Primordial black holes: from their abundance to gravitational waves.

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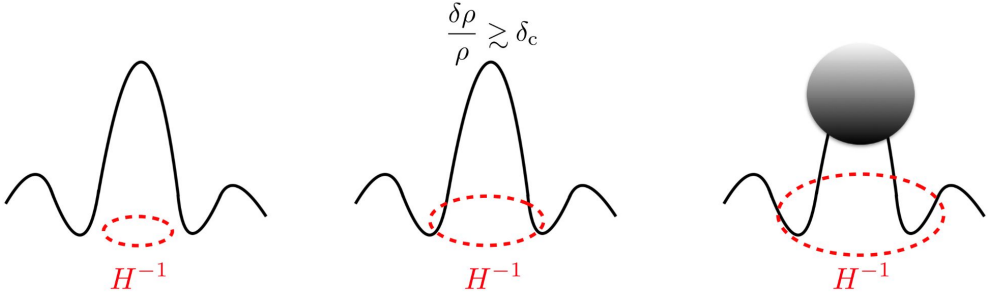
Black Holes: Astro vs Primordial

REVIEW:
A. M. Green and B. J. Kavanagh.–
arXiv:2007.10722

Astro BH: forms from the gravitational collapse of a star.

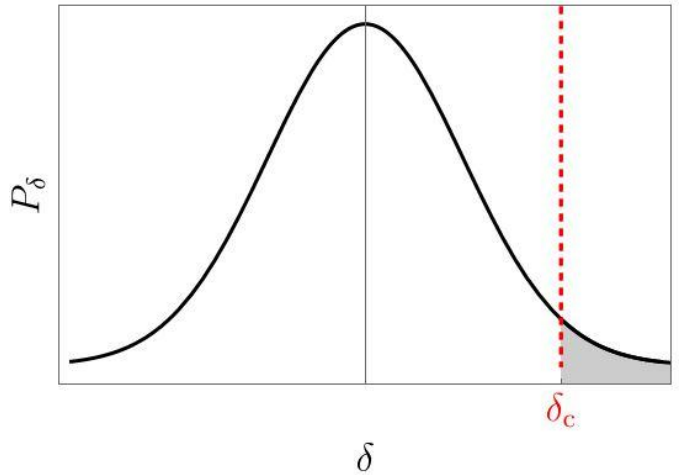
$$M > \mathcal{O}(1)\, M_\odot$$

Primordial black holes (PBHs):

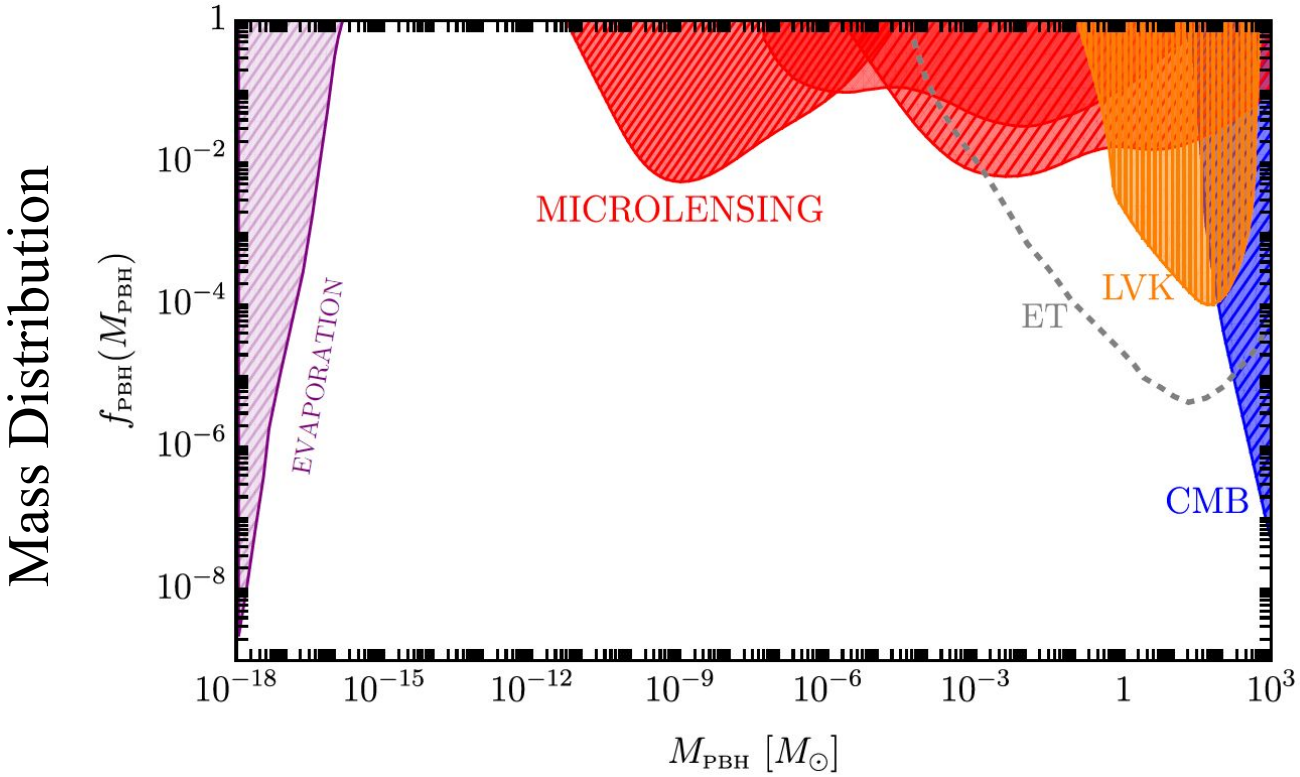


$$M_{\rm PBH} \sim M_{\rm H}$$

$$\beta = \int_{\delta_c}^{\infty} \mathcal{K}(\delta - \delta_c)^\gamma \, \mathrm{P}_\delta(\delta) d\delta$$



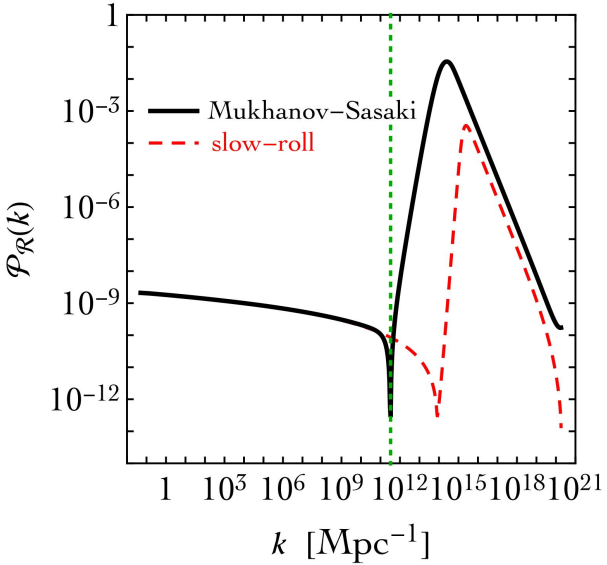
Primordial Black Holes as DM candidates



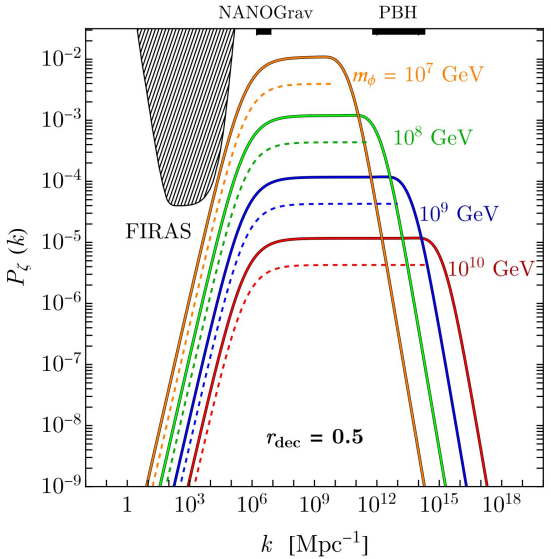
Models for PBH formation

What we can compute during inflation is the curvature perturbation field ζ (or *R*).
In order to get a sizeable amount of DM $P_\zeta \simeq 10^{-2}$ or 10^{-3}

PBH as Dark Matter:
- USR models
- Curvaton field
- And etc etc…



arXiv:2001.08220 (JCAP)
G.Ballesteros, J. Rey, M. Taoso, A.Urbano



arXiv:2305.13382 (JCAP)
G.Ferrante, G.Franciolini, A.J.I., A.Urbano

PBH abundance depends on the amplitude and shape of the power spectrum and on the amount of NGs.

arXiv:2211.01728 (PRD) G.Ferrante, G.Franciolini, A.J.I., A.Urbano

PBH and SIGW background

By a second-order effect when scalar perturbations re-enter the horizon.

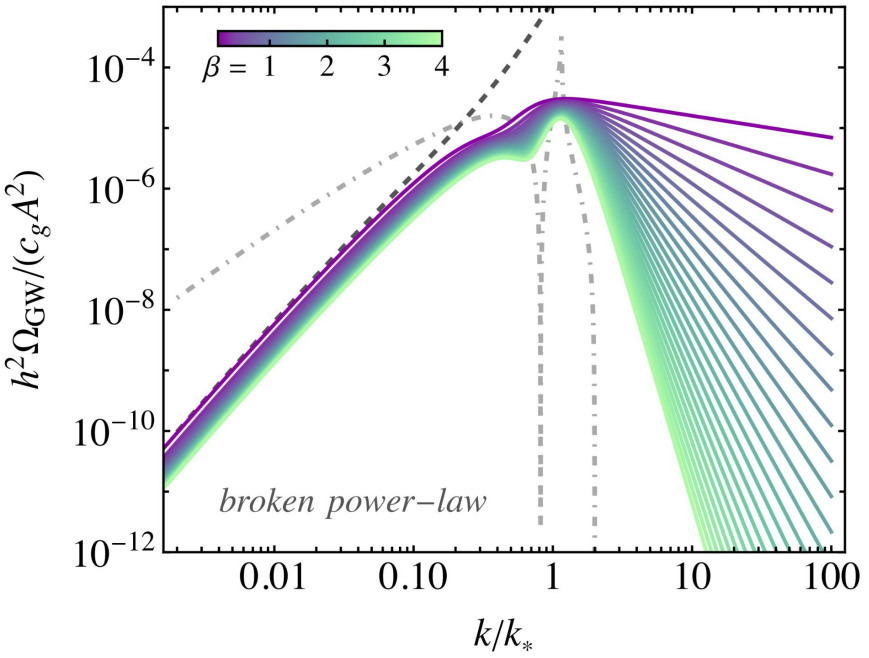
$$h^2\Omega_{\rm GW}(k) = \frac{h^2\Omega_r}{24}\left(\frac{g_*}{g_*^0}\right)\left(\frac{g_{*s}}{g_{*s}^0}\right)^{-\frac{4}{3}}\mathcal{P}_h(k)$$

REVIEW G. Domenech– arXiv:2109.01398

$$f = 1.6\,\mathrm{nHz}\left(\frac{k}{10^6\,\mathrm{Mpc}^{-1}}\right)$$

$$\mathcal{P}_\zeta^{\rm BPL}(k) = A\frac{(\alpha+\beta)^\gamma}{\left(\beta\,(k/k_*)^{-\alpha/\gamma} + \alpha\,(k/k_*)^{\beta/\gamma}\right)^\gamma}$$

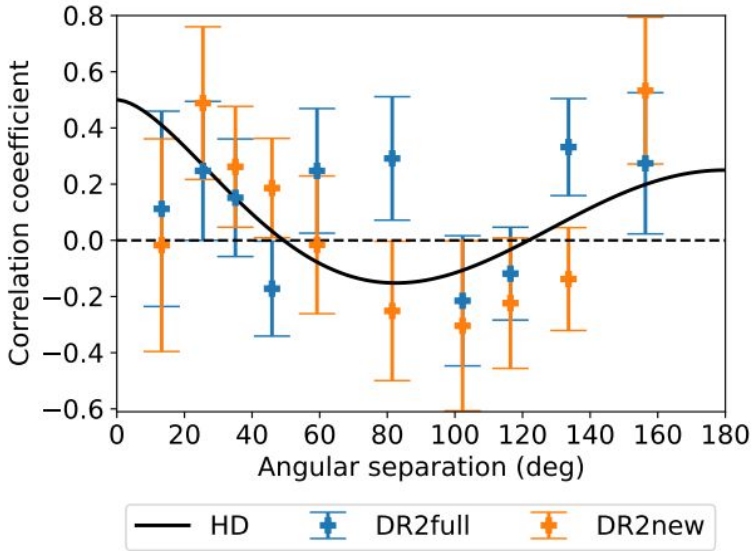
$$\mathcal{P}_h(k) \propto \mathcal{P}_\zeta^2(k)$$



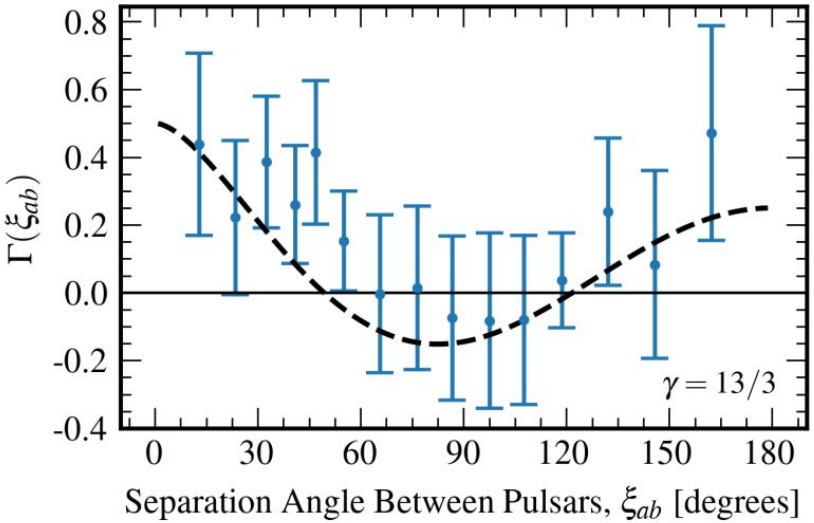
Pulsar Timing Arrays last year

Several PTA collaborations show that the correlations follow the Hellings–Downs pattern expected for a stochastic gravitational-wave background. (See Kai and Stanislav Talks)

EPTA – arXiv:2306.16214

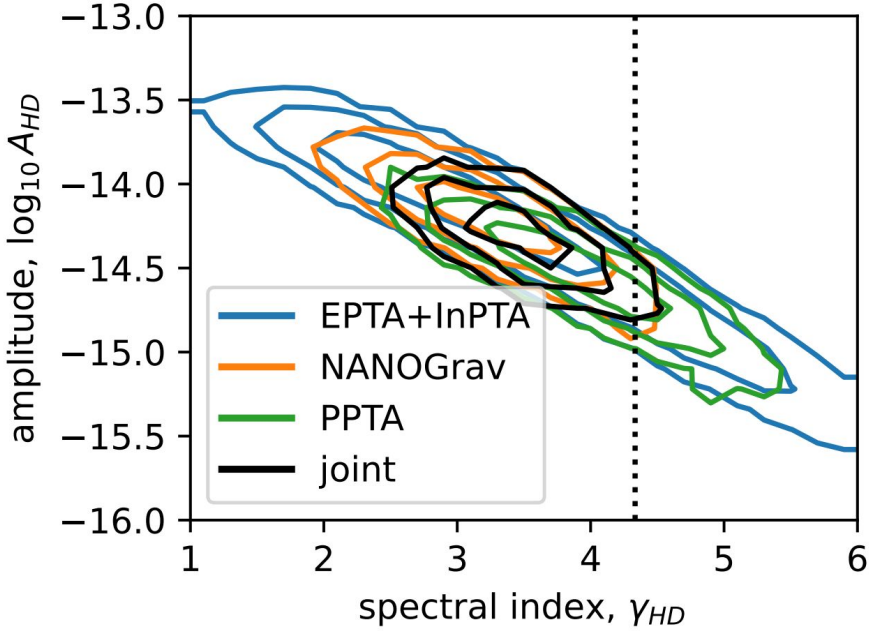


NANOGrav – arXiv:2306.16213
arXiv:2306.16219

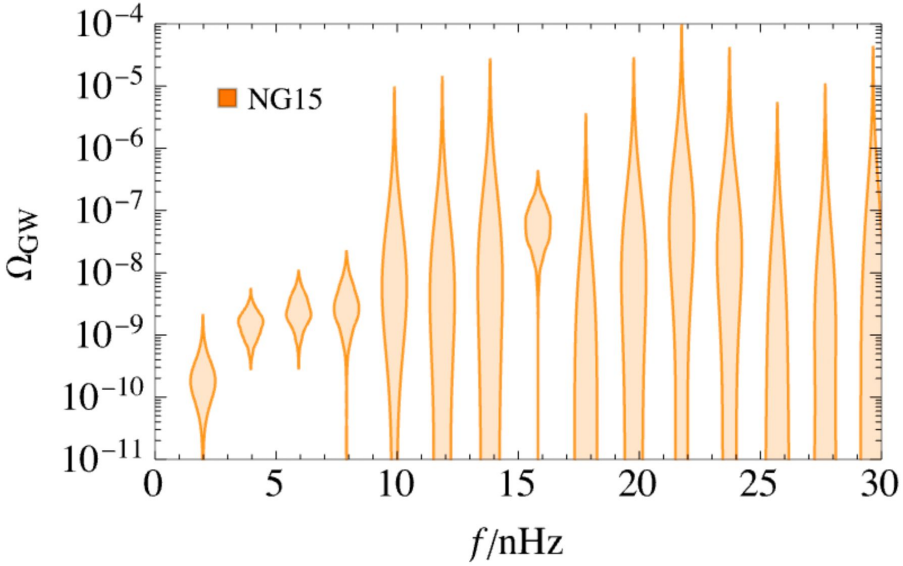


Pulsar Timing Arrays last year

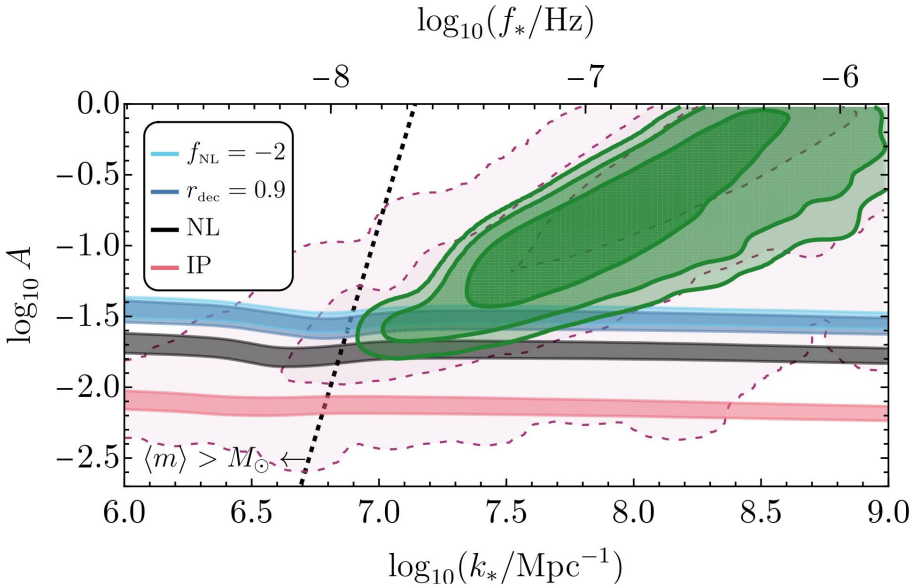
IPTA – arXiv:2309.00693

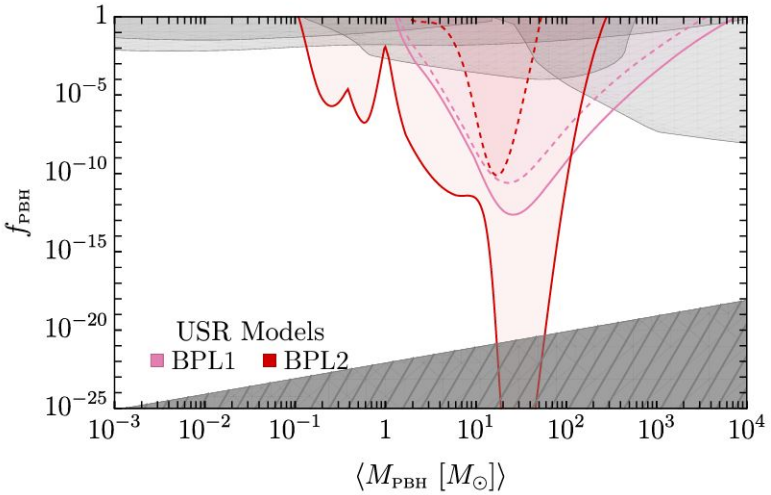


NANOGrav – arXiv:2306.16213
arXiv:2306.16219



PBHs as a possible explanation for the PTA experiments





arXiv:2306.17149 (*PRL*)
G.Franciolini, A.J.I., V. Vaskonen, H. Veermae

arXiv:2406.20089
A.J.I. G.Perna, A.Riotto and H.Veermae

The role of NGs: (Left) The tension between PTA and the PBH explanation can be alleviated for models where large negative NGs suppress the PBH abundance.
(Right) Solar Mass PBHs are possible only in model with positive NGs.

Conclusions

PBHs are very interesting objects.

It is essential to accurately calculate the abundance of PBHs to determine not only if they can be dark matter but also if they can explain recent observations related to GWs (PTA and LVK).