Constraining peaked power spectrum

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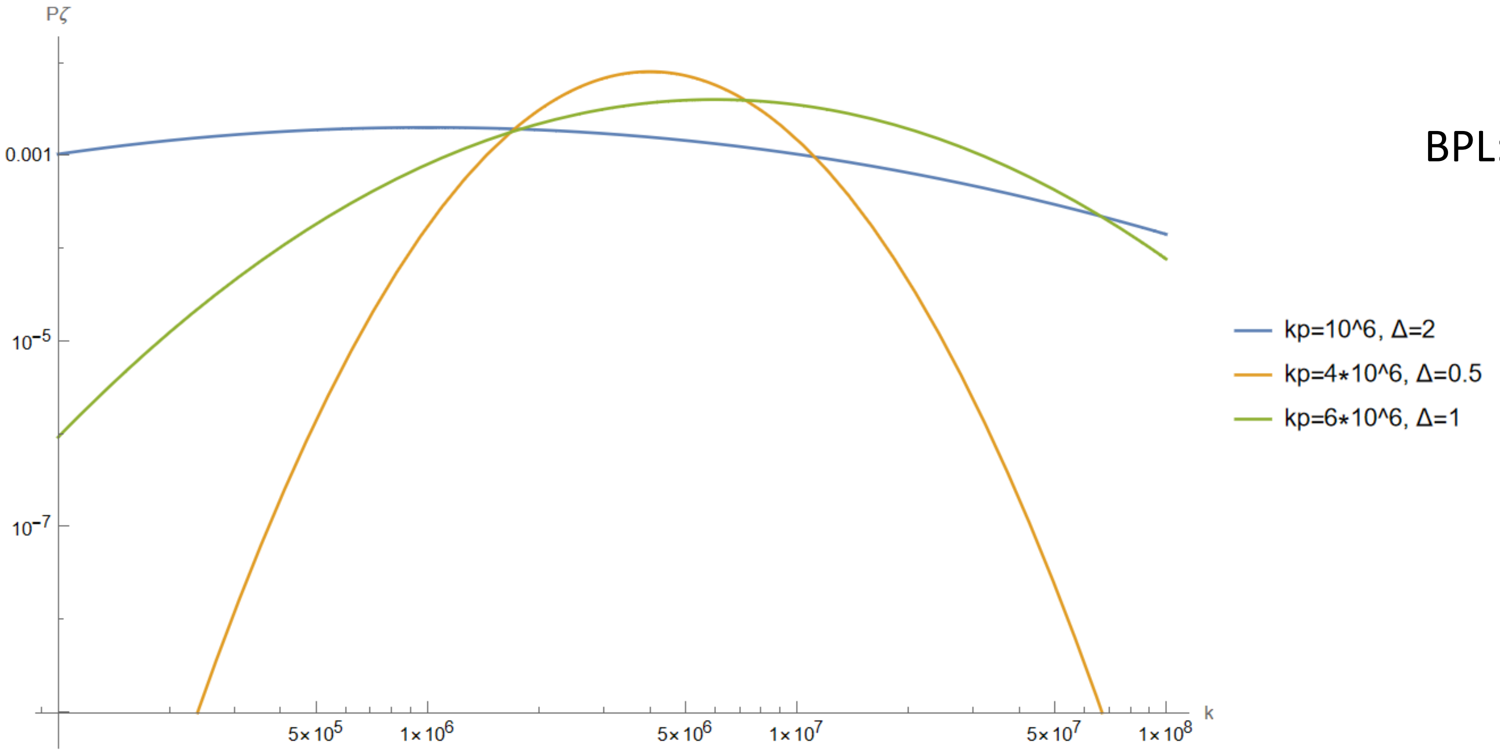
Peaked power spectra

The curvature perturbation power spectrum provides a complete description of the properties of curvature perturbations. Two examples that I have studied:

LN: $$\mathcal{P}_\zeta(k) = A\frac{1}{\sqrt{2\pi}\Delta}\exp\left(-\frac{\ln^2(k/k_p)}{2\Delta^2}\right)$$

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



Extended PBH mass distributions face many challenges. Peaked power spectra are easier to realise.

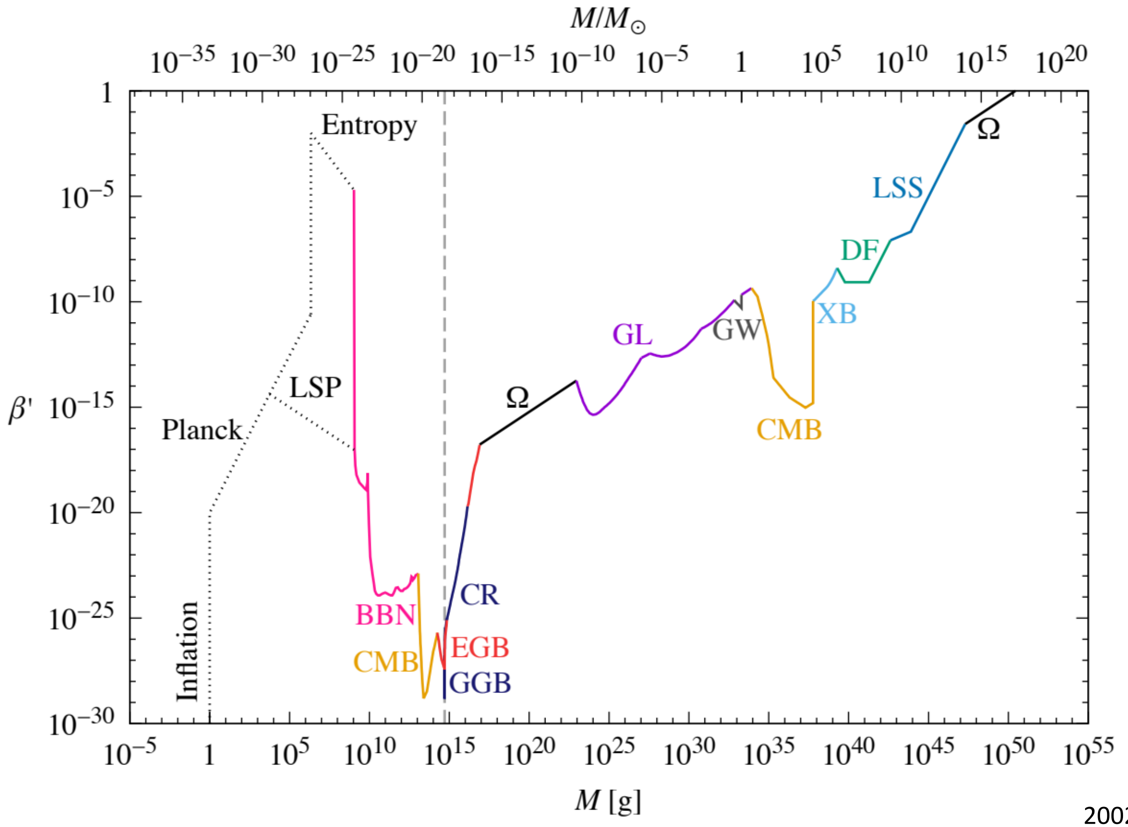
PBH abundances and direct constraints

The function β describes the mass fraction of the Universe that collapses to form PBHs at the time of formation.

In the Press-Schechter formalism, this is calculated via:

$$\beta = \mathrm{erfc}\left(\frac{\delta_c}{\sqrt{2\sigma^2}}\right)$$

Observational constraints have been placed on the abundance of PBHs. This can be used to place constraints on PPS amplitude.



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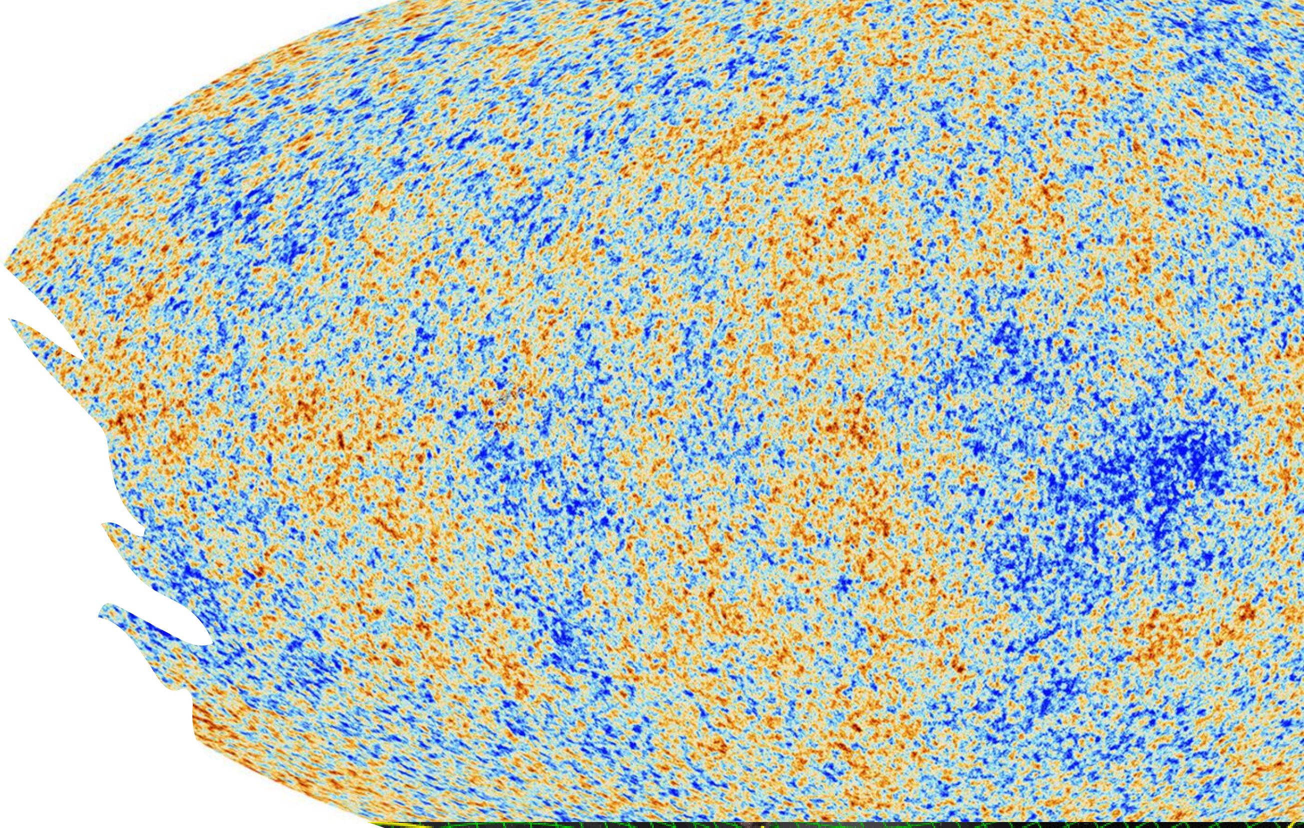
Indirect observational constraints

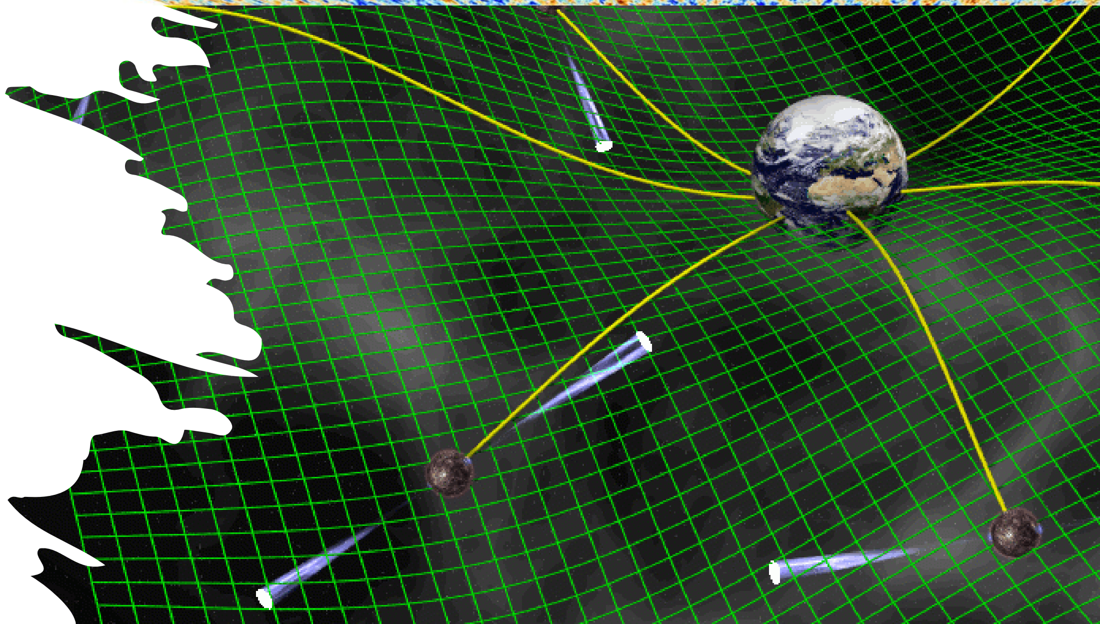
The large PPS amplitude required for PBHs to form has other implications in the early universe.

We can place constraints on the PPS through null-detections of:

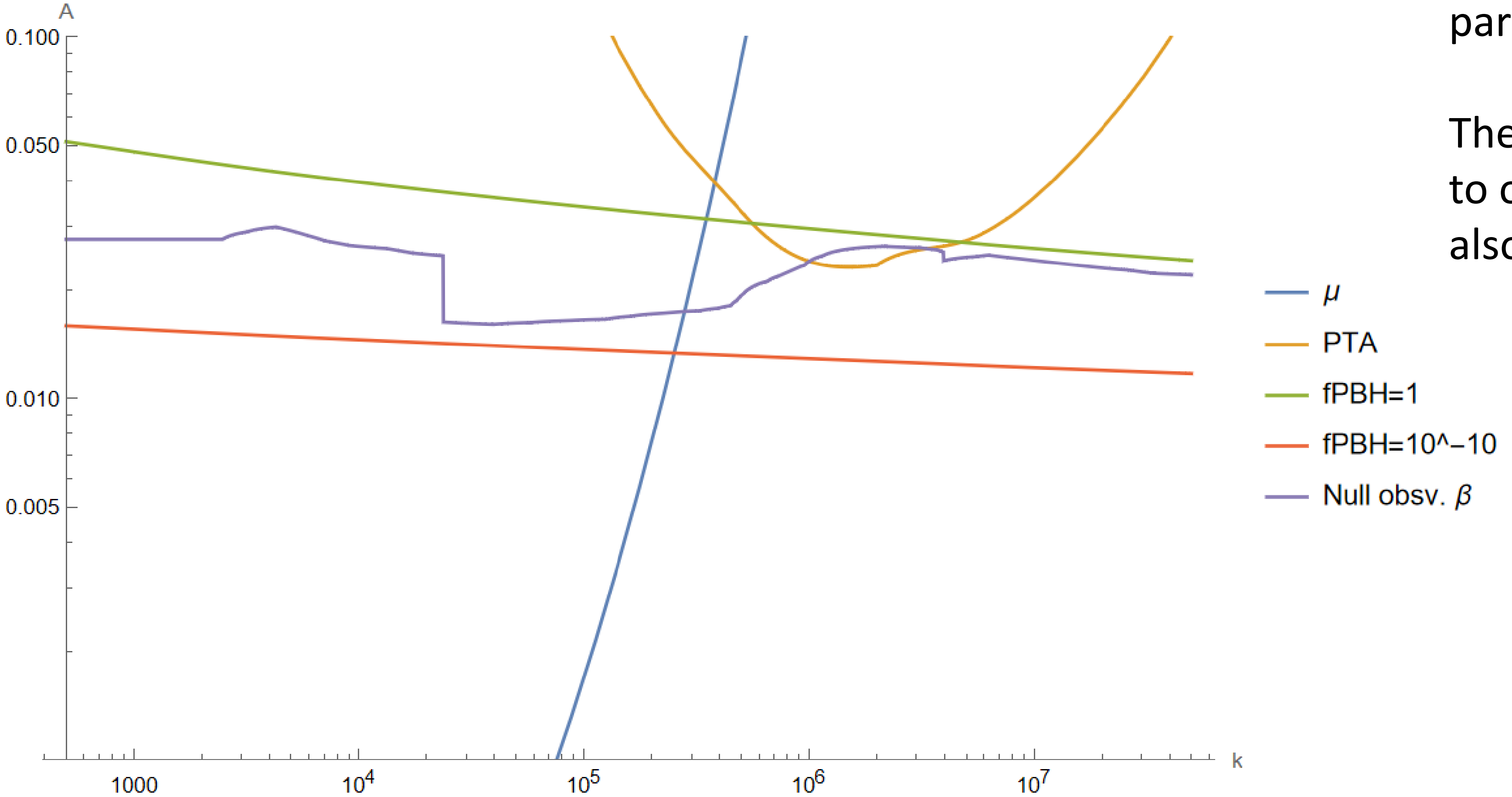
-Spectral distortions. Energy stored in perturbations dissipates, leading to deviations of the CMB's black-body temperature.

-PTAs. Large enough first-order scalar perturbations lead to a stochastic gravitational wave background.





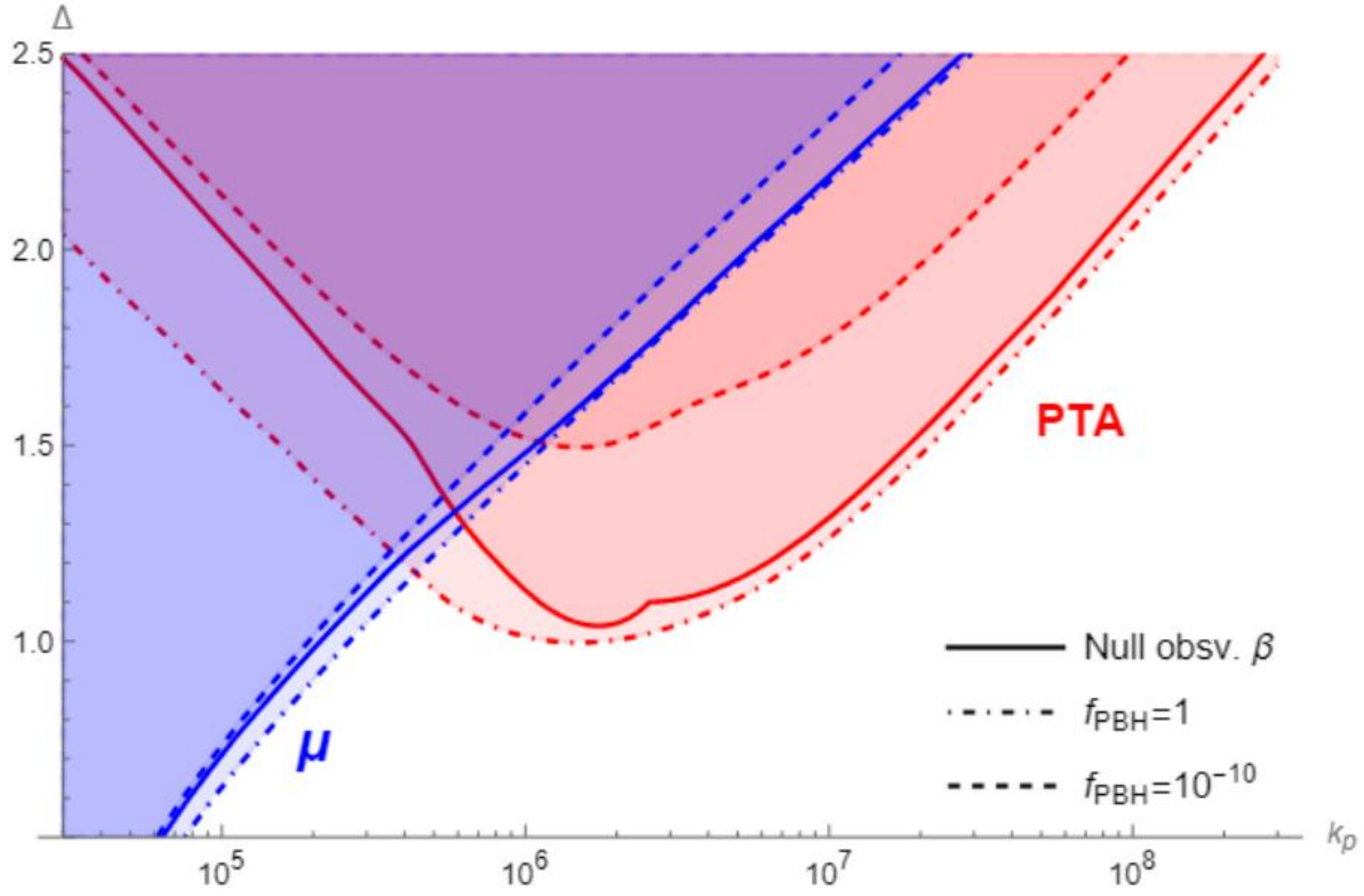
Combined constraints



We can plot each of the constraints on PPS amplitude, which will depend on power spectrum parameters.

The value of PPS amplitude needed to obtain different values of fPBH is also plotted.

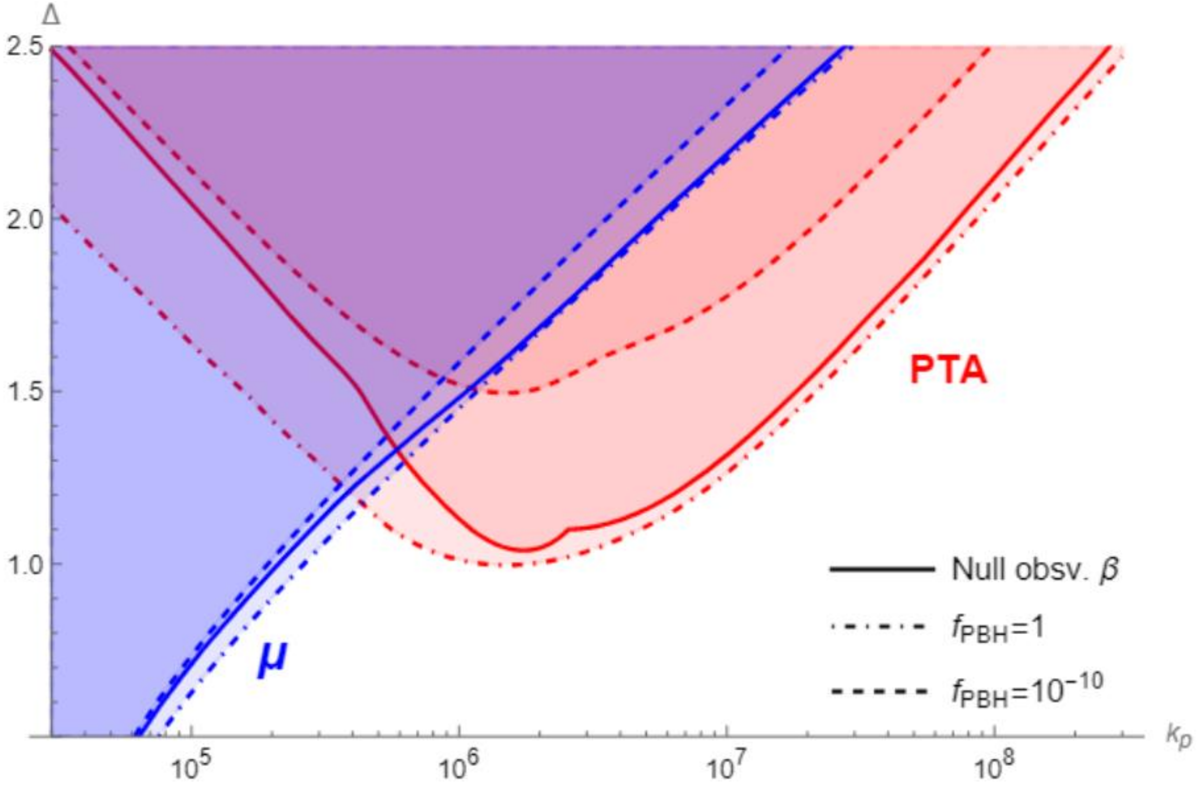
Parameter space constraints



We can combine each curve of the previous plot to constrain power spectrum parameters.

This can be done for any power spectrum!

In conclusion, there are many constraints on PBHs. These can in turn be used to constrain different parametrisations of the PPS.



Thanks for listening ☺

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