Masses and radii of compact stars in the two-families scenario

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- A.D., A.Lavagno, G.Pagliara, Phys.Rev. D89 (2014) 043014

  Two-families scenario

- A.D., A.Lavagno, G.Pagliara, D.Pigato, Phys.Rev. C90 (2014) 065809

  Delta resonances and «delta-puzzle»

- A.D., G.Pagliara, Phys. Rev. C 92 (2015) 045801

  Combustion of hadronic stars into quark stars: the turbulent and the diffusive regime

- A.D., A.Lavagno, G.Pagliara, D.Pigato, Eur.Phys.J. A52 (2016) 40

  A.D., G.Pagliara, Eur.Phys.J. A52 (2016) 41

  Review papers on the two-families scenario

- A.D., A.Lavagno, B.Metzger, G.Pagliara, Phys. Rev. D93 (2016) 103001

  Quark deconfinement and duration of short GRBs

- A.G.Pili, N.Bucciantini, A.D., G.Pagliara, L. del Zanna, MNRAS 462 (2016) L26

  Quark deconfinement and late-time activity in long GRBs

- G.Wiktorowicz, A.D., G.Pagliara, S.Popov, Astrophys.J. 846 (2017) 163

  Strange quark stars in binaries: formation rates, mergers and explosive phenomena

- A.D., G.Pagliara, Astrophys.J. 852 (2018) L32

  Merger of two neutron stars: predictions from the two-families scenario

- F.Burgio, A.D., G.Pagliara, H.-J. Schulze, J.B.Wei, Astrophys.J 860 (2018) 139

  Are small radii for hadronic stars compatible with GW170817/AT2017gfo?

- R.De Pietri, A.D., A.Feo, G.Pagliara, M.Pasquali, S.Traversi, G.Wiktorowicz, Astrophys.J. 881 (2019) 122

  Merger of compact stars in the two-families scenario

- A.D., G.Pagliara; Phys.Rev.D 102 (2020) 063003

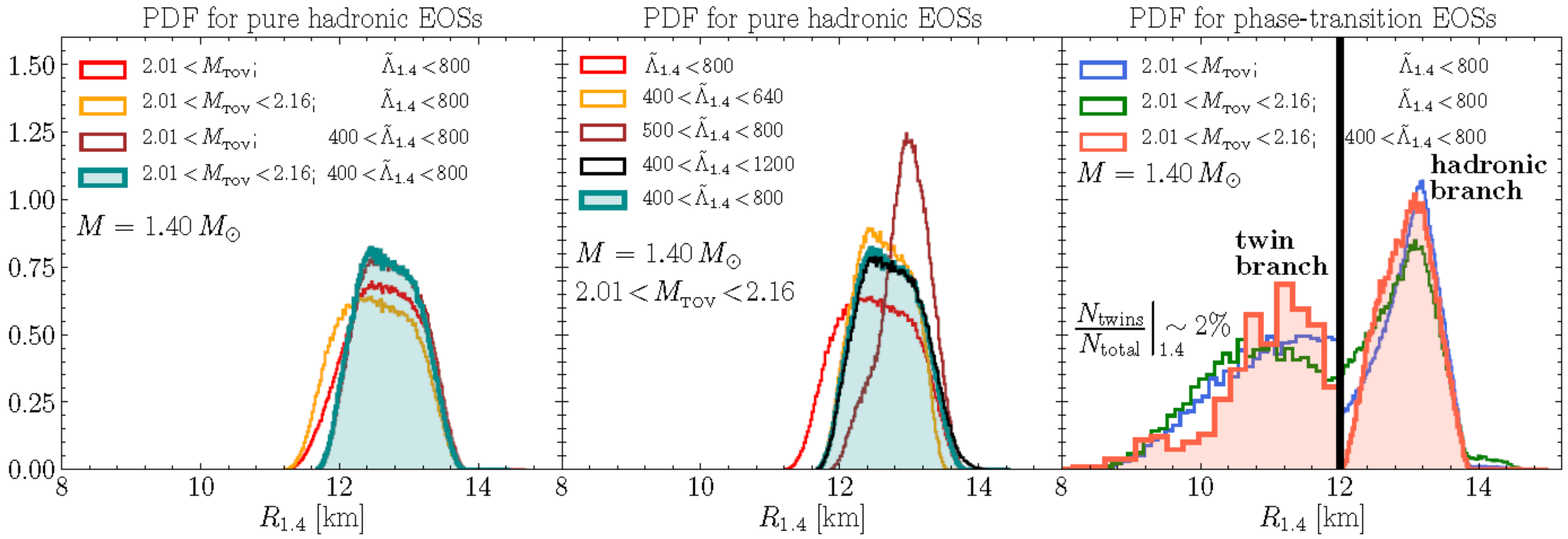
  Why can hadronic stars convert into strange quark stars with larger radii

- I.Bombaci, A.D., D. Logoteta, G.Pagliara, I.Vidana; Phys.Rev.Lett. 126 (2021) 16

  Was GW190814 a Black Hole–Strange Quark Star System?

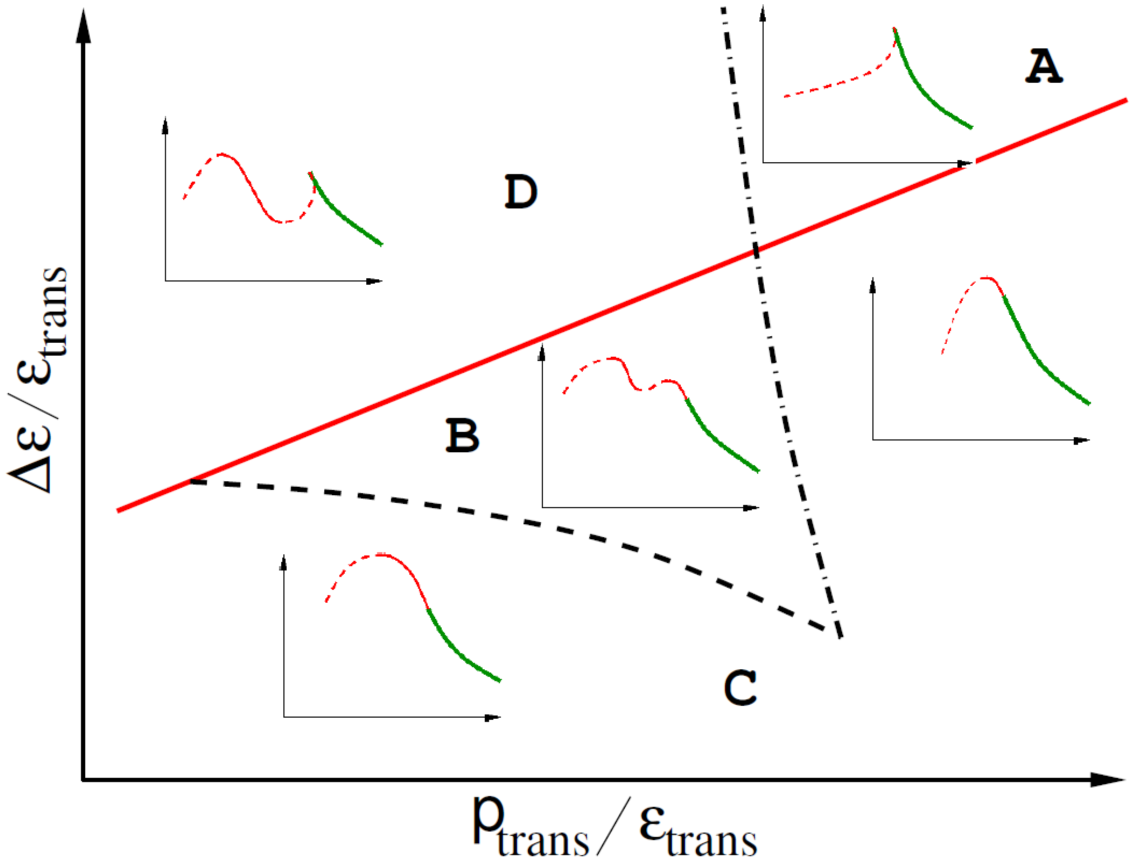
Radii for M=1.4 M_s smaller than about 11.5 km are *impossible* in the absence of a strong phase transition

Most et al. Phys.Rev.Lett. 120 (2018) 261103



The twin-stars scenario: classification of all possible hybrid stars

From Alford, Han, Prakash, Phys.Rev. D88 (2013) 083013

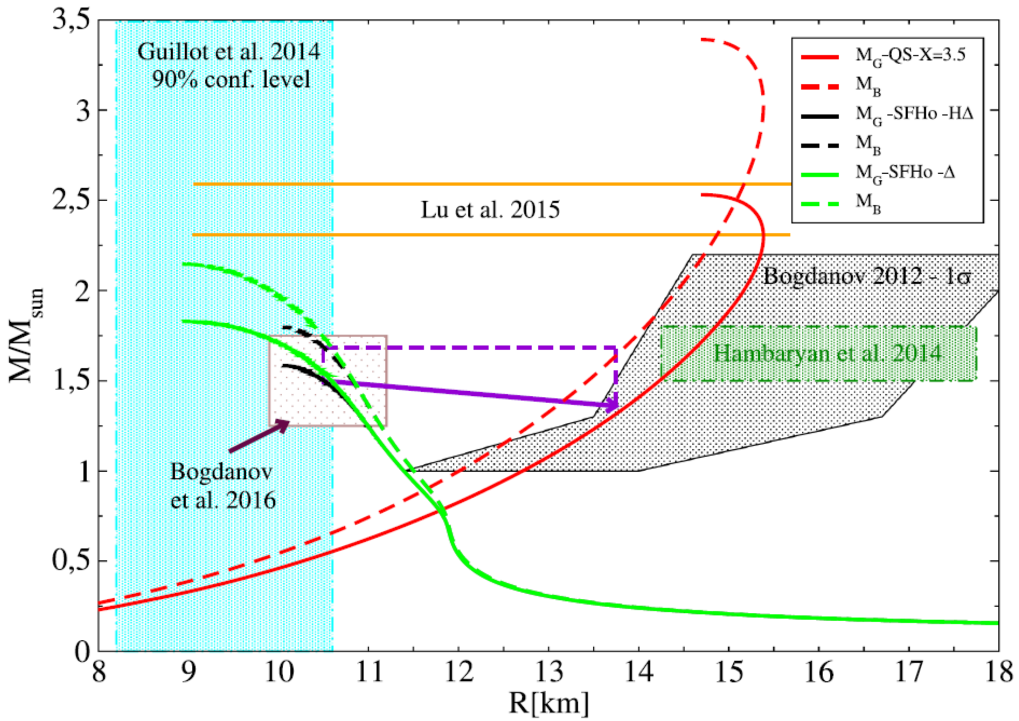


Note that in B and D the formation of quarks triggers the instability, i.e. quarks are at the origin of the instability producing the formation of the second configuration.

At variance, in the two-families scenario the first family becomes chemically unstable while quark are not yet present. The quark matter phase stabilizies the system.

A model with a strong phase transition: two-families of compact stars. Stars made of hadrons co-exist with stars made of strange quark matter

G. Wiktorowicz, A.Drago, G. Pagliara, S. Popov; Astrophys. J. 846 (2017) 163



The existence of strange quark stars is based on the validity of the validity of the Witten's hypothesis, telling that the absolute ground state of matter is made of a mix of deconfined up, down and strange quarks.

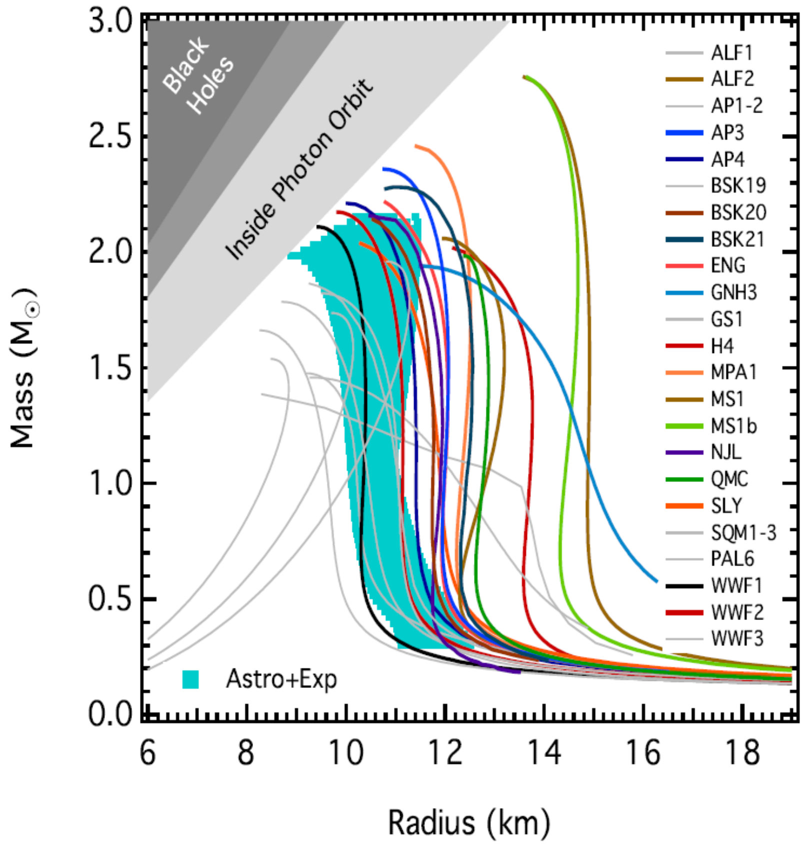
The velocity of sound in quark matter need not to be close to 1 in this scheme.

Massive stars have larger radii, at variance with models based on one family and with the twin stars scenario.

The process of quark deconfinement is triggered by the formation of a large hyperon content (or maybe by kaon condensation) at the center of the hadronic star.

Small radii from x-ray spectra

Oezel and Freire,
Ann.Rev.Astron.Astrophys. 54 (2016) 401

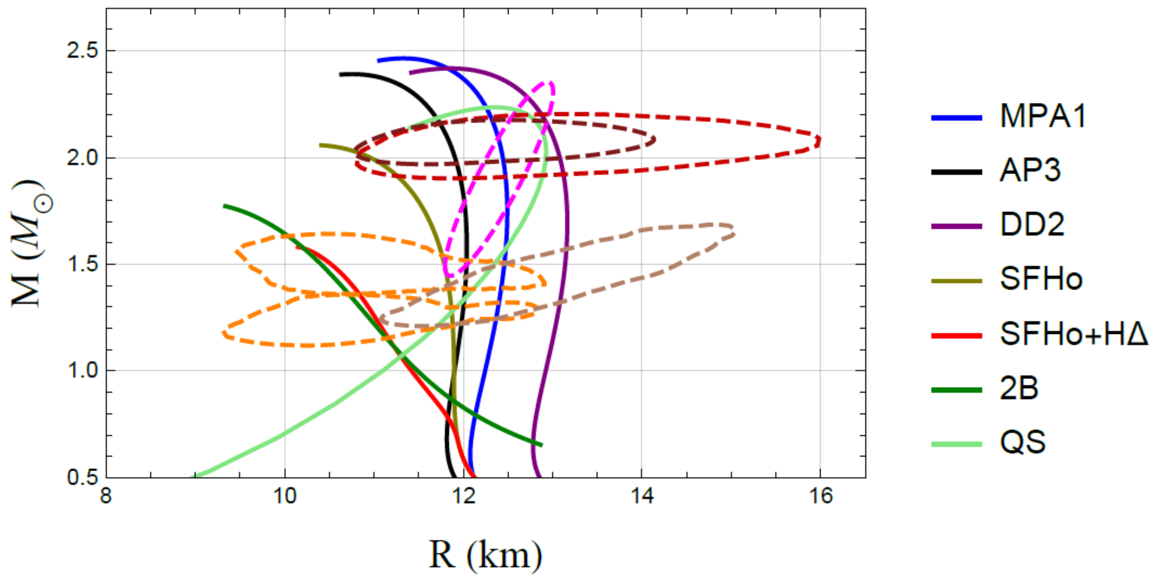


Steiner et al. MNRAS 476 (2018) 412
«Our model with the largest evidence suggests that $R_{1.4}$ is less than 12 km to 95 percent of confidence»

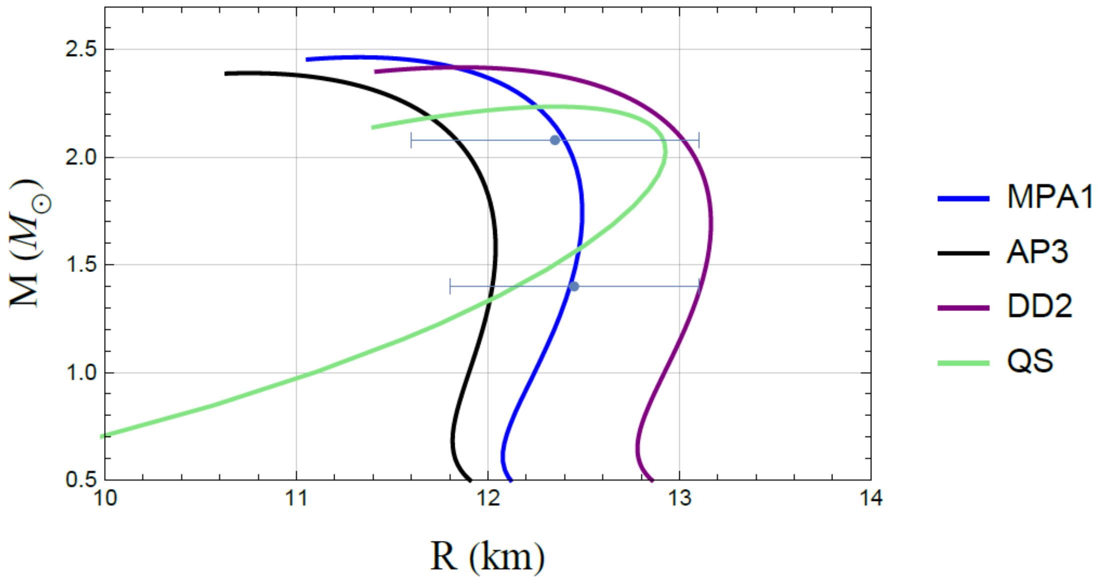
d’Etivaux et al. ApJ 887 (2019) 48
“In our analysis, we have shown that without nuclear physics inputs, the constant-RNS approximation prefers radii around ~11.1 +/- 0.4 km “

NICER results and representative EoSs

2106.16151, F. Di Clemente, A.D. and G. Pagliara



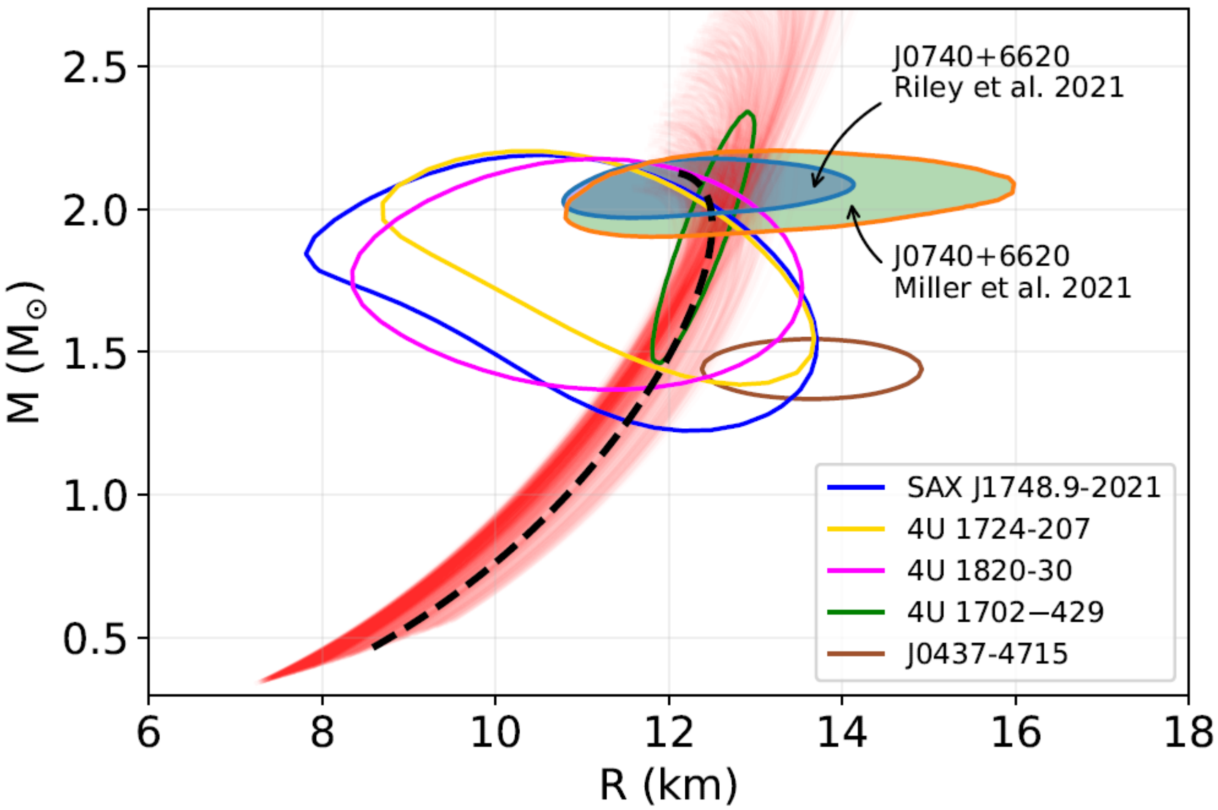
NICER results for PSR J0740+6620: brown from Riley et al. (2021) and dark red from Miller et al. (2021). NICER results for PSR J0030+0451, sepia, from Riley et al. (2019). Violet, limits on 4U 1702-429 from Nattila et al. (2017). Orange, limits from GW170817 from Abbott et al. (2018).



Limits on the radius at 68% of credibility interval for stars with masses 1.4 Ms and 2.08 Ms based on the analysis of NICER results and on GW170817 (Miller et al. 2021), with three nucleonic EoSs and a QS. The nucleonic EoSs are MPA1 (Muther et al. 1987), DD2 (Typel et al. 2010), AP3 (Akmal et al. 1998), SFHo (Steiner et al. 2013). SFHo+HD (Drago et al. 2014b) incorporates Δ-resonances and hyperons and 2B is a soft piece-wise polytropic used as a reference (Markakis et al. 2009).

NICER analysis of J0740+6620 suggests a rather stiff EOS: a QS satisfies perfectly that request. Analysis NOT based onto J0740+6620, whose radius is predicted

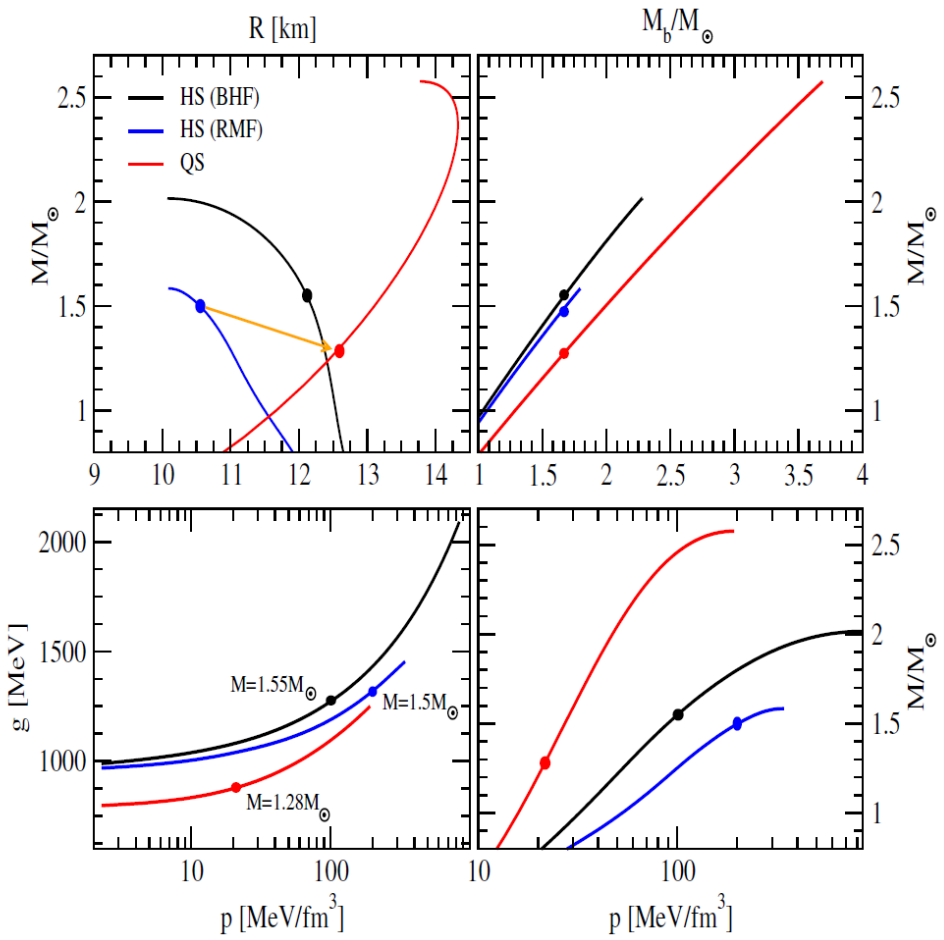
Traversi, Char, Pagliara, Drago, sent for publication

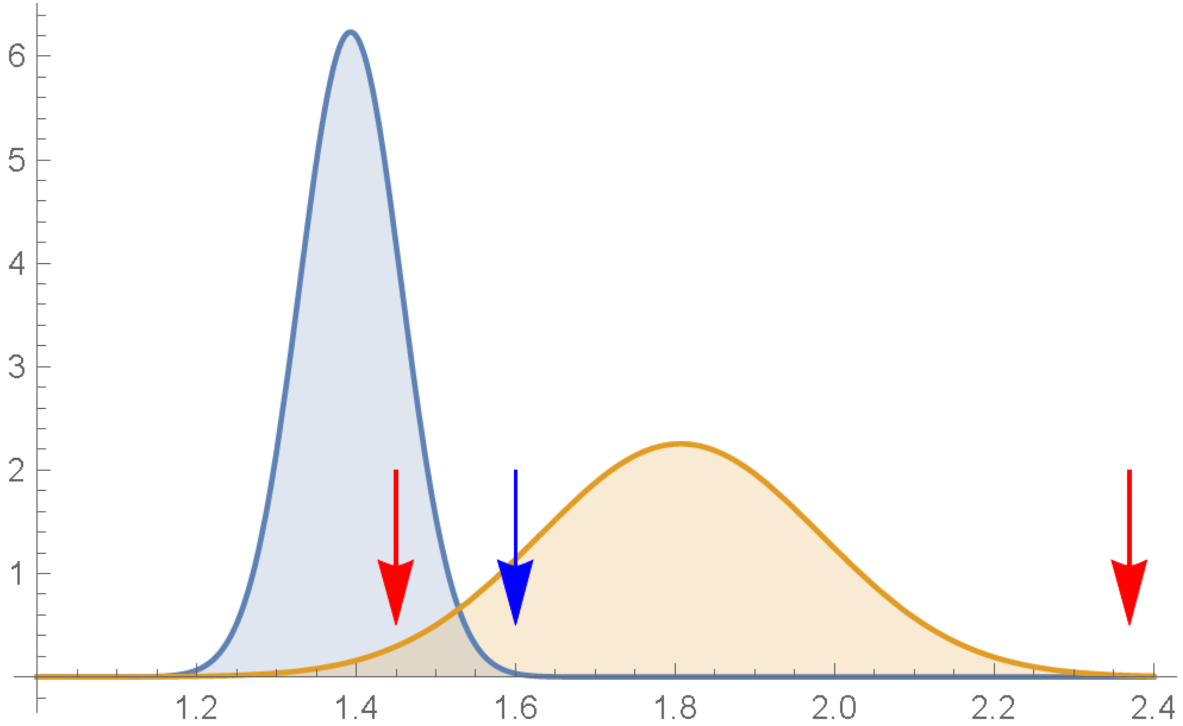


No indication of softening at large masses: it raises doubts on the twin stars scenario. Perfectly fine for the two-families scenario.

Evidence of bimodality in the mass distribution of MSPs with a WD companion (from Antoniadis et al. 2016 and Tauris et al. 2017) compared with the two-families scenario

Bombaci, I., Drago, A., Logoteta, D., Pagliara, G., & Vidana, I. 2021, Phys. Rev. Lett., 126, 162702,





The Rough Guide to dense matter in compact stars

- $R_{1.4}$ >= 13 km or I_{45} >= 1.6 purely nucleonic stars ($\rho_{max} \leq 3\ \rho_0$)
- 11.5 km < $R_{1.4}$ < 13 km or 1.3 <= I_{45} <= 1.6 hyperonic or hybrid stars (ρ_{max} as large as 5 ρ_0)
- $R_{1.4}$ << 11.5 km or I_{45} << 1.3 two-families or twin stars (solutions in which a new stable branch entirely or almost entirely made of deconfined quarks is present), but the twin-stars scenario is maybe already ruled out by NICER results.

The role of eXTP

The main prediction of the two-families scenario is the existence of compact stars having masses ≤ 1.5 M_s with radii smaller than those of compact stars having masses ≥ 1.5 M_s .

The most interesting objects for this scenario have masses in the range (1.3 -- 1.4) M_s, since they should be hadronic stars (first family) with small radii.

Among the possible targets of eXTP are rotation-powered pulsars having masses:

- PSR J1614−2230 with $M = (1.928 \pm 0.017)\ M_\odot$,
- PSR J0751+1807 with $M = (1.64 \pm 0.15)\ M_\odot$,
- PSR J1909−3744 with $M = (1.54 \pm 0.027)\ M_\odot$,
- PSR J2222−0137 with $M = (1.20 \pm 0.14)\ M_\odot$.

In the two-families scenario we expect radii in excess of about 12-13 km for the most massive objects, but the radius of PSR J2222−0137 can be significantly smaller, of the order of 11 km or even smaller. The detection of such a behaviour, not possible to interpret in the absence of a strong first order transition and opposite respect to the twin-stars scenario would constitute a clear indication of the validity of the two-families scenario.