Non-Gaussian Features with Generalized Slow Roll

Peter Adshead (KICP)
with W. Hu, C. Dvorkin, and H. V. Peiris.

arXiv: 1102.3435

Primordial Non-Gaussianity: Theory Confronts observation

Michigan, 05/14/2011

Machine Gun Overview

- Generalized Slow Roll (GSR)
- GSR applied to the bispectrum
- Summary

Generalized Slow Roll

- GSR proceeds by iteratively correcting the de-Sitter wavefunction via the Born approximation (Stewart 2002)
- Curvature fluctuation is a gauge mode in this limit, so work with the scalar fluctuations

$$y_i = \sqrt{\frac{k^3}{2\pi^2}}\frac{f}{x}\mathcal{R}, \quad f = \frac{\sqrt{8\pi^2\epsilon_H}}{H}(aH\eta), \quad \frac{d^2y_i}{dx^2} + \left(1 - \frac{2}{x^2}\right)y_i = \frac{1}{x^2}\left(\frac{f'' - 3f'}{f}\right)y_i$$

- RHS is related to the potential -- quantifies deviation from de Sitter

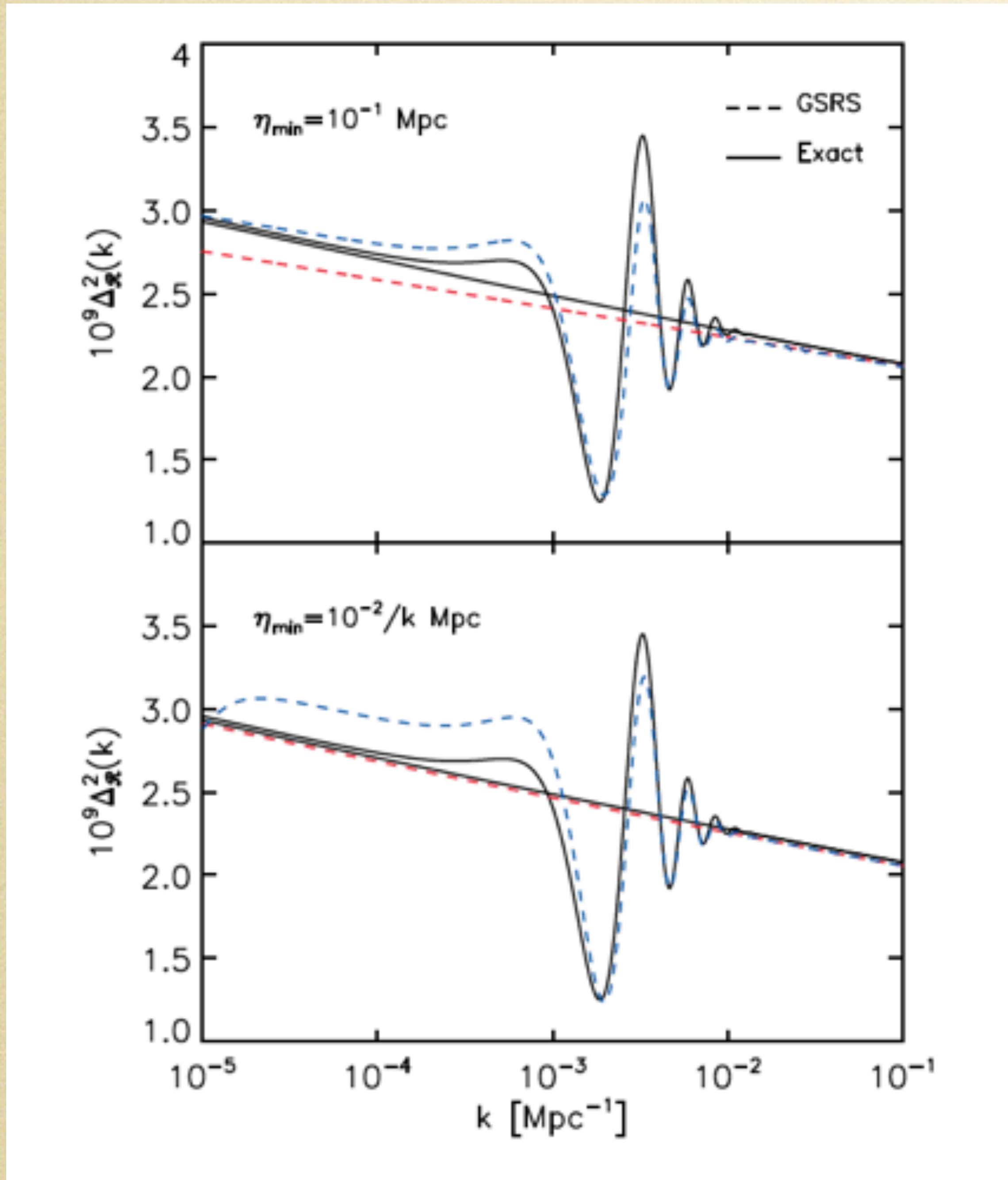
$$y_i(x) \approx y_0(x) - \int_x^\infty \frac{du}{u^2} g(\ln u) y_0(u) \Im[y_0^*(u) y_0(x)]$$

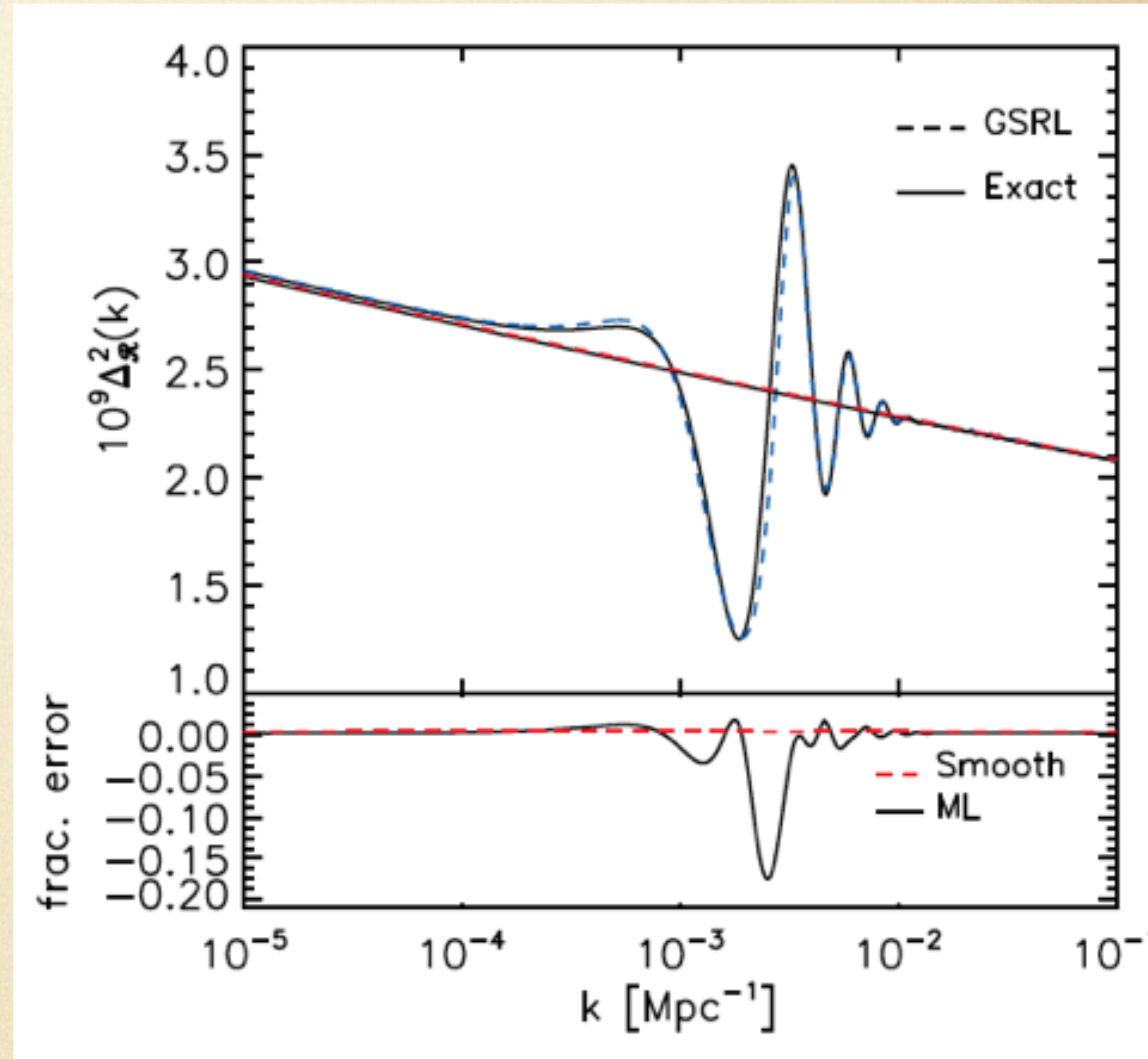
- Guiding principle for constructing approximations to correlation functions: Conservation of curvature

$$\frac{k^3}{2\pi^2}\langle\mathcal{R}_k^2\rangle = \Delta^2(k) \approx G(\ln\eta_*) + \int_{\eta_*}^\infty \frac{d\eta}{\eta} W(k\eta) G'(\ln\eta)$$

- `Second-order' source modification: $\frac{2}{3}g \to G' = \frac{2}{3}\left(g - \left(\frac{f'}{f}\right)^2\right)$

Source Correction





(Dvorkin and Hu 2009)

- Inclusion of `second-order' source modification 'cures' the time-dependence and superhorizon evolution

Application to the Bispectrum

- In-in formalism gives:

$$B_{\mathcal{R}}(k_1,k_2,k_3) = 4\Re\left\{ i\mathcal{R}_{k_1}(\eta_*)\mathcal{R}_{k_2}(\eta_*)\mathcal{R}_{k_3}(\eta_*)\left[\int_{\eta_*}^{\infty}\frac{d\eta}{\eta^2}\,a^2\epsilon_H(\epsilon_H-\eta_H)'(\mathcal{R}^*_{k_1}\mathcal{R}^*_{k_2}\mathcal{R}^*_{k_3})' + \frac{a^2\epsilon_H}{\eta_*}(\epsilon_H-\eta_H)(\mathcal{R}^*_{k_1}\mathcal{R}^*_{k_2}\mathcal{R}^*_{k_3})'\Big|_{\eta=\eta_*}\right]\right\}.$$

- Manifestly time independent
- Reduce to simple product of 1D functions

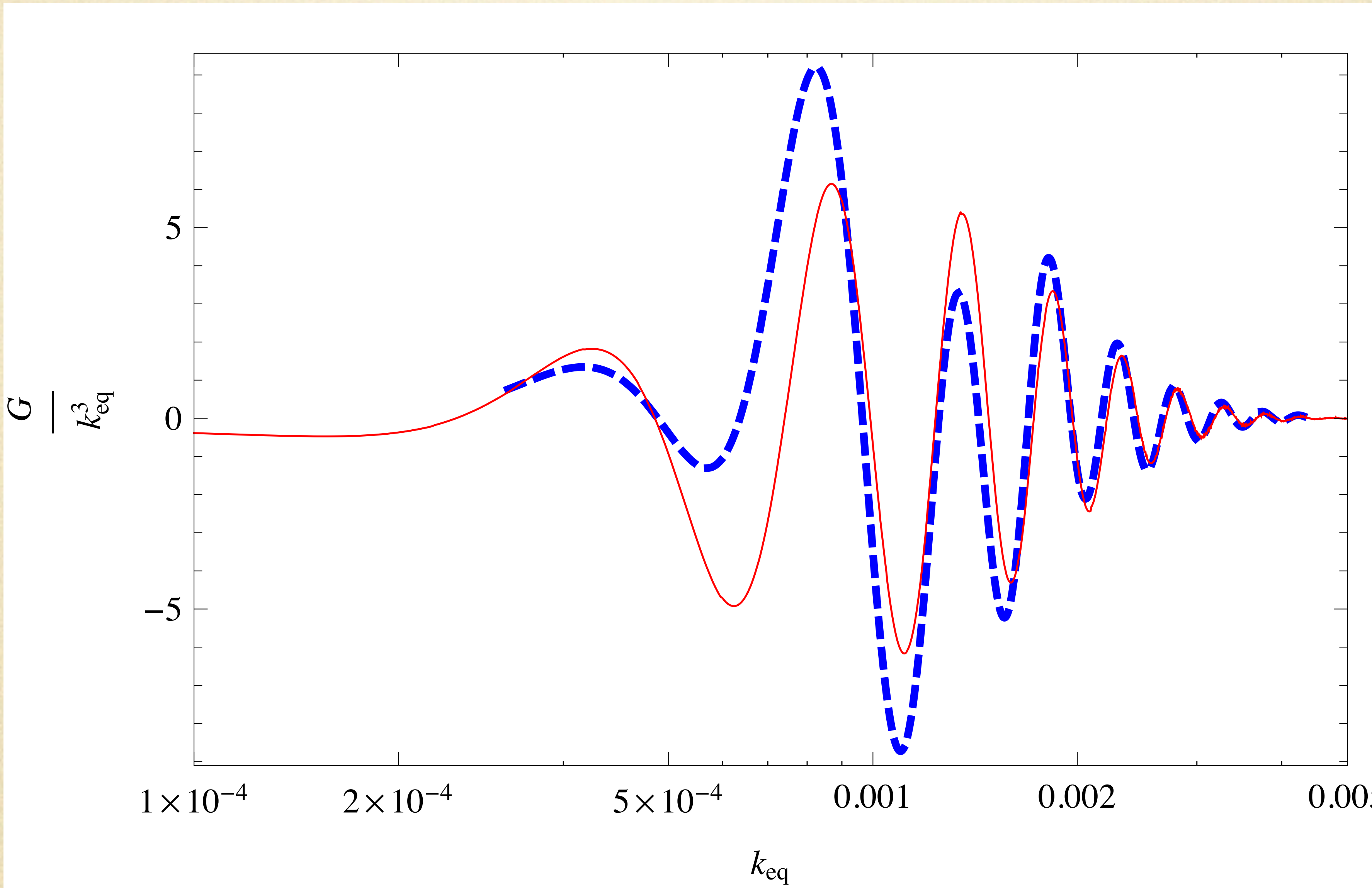
$$B_{\mathcal{R}}(k_1,k_2,k_3) \approx \frac{(2\pi)^4}{k_1^2k_2^2k_3^2}\frac{\Delta_{\mathcal{R}}(k_1)\Delta_{\mathcal{R}}(k_2)\Delta_{\mathcal{R}}(k_3)}{4}\Big[-I_0(K)k_1k_2k_3 - I_1(K)\sum_{i\neq j}k_i^2k_j + I_2(K)K(k_1^2+k_2^2+k_3^2)\Big]$$

$$I_0(K) = \int_0^{\infty}\frac{d\eta}{\eta}G'_B(\ln\eta)(K\eta)\sin(K\eta), \quad I_1(K) = G_B(\ln\eta_*) + \int_{\eta_*}^{\infty}\frac{d\eta}{\eta}G'_B(\ln\eta)\cos(K\eta),$$

$$I_2(K) = G_B(\ln\eta_*) + \int_{\eta_*}^{\infty}\frac{d\eta}{\eta}G'_B(\ln\eta)\frac{\sin(K\eta)}{K\eta}$$

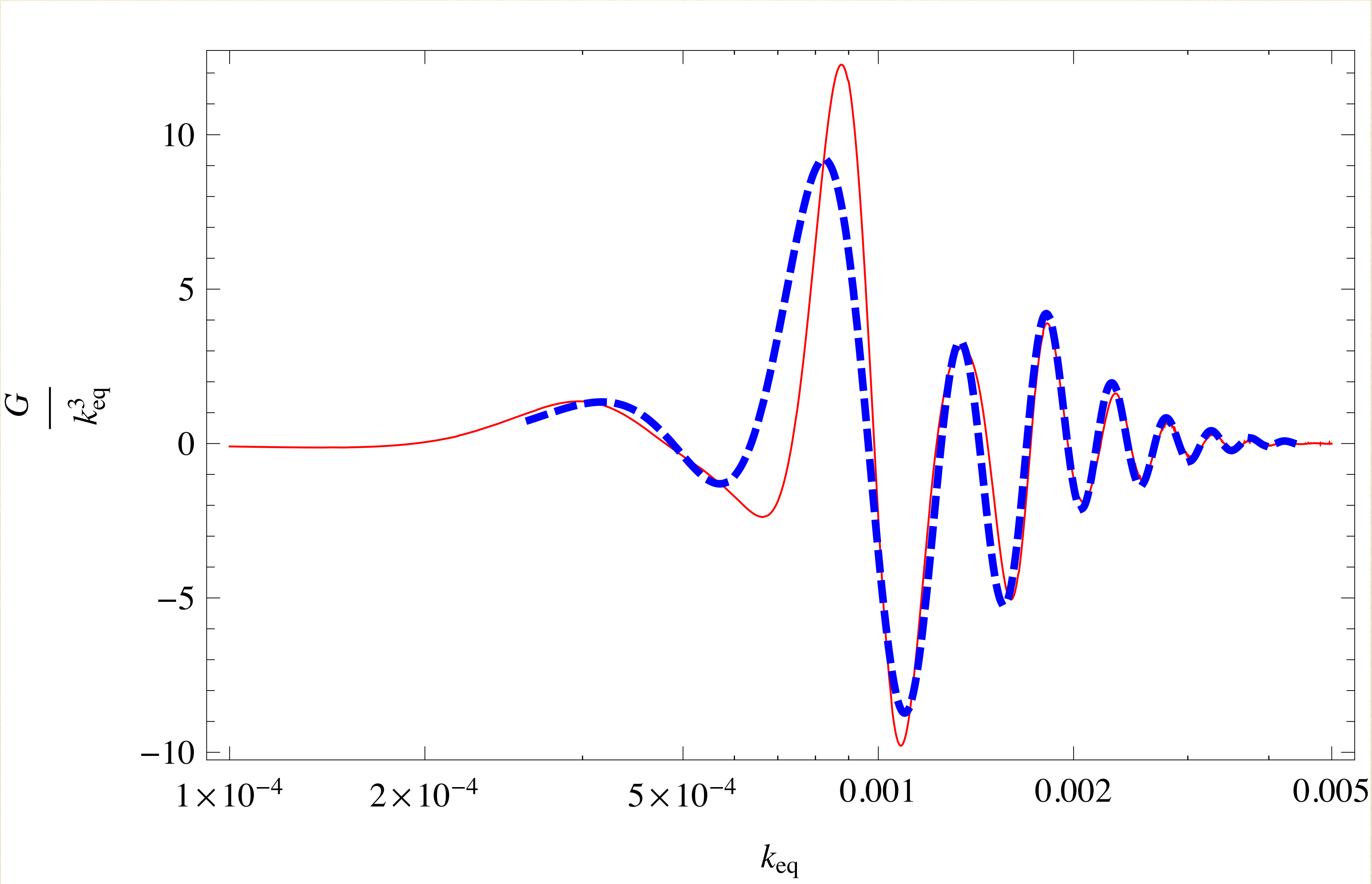
- `Second-order' source modification: $G'_B = \left(\frac{\epsilon_H-\eta_H}{f}\right)'$

Zeroth Order



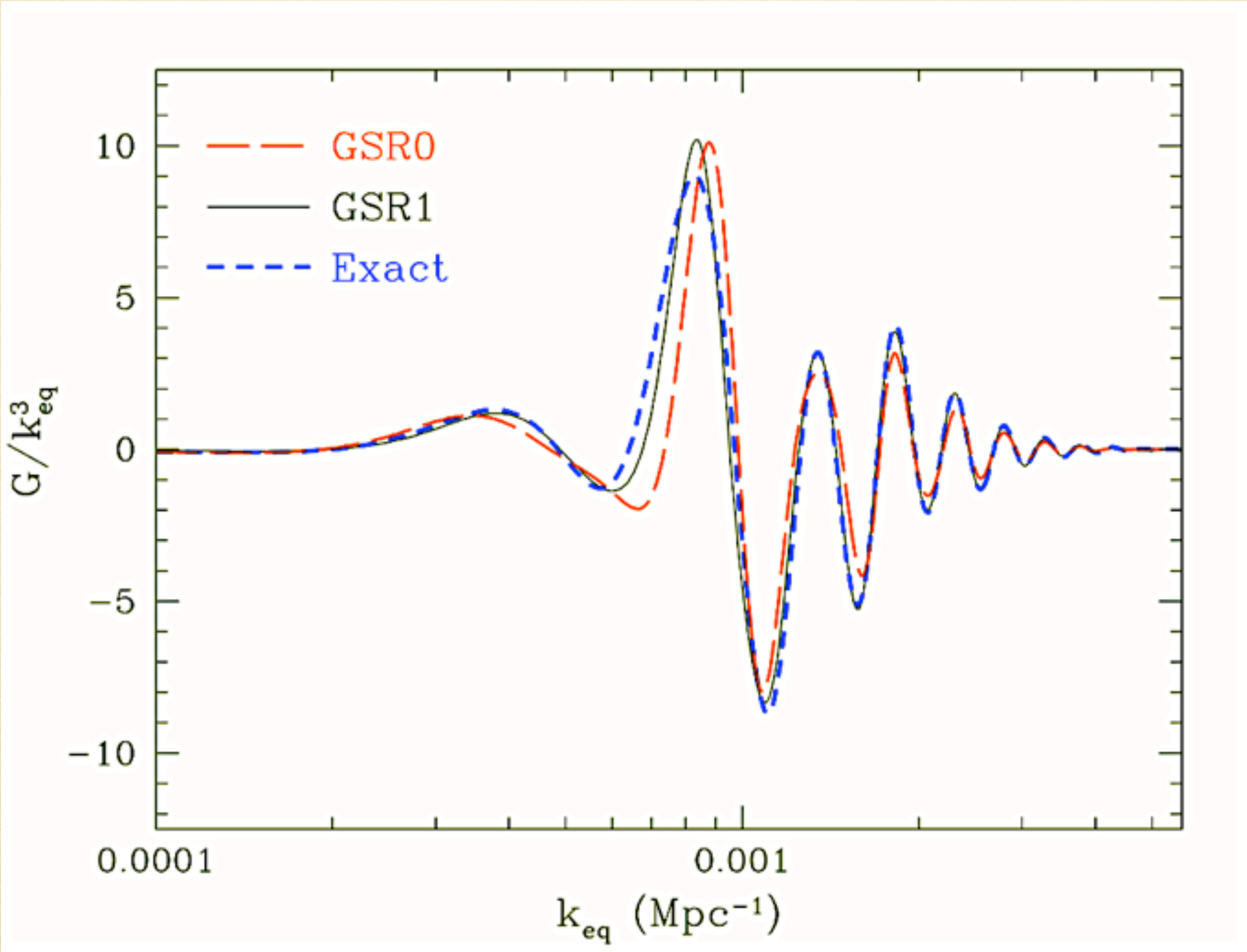
- Approximation is worst for modes crossing the horizon at the feature, improves on subhorizon.

"Improved" Zeroth Order



- Amplitude boosted
- Asymmetric oscillations
- Largest error for modes crossing horizon at the feature

First Order



- Good agreement on sub horizon scales
- Large improvement near horizon crossing

Summary

- Non-G correlation dominated by the interaction of dS modes
- Largest correction due to “external” wavefunctions
- Small corrections required in order to preserve conservation of curvature on large scales