Strangeness in Neutron Stars

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1. A Brief History of the Hyperon Crisis
2. The Quark-Meson Coupling Model
3. Results
4. The Nature of Strangeness Puzzle

A Brief History of the Hyperon Crisis

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- 1967 Jocelyn Bell & Anthony Hewish discover PSR B1919+21

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$$\frac{dp}{dr} = -\frac{G}{r^2}\left(\epsilon(p(r)) + \frac{p}{c^2}\right)\left(M + 4\pi r^3 \frac{p}{c^2}\right)\left(1 - \frac{2GM}{c^2 r}\right)^{-1}.$$

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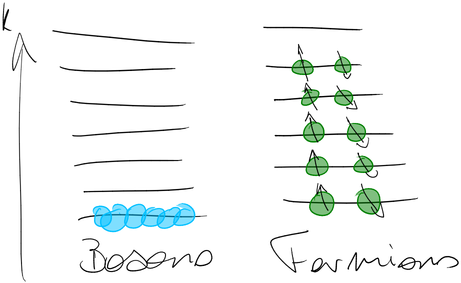

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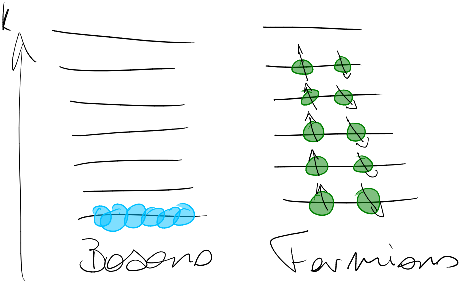

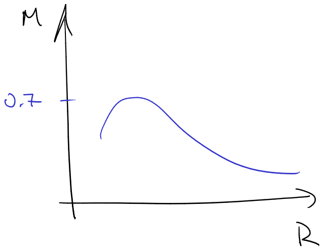

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where $M^\star = M - g_\sigma\bar{\sigma}$ and $p_0^\star = p_0 + g_\omega\bar{\omega}$

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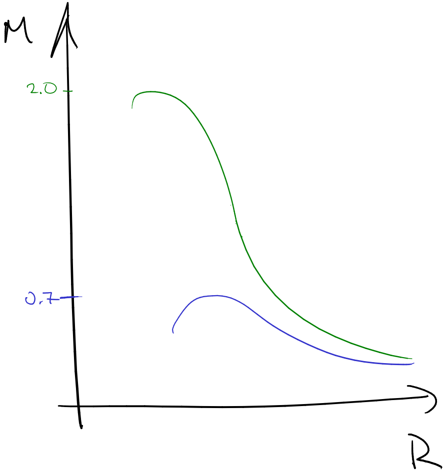

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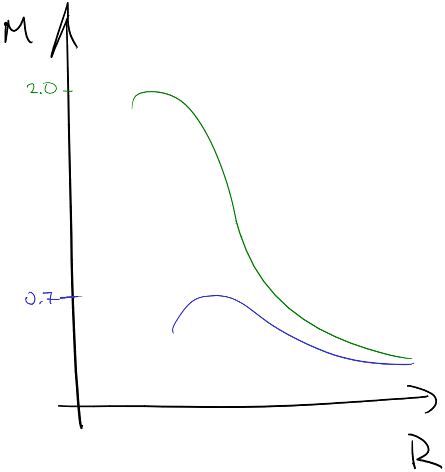

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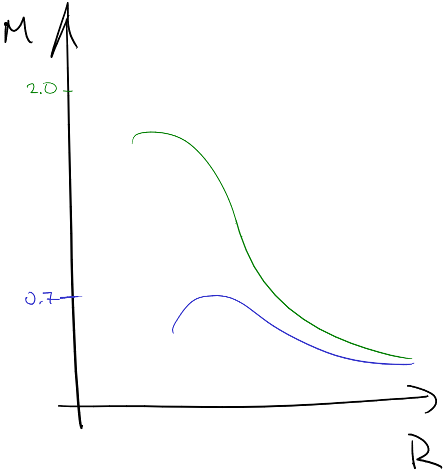

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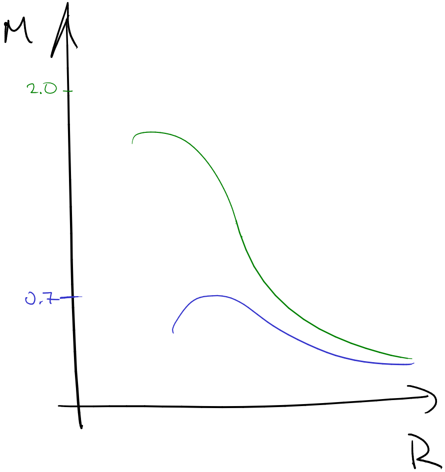

- PSR J1614-2230
  $M = 1.908 \pm 0.016 M_{\odot}$
- PSR J0348+0432
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- PSR J0740+6620
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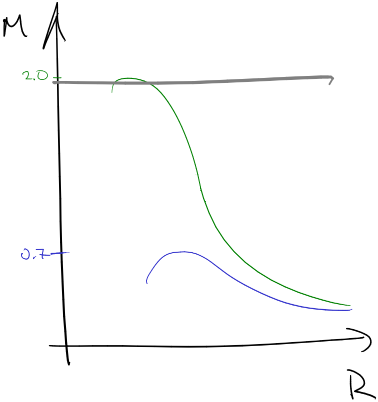

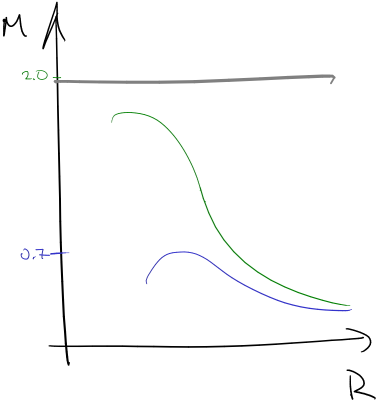

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- Extra hyperon repulsion
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- Also the deconfinement question...

The Quark-Meson Coupling Model

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- The QMC model is one of the relativistic phenomenological models. What we want, fundamentally, is

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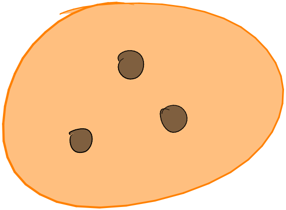

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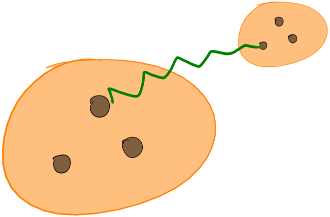
- We choose to model baryon-baryon interactions as a quark-meson interaction in the subhadronic level.



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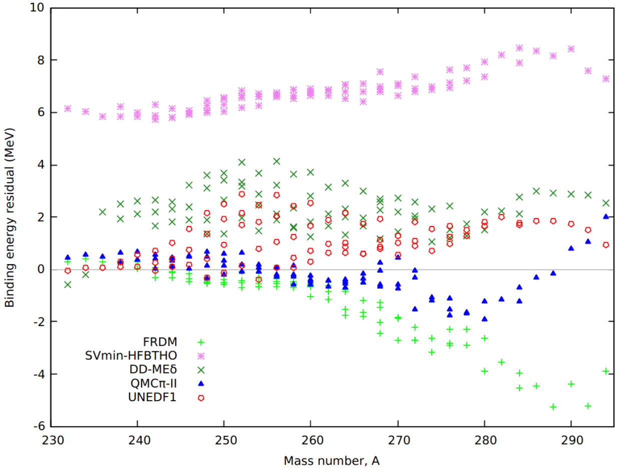

Figure: Nuclei binding energies from Martinez et al. [2019]

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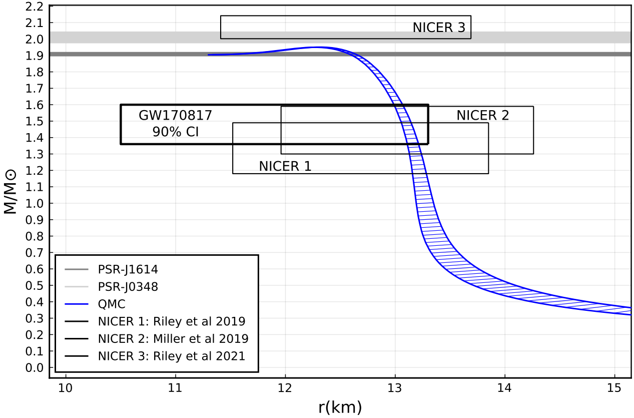

Figure: Stellar structure results from Motta et al. [2021] plus recent NICER results such as et al [2021]

Results

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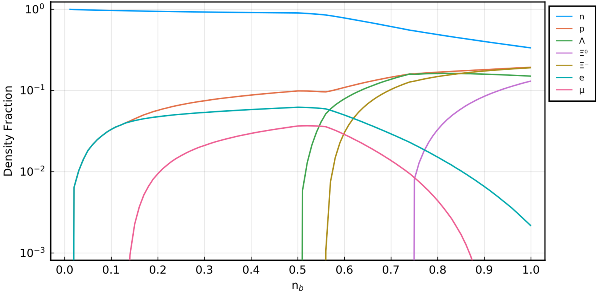

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- This complicates things. And we **do not expect a big change on the mass** of the neutron star.

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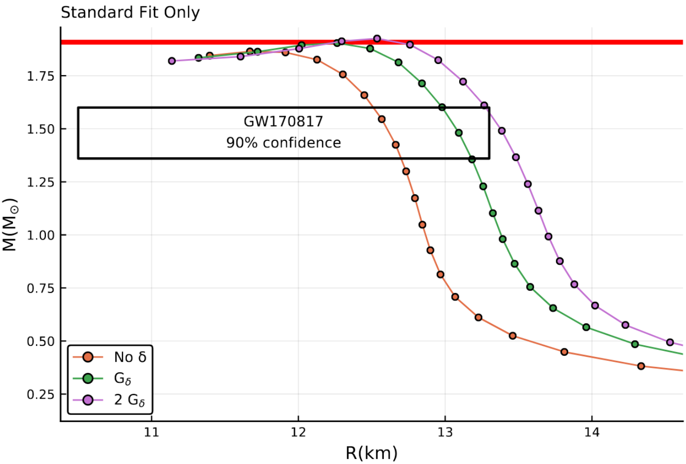

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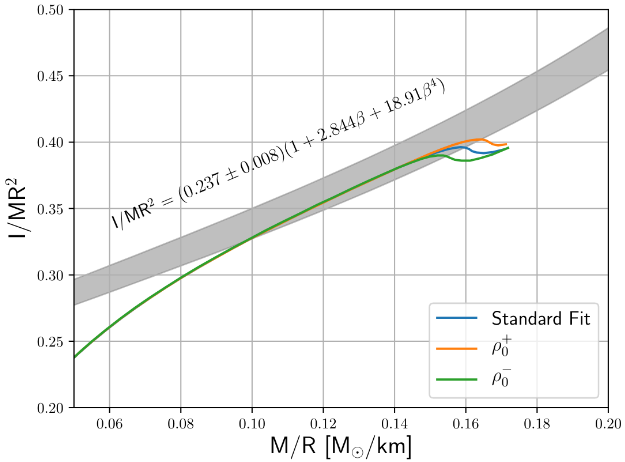
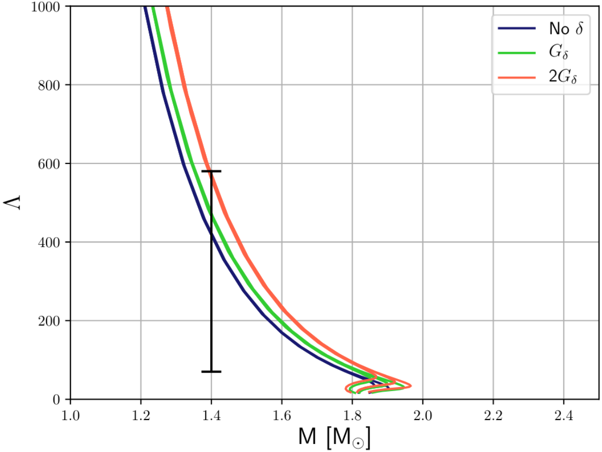


Tidal Deformability



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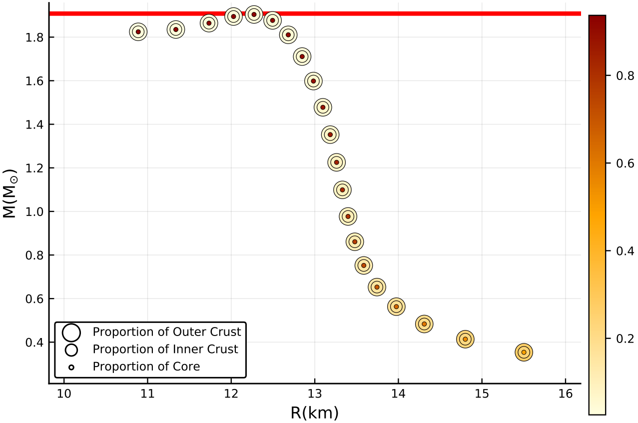

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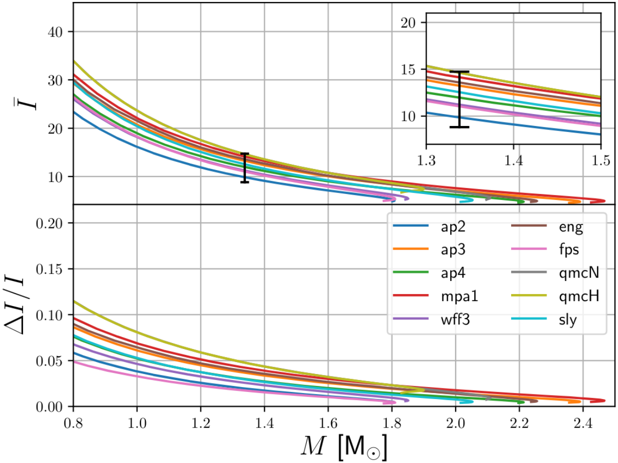

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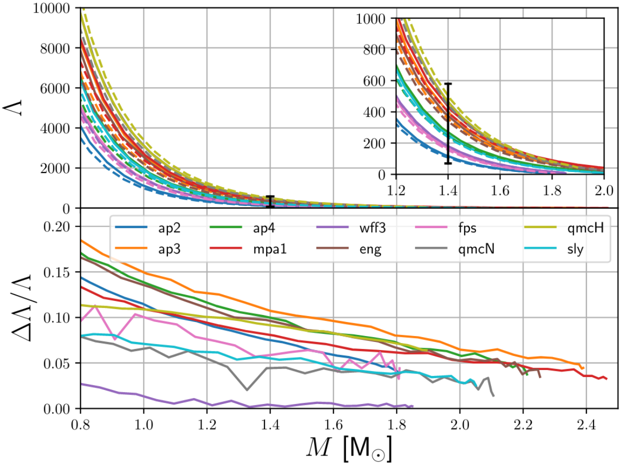

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- In particular, what is the δ meson influence?

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- So how do we approach the problem?

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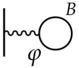
- We can calculate μ_{Δ^-} by

$$M_{\Delta^-} + \sum_{\varphi,B}$$



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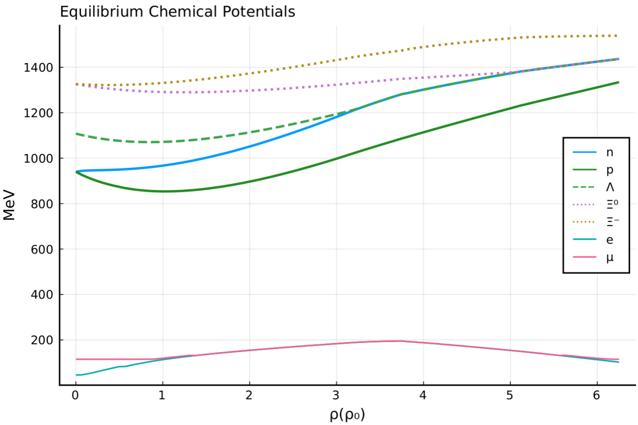

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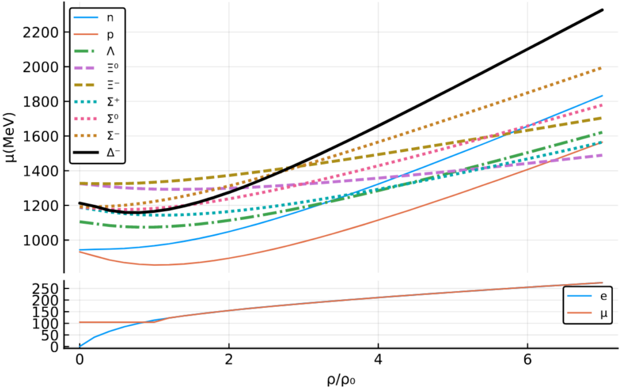

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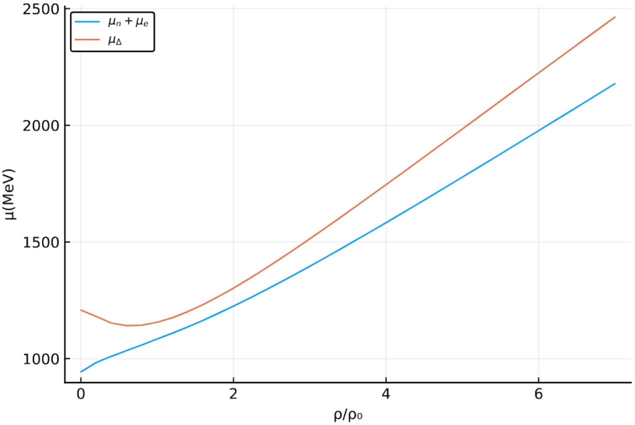

The Nature of Strangeness Puzzle

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- However, one puzzle to be addressed is that of deconfinement.
- One interesting approach is to try the inverse problem, get NS constraints and from there infer what the EoS is. See Annala et al. [2020]

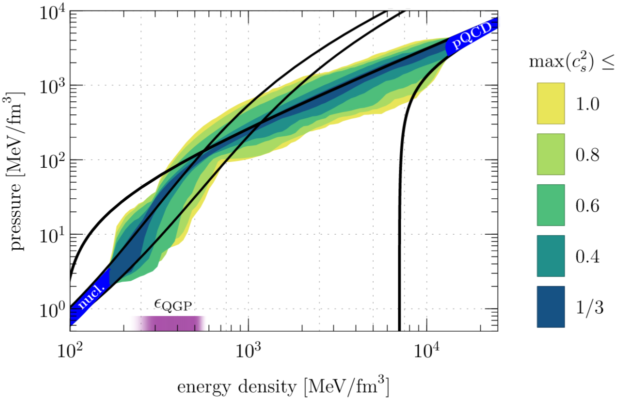


Figure: Results from Annala et al. [2020]

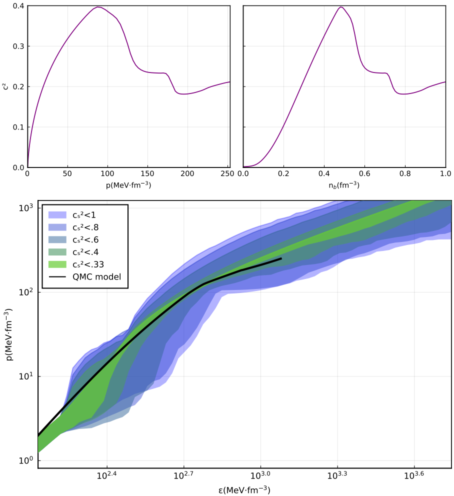
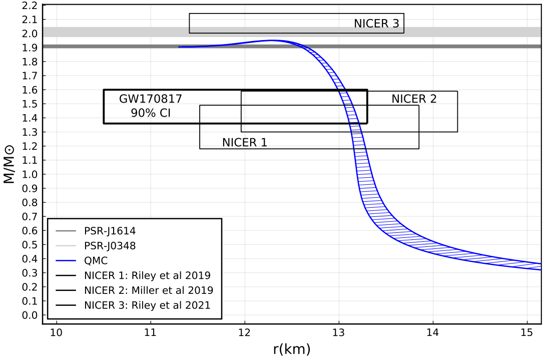


Figure: Motta et al. [2021] comparing QMC with Annala et al. [2020]

Conclusions

- The QMC model is in agreement with data
- There isn't much of a Hyperon puzzle anymore
- We still cannot discriminate between QM and Hyperonic matter



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