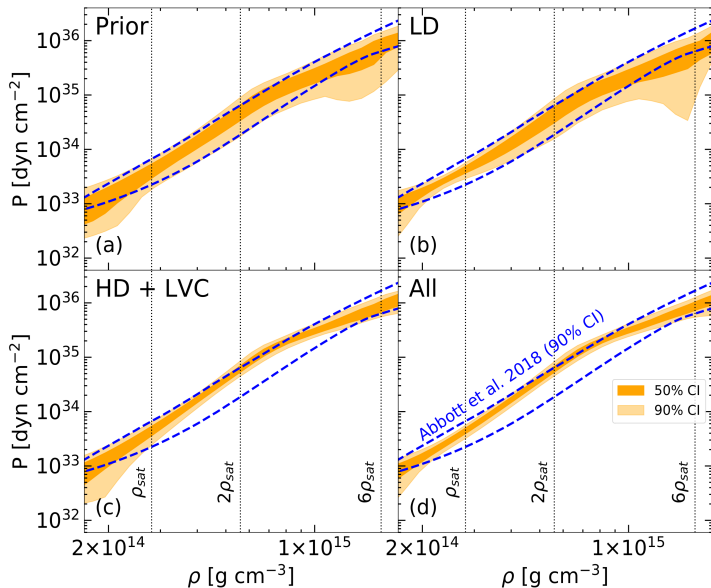


LVC



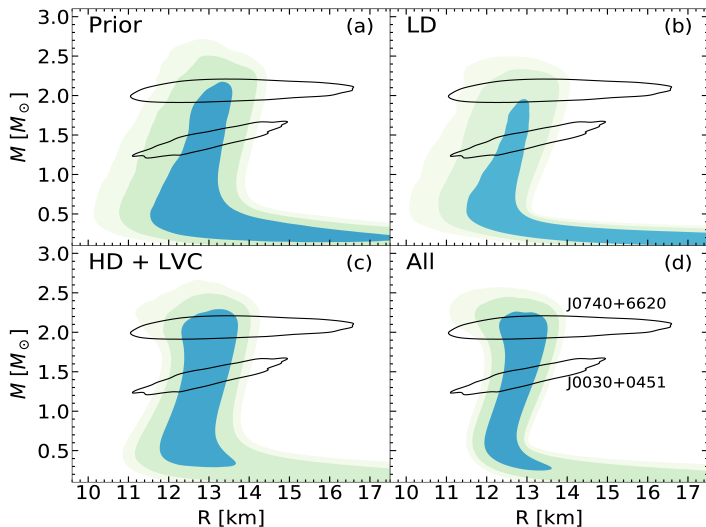
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EoS



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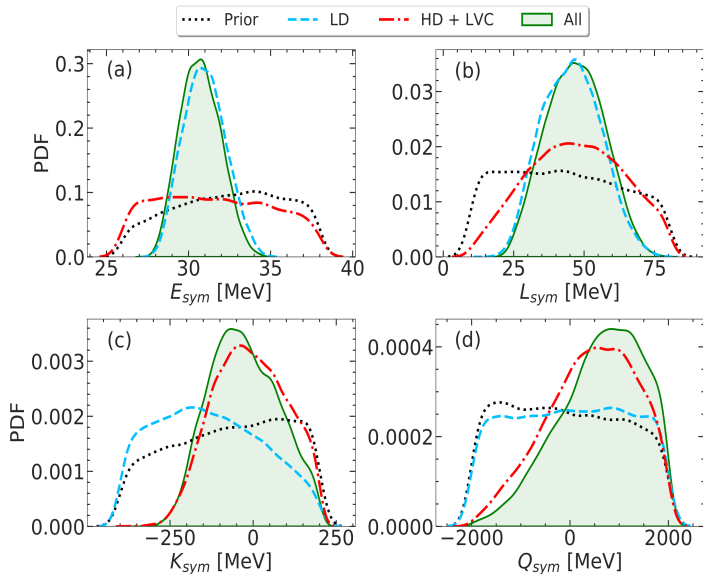
Mass-Radius



Hoa Dinh Thi, CM & F. Gulminelli (In press, Universe)

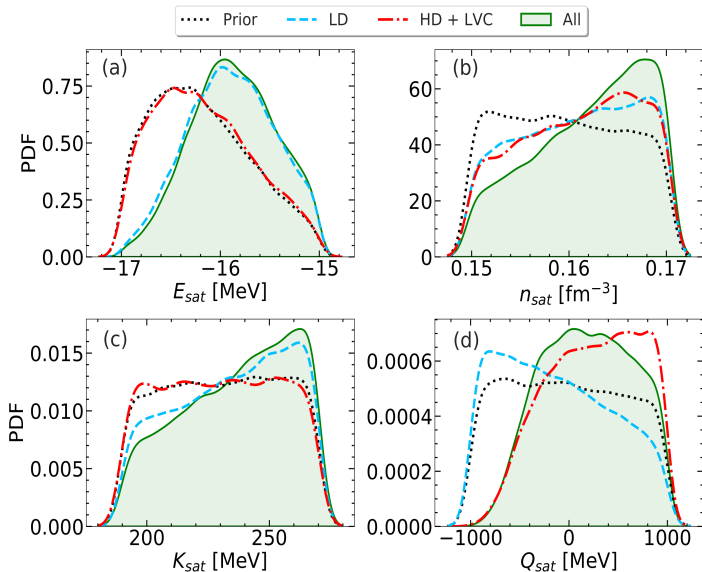
Impact of recent data on Meta-model

Isvector parameters



Impact of recent data on Meta-model

Isoscalar parameters



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Wish list

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Thank You