Tensor non-Gaussianities and fundamental physics

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A closer look to vacuum fluctuations

$$h_k'' + 2\mathscr{H} h_k' + k^2 h_k = 0$$

Homogeneous differential equation

$$h_k(\tau) = A_k \sqrt{-k\tau} H_\nu^{(1)}(-k\tau) + B_k \sqrt{-k\tau} H_\nu^{(2)}(-k\tau)$$

General solution

$$A_k = 1 \qquad B_k = 0$$

Bunch-Davies choice

$$B_k = \frac{\Lambda}{2H} \qquad A_k = \sqrt{1 + B_k^2}$$

Cut-off energy scale

$$P_{BD}^t = \frac{2H^2}{\pi^2 M_{Pl}^2}$$

Nearly scale invariant

$$P_{\alpha-vacua}^t = \frac{2H^2}{M_{Pl}^2 \pi^2} \left[1 + \frac{H}{\Lambda} \sin\left(\frac{2\Lambda}{H}\right) + \ldots \right]$$

Alpha-vacua

Danielsson: arxiv 0203198
Broy: arxiv1609.03570

For recent developments see: Kanno, Sasaki arxiv 2206.03667

Induced degeneracy by a stochastic source

Our set-up

$$h_k'' + 2\mathcal{H} h_k' + k^2 h_k = 16\pi G\, \Pi_k \qquad \tau \le \bar\tau(k)$$
$$h_k'' + 2\mathcal{H} h_k' + k^2 h_k = 0 \qquad \tau > \bar\tau(k)$$

$$\bar\tau(k) = -\frac{\Lambda}{kH}$$

Source

$$\hat\Pi_k^r(\tau) = \Pi_k(\tau)\hat a_k^r + \Pi_k^*(\tau)\hat a_{-k}^{r\dagger} \quad , \quad \langle \Pi_k(\tau)\rangle = 0, \quad \langle \Pi_k(\tau)\Pi_k^*(\tau')\rangle = \mathcal{N}\delta(\tau-\tau')F(k)$$

Matching

$$\tilde h_k(\bar\tau_-) = h_k(\bar\tau_+)$$
$$\tilde h_k'(\bar\tau_-) = h_k'(\bar\tau_+)$$

$$A_k = \frac{e^{ik\bar\tau}[\tilde h(\bar\tau)(-1+ik\bar\tau+k^2\bar\tau^2) - \tilde h_k'(\bar\tau)(\bar\tau - ik\bar\tau^2)]}{\sqrt{2}k^{3/2}\bar\tau^2}$$

$$B_k = \frac{e^{-ik\bar\tau}[\tilde h(\bar\tau)(-1-ik\bar\tau+k^2\bar\tau^2) - \tilde h_k'(\bar\tau)(\bar\tau + ik\bar\tau^2)]}{\sqrt{2}k^{3/2}\bar\tau^2}$$

Cielo, Mangano, Pisanti. arXiv:2209.xxxx

Phenomenological model for F(k)

Power-law:

$$F(k) = \left(\frac{k}{k_0}\right)^{\beta}$$

Black Hole gas model:

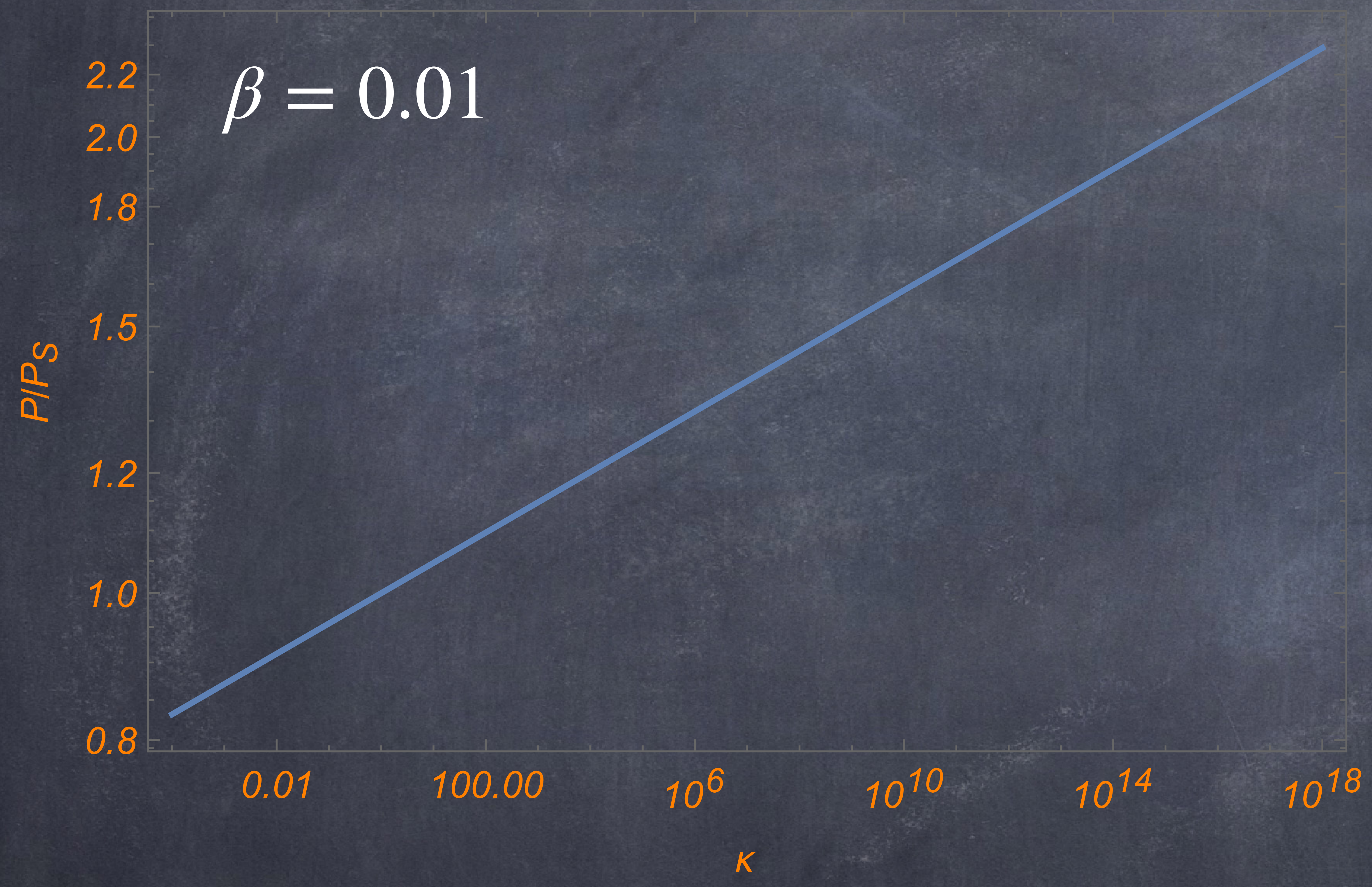
$$F(k) = \int_0^{\infty} \underbrace{\xi(M)dM}\, \underbrace{e^{-\frac{k_{phys}}{T_H}}}$$

$$\xi(M)dM = \frac{e^{-M/\Lambda}}{\Lambda}dM$$

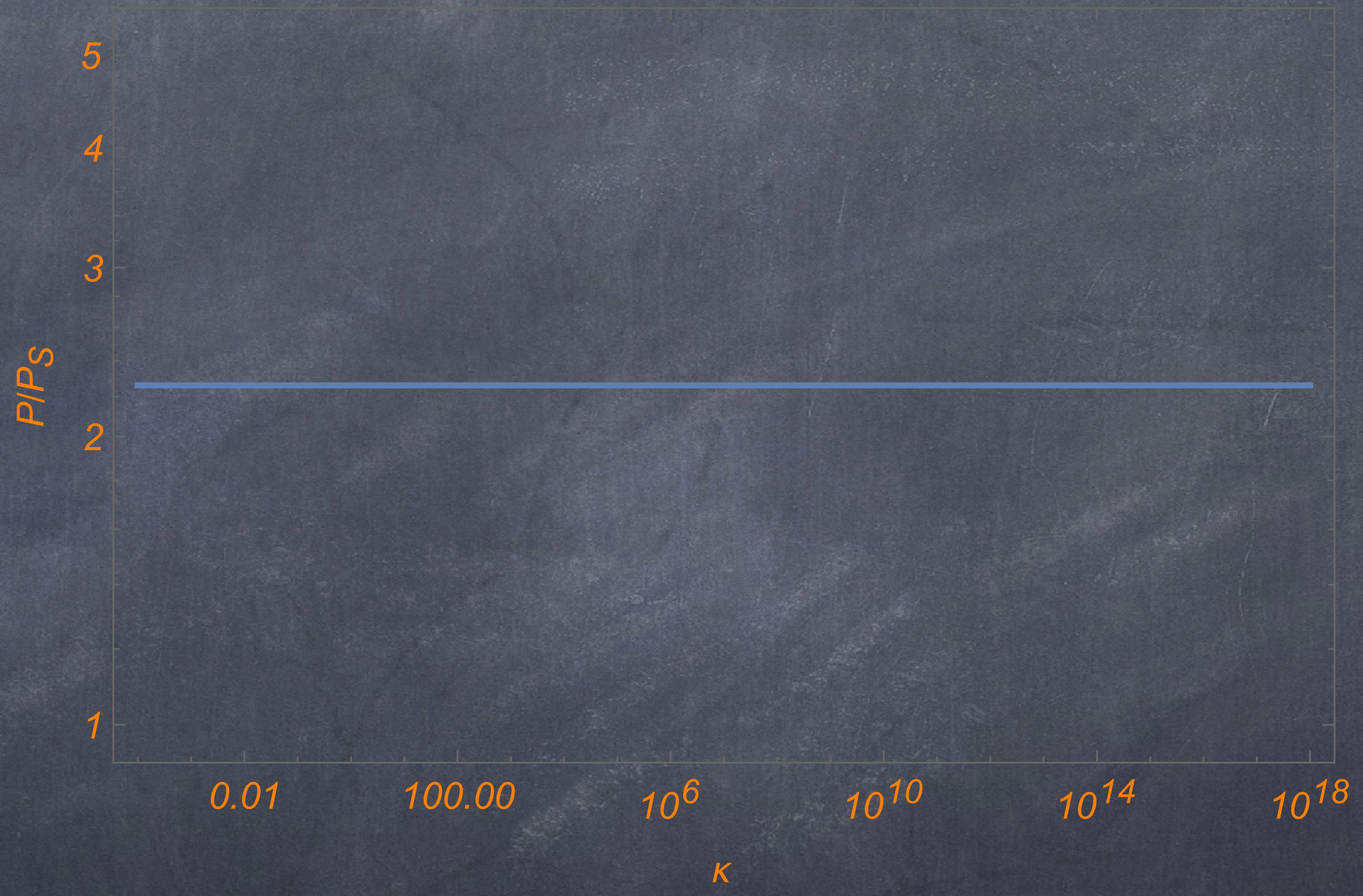
M-B distribution for Hawing radiation

Power Spectra

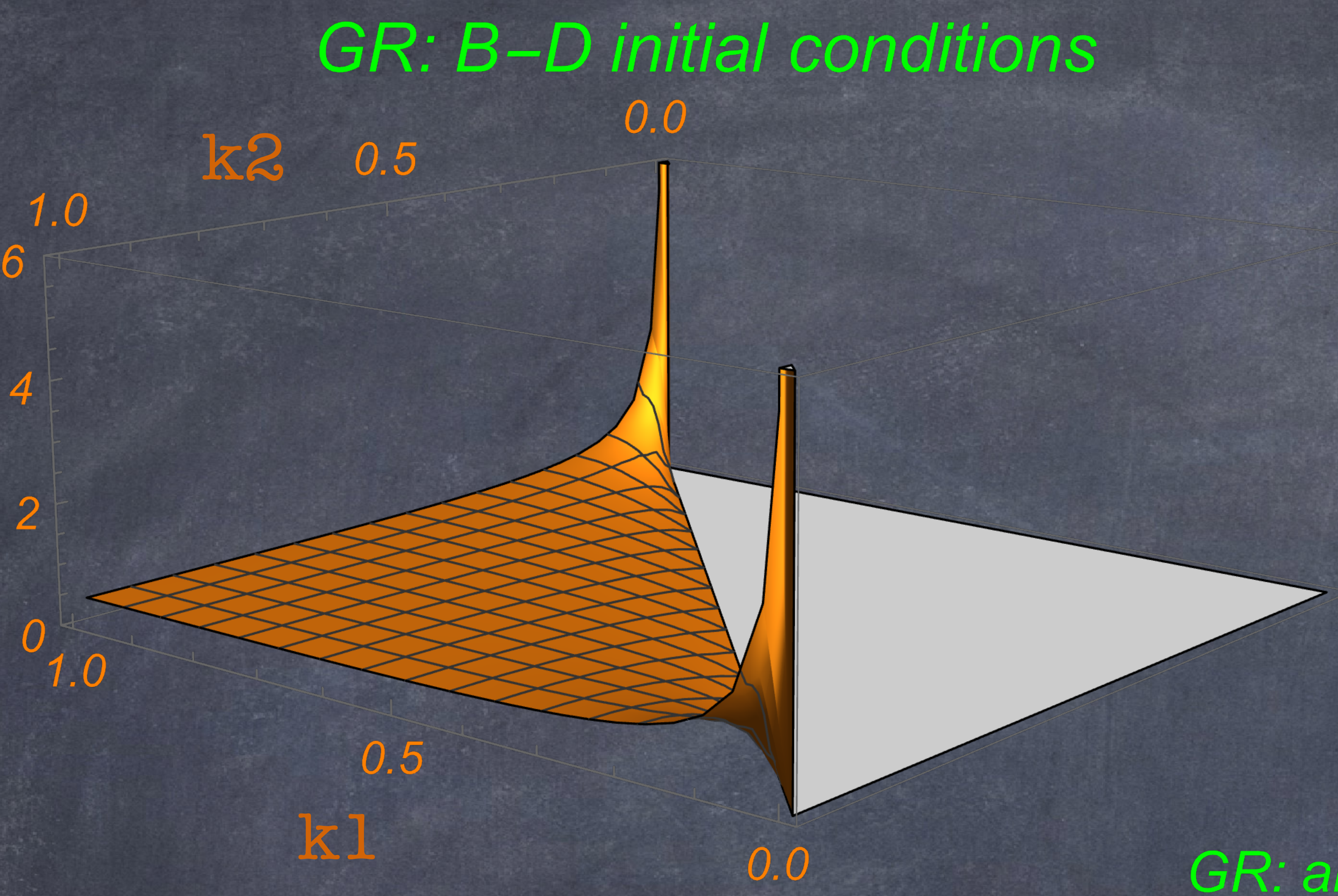
Power Law: $\dfrac{P_{Source}}{P_{Standard\ vacuum}}$ vs k

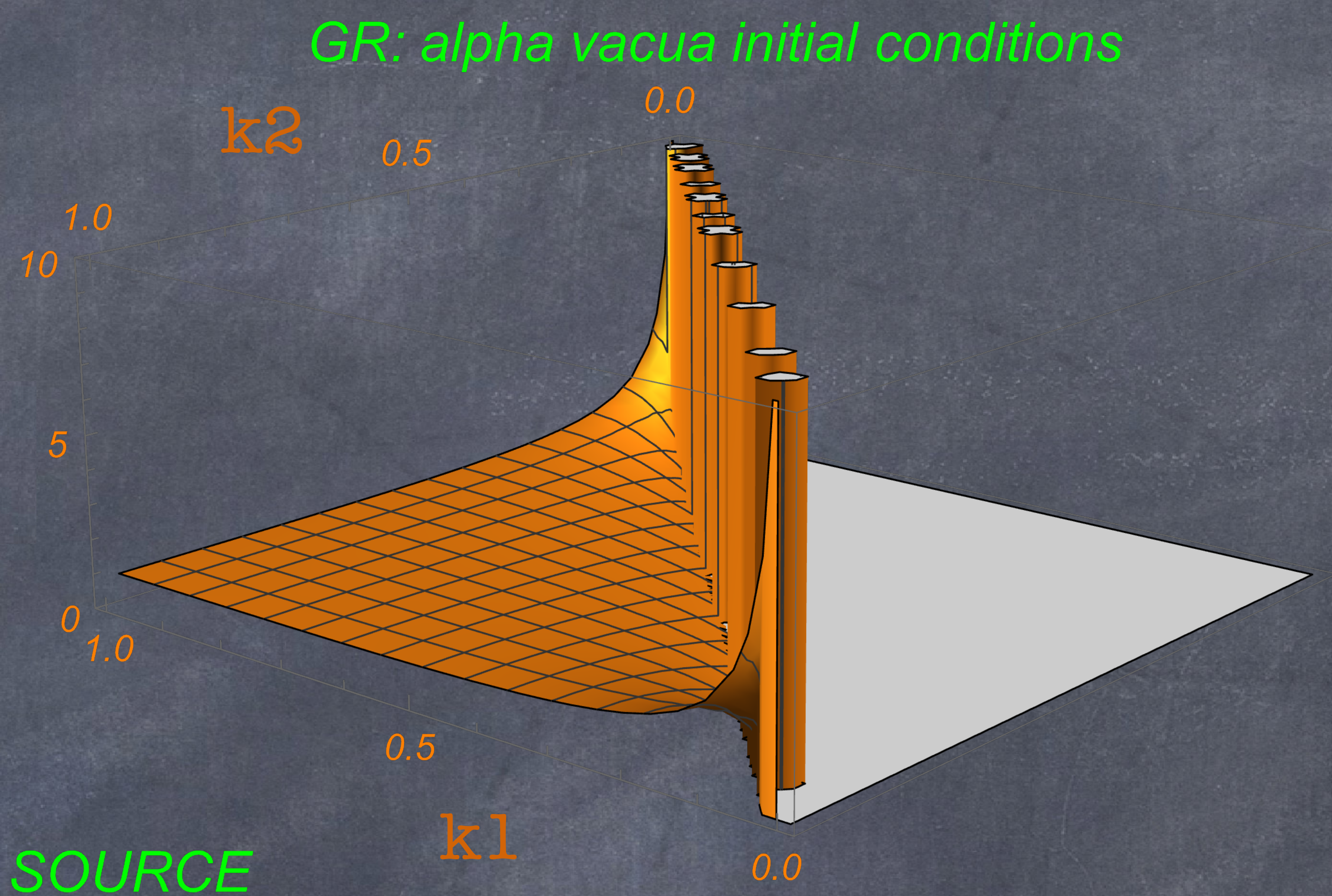


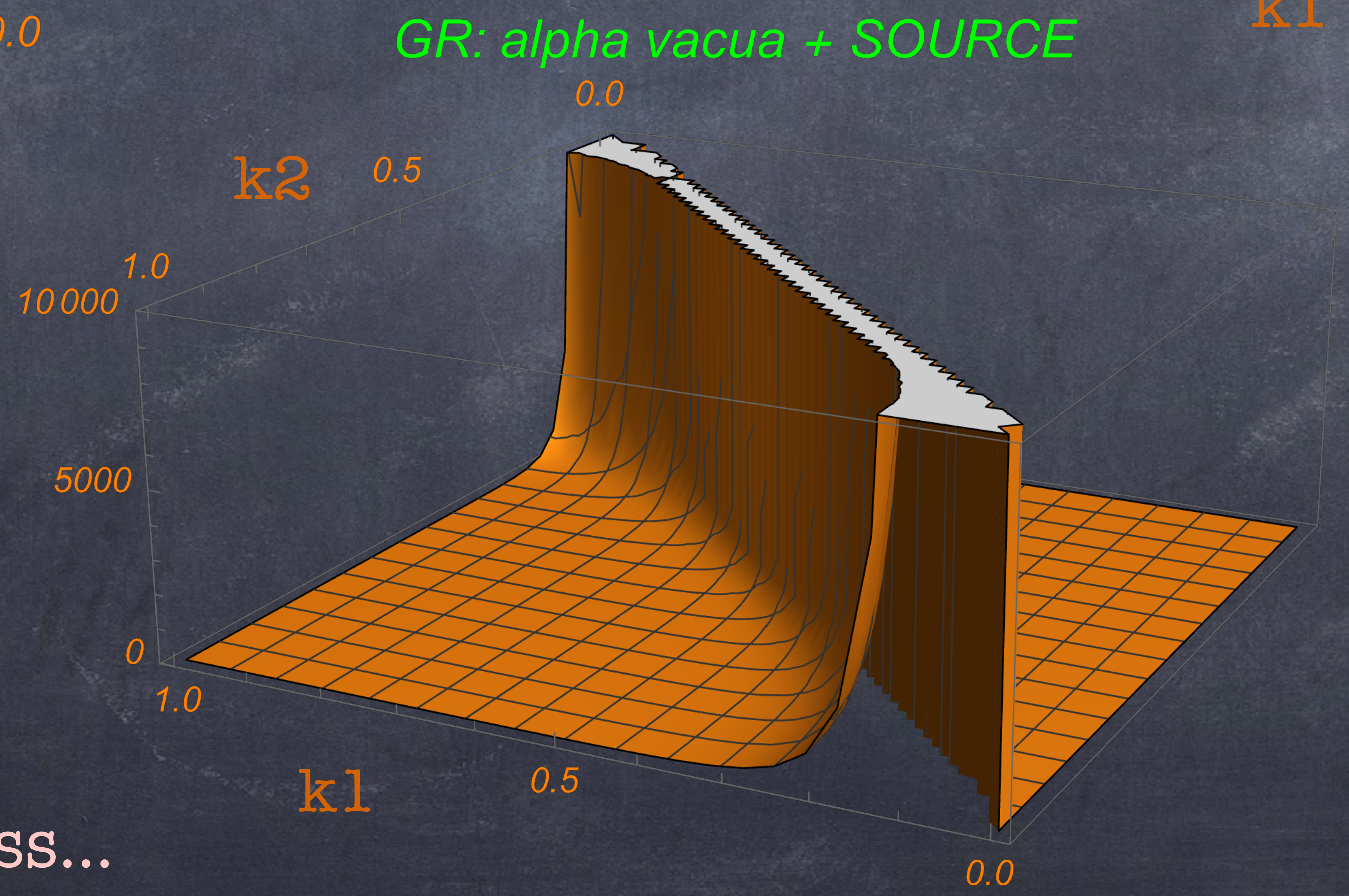
BH gas model: $\dfrac{P_{Source}}{P_{Standard\ vacuum}}$ vs k



Non-Gaussianities







Cielo, Fasiello. Work in progress...

Thank you!