Third family with nonlocal chiral quark EoS

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1. **Nonlocal chiral quark model**
2. **Interpolation vs. medium-dependence of parameters**
3. **Compact hybrid star phenomenology**

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Nonlocal chiral quark model - generalized

$$S_E = \int d^4x \left\{ \bar\psi(x)\left(-i\partial\!\!\!/ + m_c\right)\psi(x) - \frac{G_S}{2} j_S^f(x) j_S^f(x) - \frac{H}{2}\left[j_D^a(x)\right]^\dagger j_D^a(x) - \frac{G_V}{2} j_V^\mu(x)\, j_V^\mu(x) \right\}$$

$$j_S^f(x) = \int d^4z\; g(z)\; \bar\psi(x+\frac{z}{2})\;\Gamma_f\,\psi(x-\frac{z}{2}),$$

$$j_D^a(x) = \int d^4z\; g(z)\; \bar\psi_C(x+\frac{z}{2})\;\Gamma_D\;\psi(x-\frac{z}{2})$$

$$j_V^\mu(x) = \int d^4z\; g(z)\; \bar\psi(x+\frac{z}{2})\; i\gamma^\mu\;\psi(x-\frac{z}{2}).$$

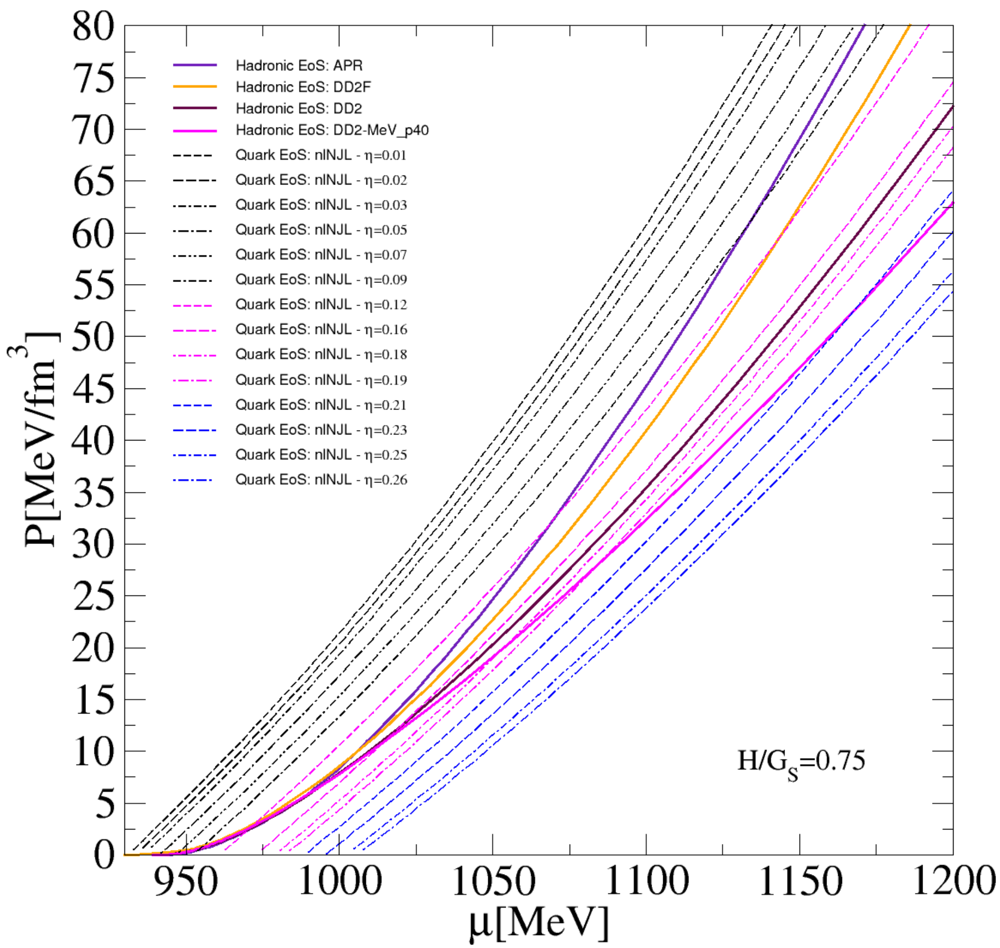
$$\Omega^{MFA} = \frac{\bar\sigma^2}{2G_S} + \frac{\bar\Delta^2}{2H} - \frac{\bar\omega^2}{2G_V} - \frac{1}{2}\int \frac{d^4p}{(2\pi)^4}\;\ln\det\left[\, S^{-1}(\bar\sigma, \bar\Delta, \bar\omega, \mu_{fc})\right]$$

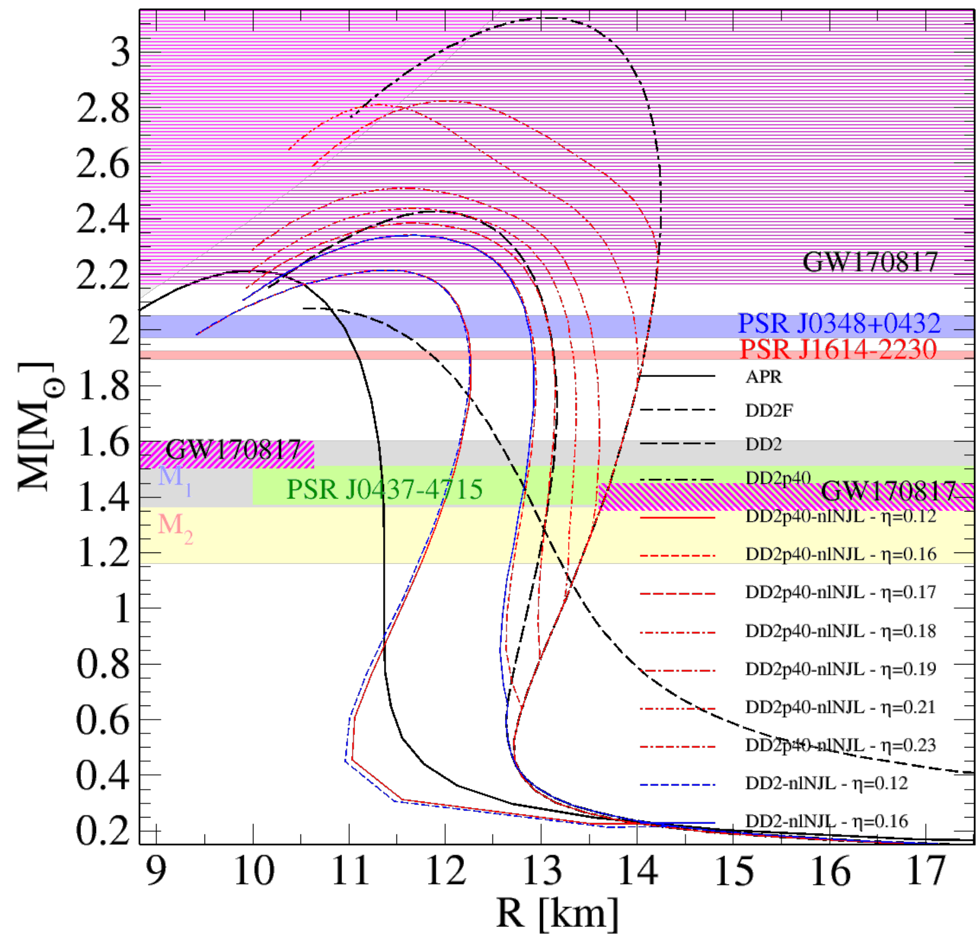
$$\frac{d\Omega^{MFA}}{d\bar\Delta} = 0\,, \quad \frac{d\Omega^{MFA}}{d\bar\sigma} = 0\,, \quad \frac{d\Omega^{MFA}}{d\bar\omega} = 0\,.$$

$$P(\mu;\eta,B) = -\Omega^{MFA} - B$$

D.B., D. Gomez-Dumm, A.G. Grunfeld, T. Klaehn, N.N. Scoccola, "Hybrid stars within a covariant, nonlocal chiral quark model", Phys. Rev. C 75, 065804 (2007)

Hybrid EoS and Hybrid Stars





No third family – no twins!

Interpolation vs. medium dependence of coefficients

$$P(\mu) = [f_<(\mu)P(\mu;\eta_<,B) + f_>(\mu)P(\mu;\eta_<,0)]f_\ll(\mu) + f_\gg(\mu)P(\mu;\eta_>)$$

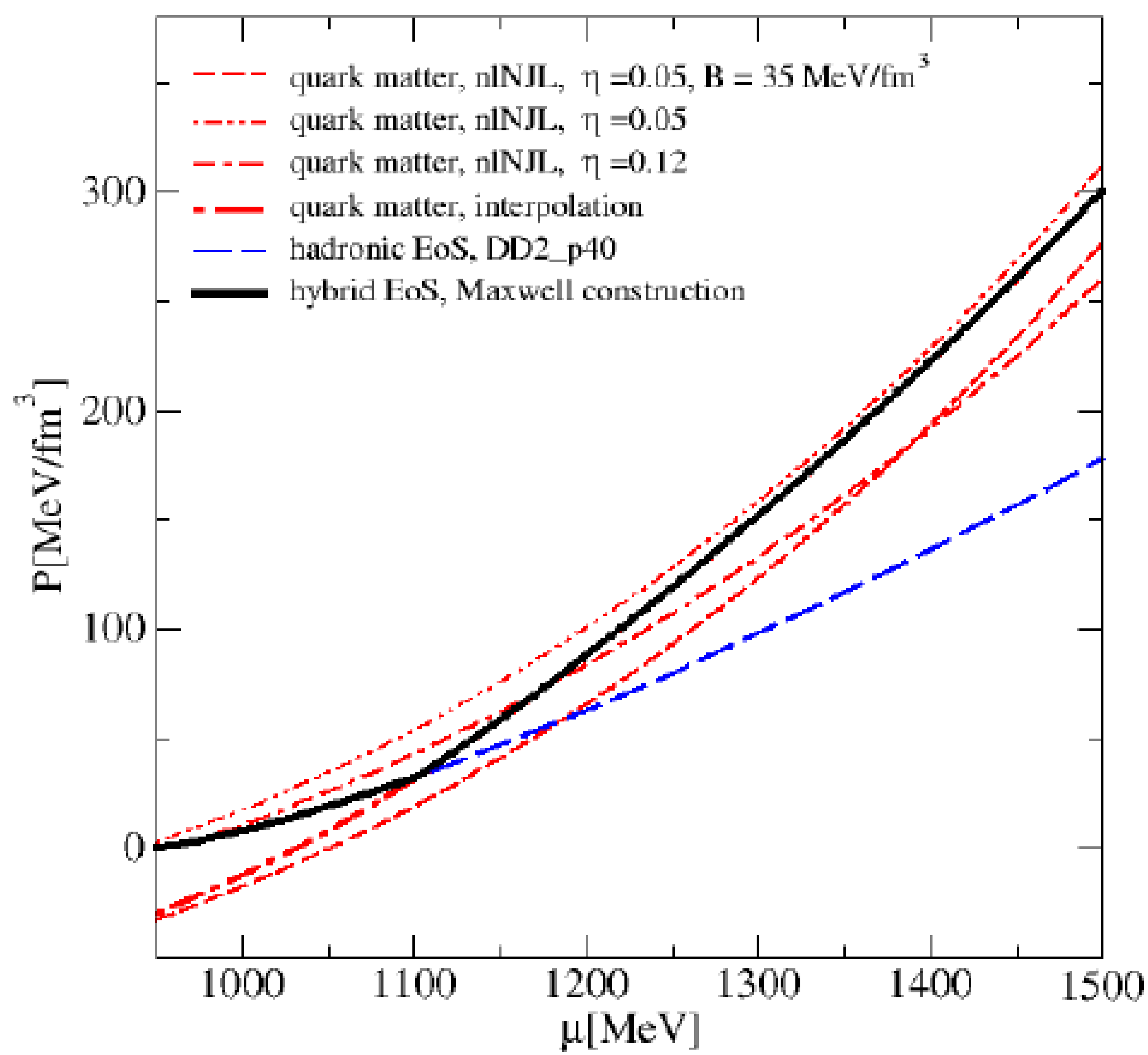
$$f_<(\mu) = \frac{1}{2}\left[1 - \tanh\left(\frac{\mu-\mu_<}{\Gamma_<}\right)\right],$$

$$f_\ll(\mu) = \frac{1}{2}\left[1 - \tanh\left(\frac{\mu-\mu_\ll}{\Gamma_\ll}\right)\right]$$

$$f_>(\mu) = 1 - f_<(\mu)\ ,$$

$$f_\gg(\mu) = 1 - f_\ll(\mu).$$

	set 1	set 2	set 3
$\mu_<$ [MeV]	1600	1150	1090
$\Gamma_<$ [MeV]	270	170	170
$\mu_\ll$ [MeV]	1500	1700	1700
$\Gamma_\ll$ [MeV]	300	300	300
B [MeV/fm^3]	35	35	35
$\eta_<$	0.09	0.05	0.05
$\eta_>$	0.12	0.12	0.12



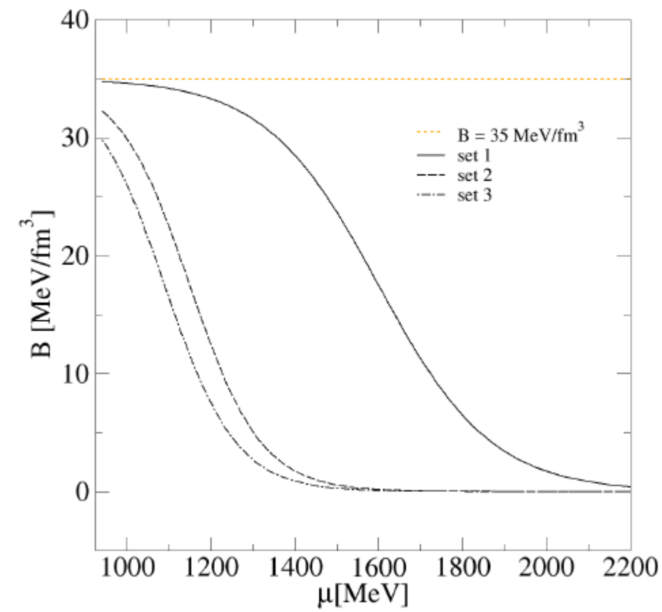
Interpolation vs. medium dependence of coefficients

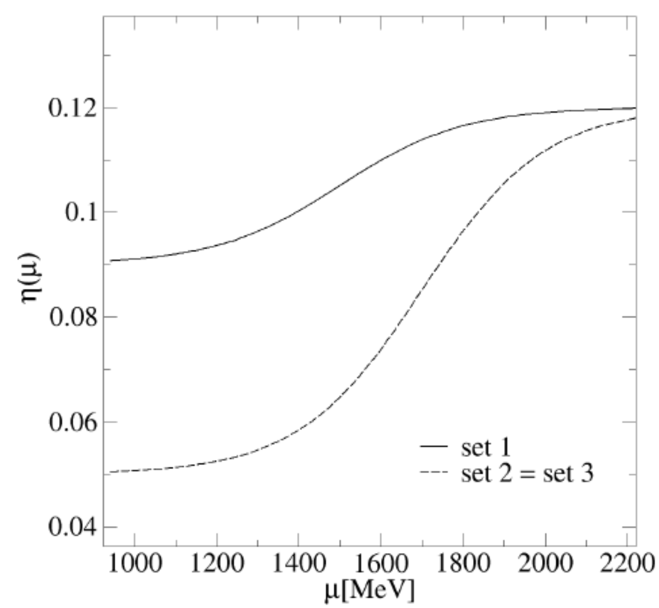
$$
\begin{aligned}
P(\mu) &= P(\mu;\eta,B)f_<(\mu) + P(\mu;\eta,0)f_>(\mu) \\
&= P(\mu;\eta,0)[f_<(\mu)+f_>(\mu)] - Bf_<(\mu) \\
&= P(\mu;\eta,B(\mu)),
\end{aligned}
$$

$B(\mu) = Bf_<(\mu)$ is the $\mu-$dependent bag pressure

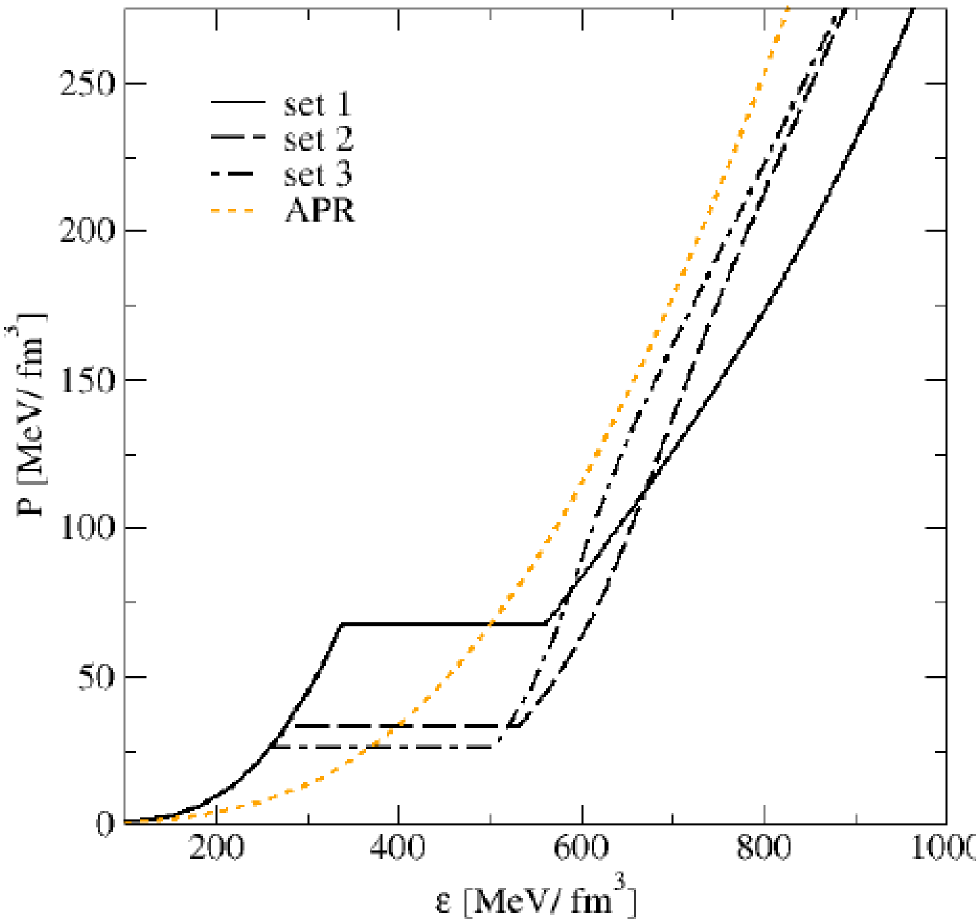
$$
\begin{aligned}
P(\mu) &= P(\mu;\eta_<,B)f_\ll(\mu) + P(\mu;\eta_>,B)f_\gg(\mu) \\
&= P(\mu;\eta_<,B)[f_\ll(\mu)+f_\gg(\mu)] \\
&\quad +(\eta_> - \eta_<)f_\gg(\mu)\frac{dP(\mu;\eta,B)}{d\eta}\bigg|_{\eta=\eta_<} \\
&= P(\mu;\eta_<,B) \\
&\quad +[\eta_> f_\gg(\mu) + \eta_< f_\ll(\mu) - \eta_<]\frac{dP(\mu;\eta,B)}{d\eta}\bigg|_{\eta=} \\
&= P(\mu;\eta(\mu),B)\ ,
\end{aligned}
$$

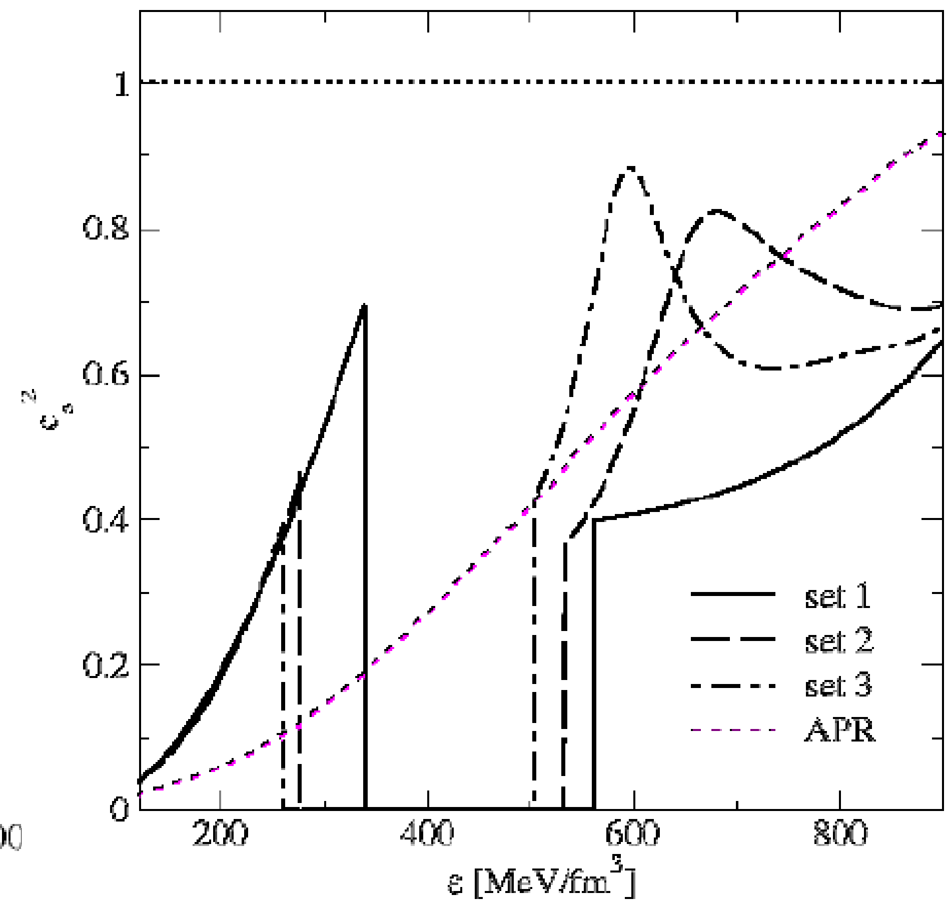
$\eta(\mu) = \eta_> f_\gg(\mu) + \eta_< f_\ll(\mu)$ is the medium-dependent vector meson coupling



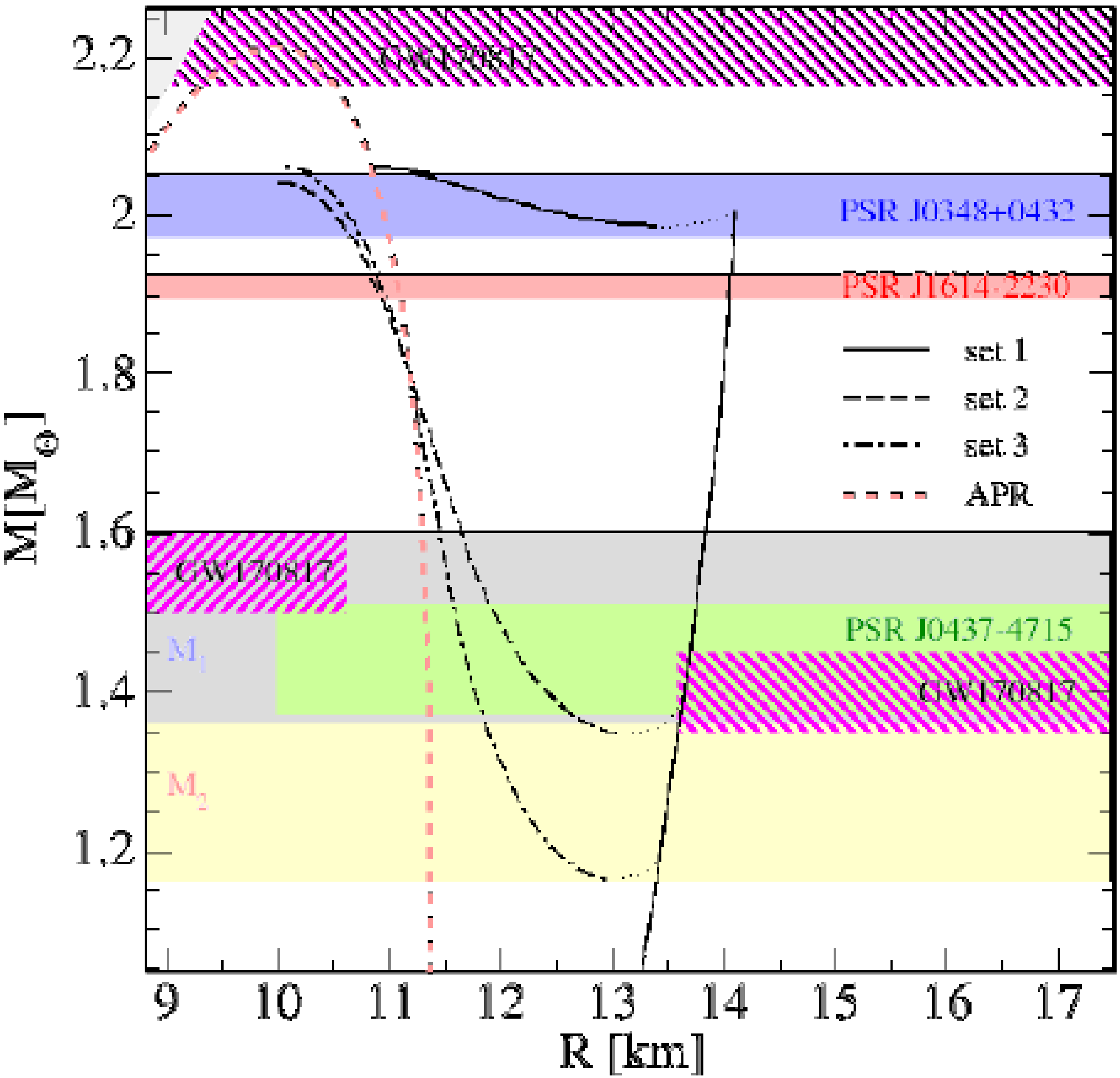


Hybrid star EoS

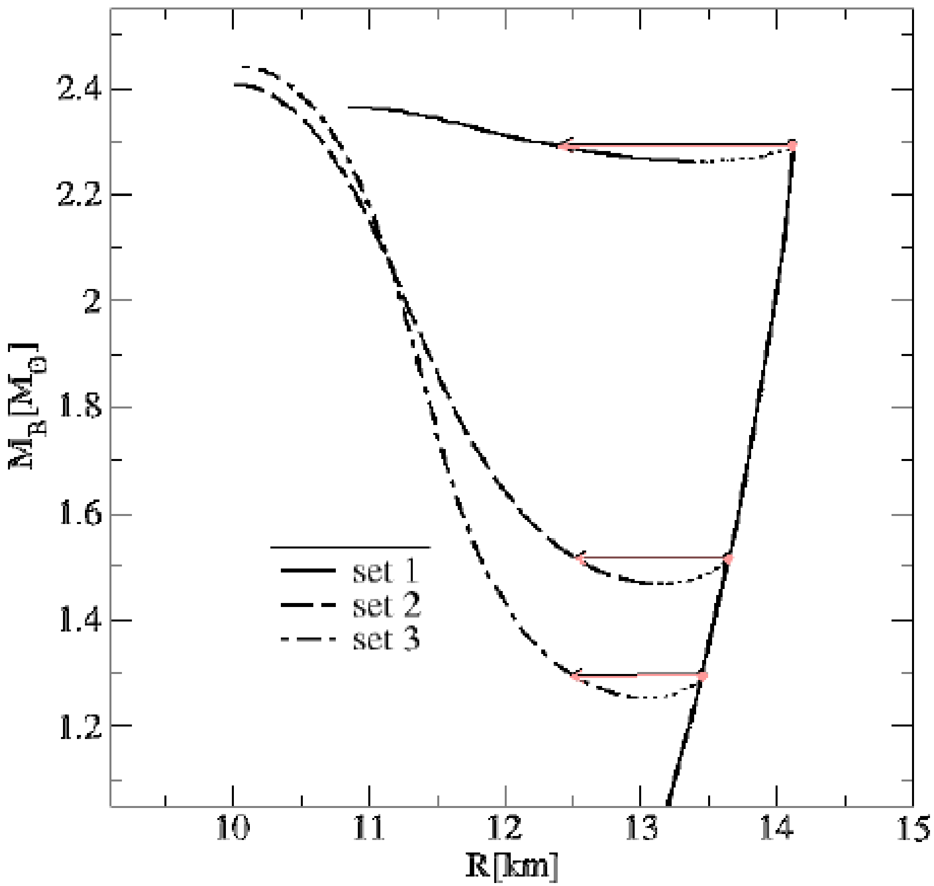


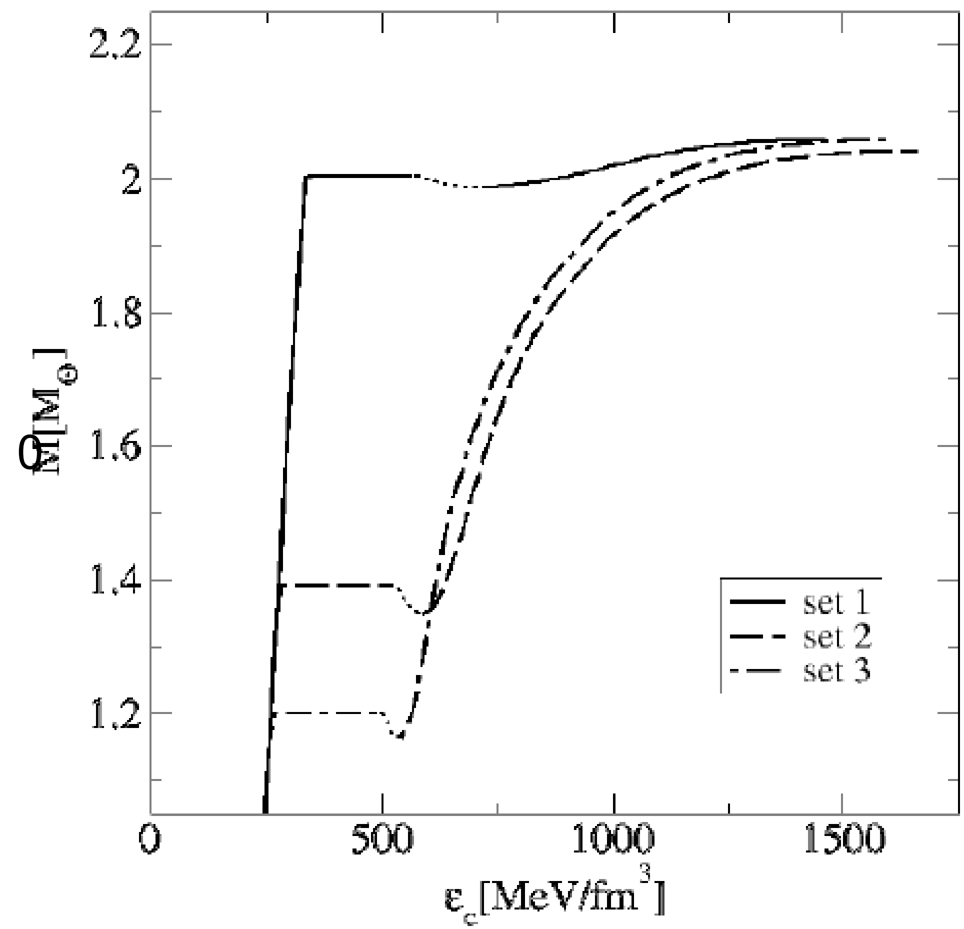


Hybrid star phenomenology

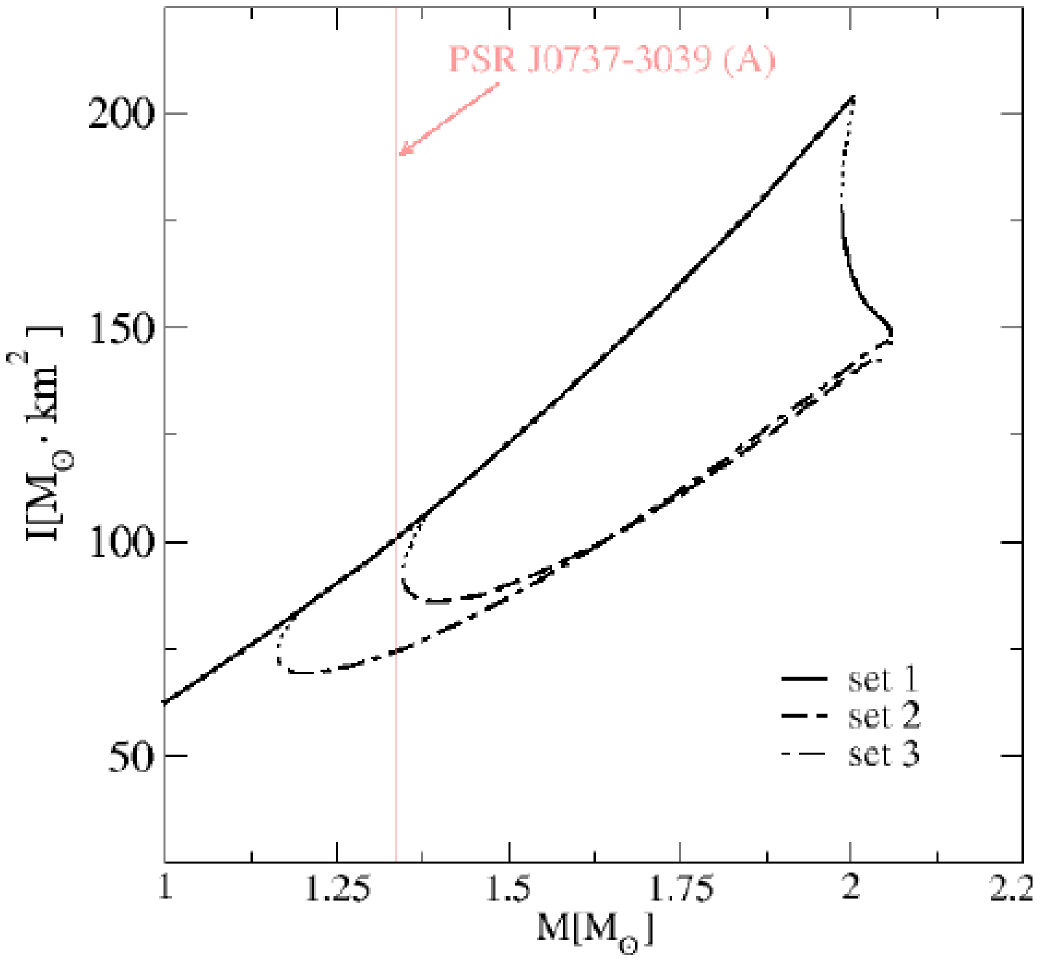


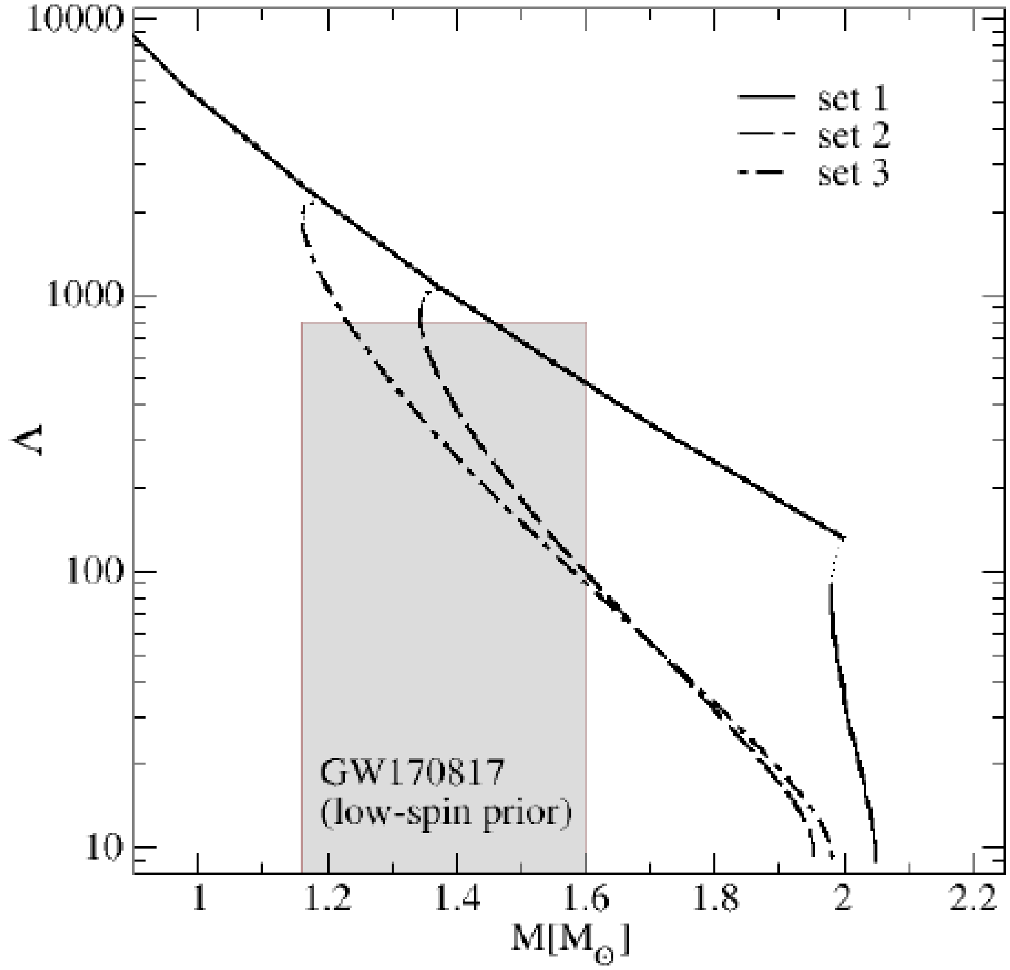
Hybrid star phenomenology



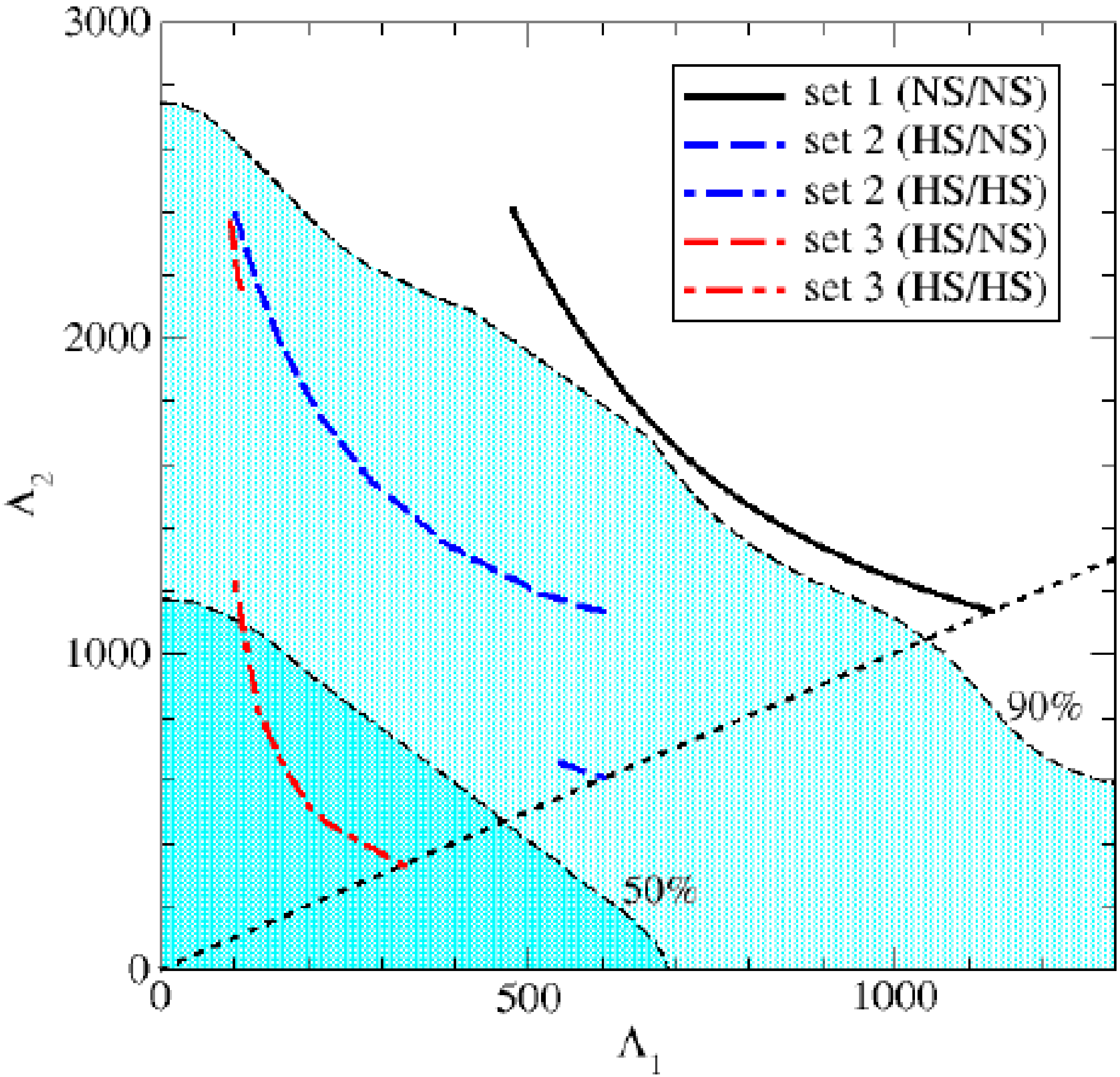


Hybrid star phenomenology





Hybrid star phenomenology



More details on:

arxiv:1805.04105v2