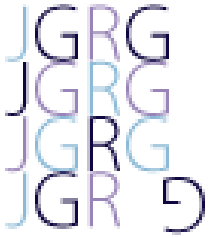
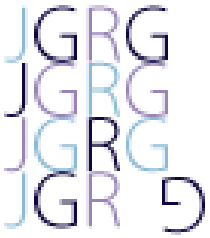


Toshifumi Noumi, JGRG 22(2012)111207

"Effective field theory approach to quasi-single inflation"



RESCEU SYMPOSIUM ON

GENERAL RELATIVITY AND GRAVITATION

JGRG 22

November 12-16 2012

Koshiba Hall, The University of Tokyo, Hongo, Tokyo, Japan

Effective field theory approach to quasi-single field inflation

Toshifumi Noumi

(The University of Tokyo, Komaba)

based on arXiv: 1211.1624

with Masahide Yamaguchi and Daisuke Yokoyama
(Tokyo Institute of Technology)

JGRG22 - RESCEU, 12th November 2012

Quasi-single field inflation

classification of inflation models w.r.t. relevant dof

	relevant dof
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multiple field	adiabatic + isocurvatures

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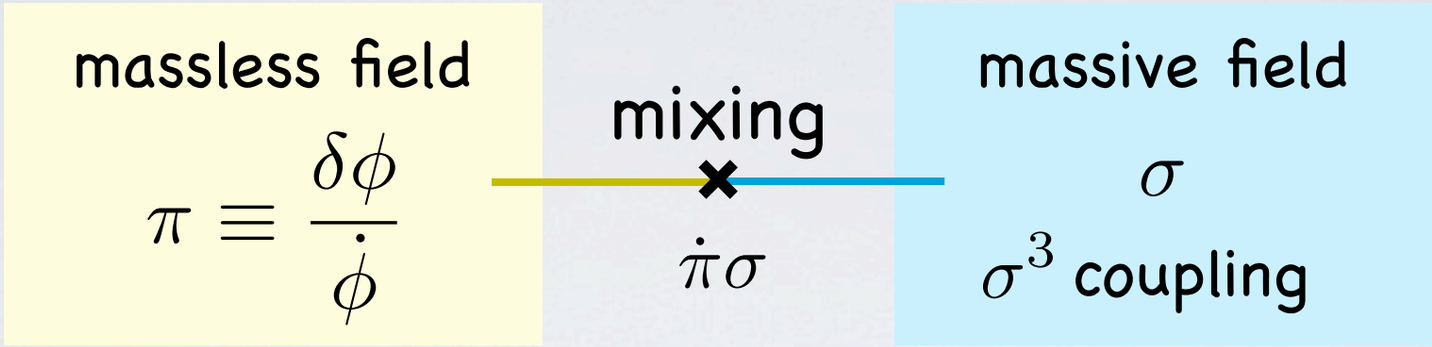
- phenomenologically interesting
(characteristic signatures in primordial perturbations)

QSI & non-Gaussianities

quasi-single field inflation [Chen-Wang '09]



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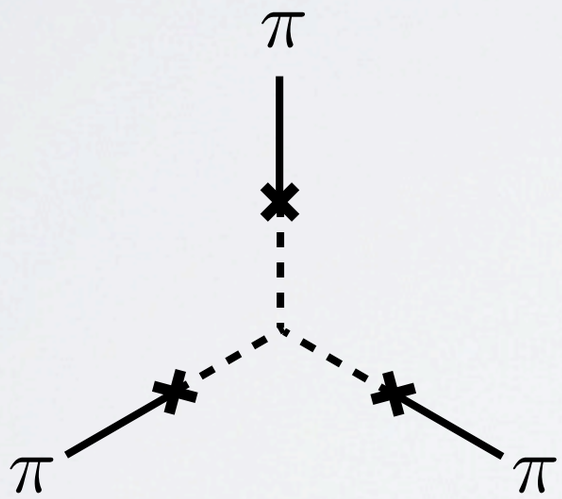

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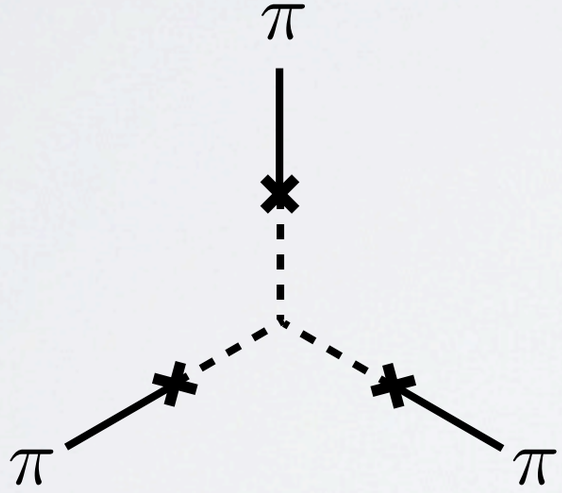

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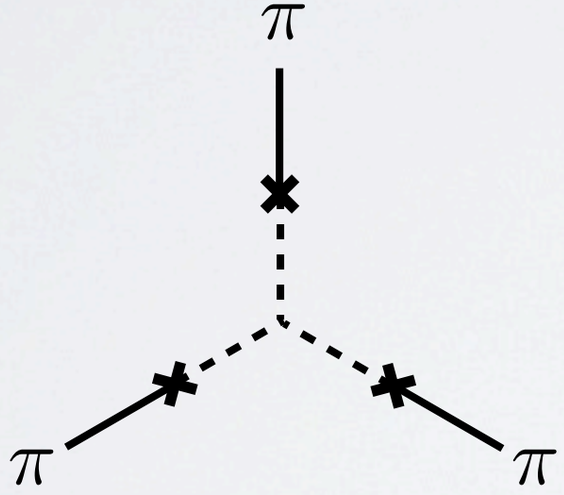

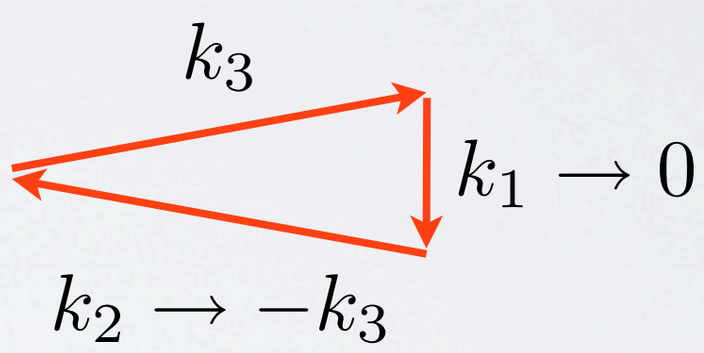

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$$\langle \pi_{k_1} \pi_{k_2} \pi_{k_3} \rangle \propto \kappa^{-3/2-\nu} k^{-6} \qquad \nu = \sqrt{9/4 - m_\sigma^2/H^2}$$

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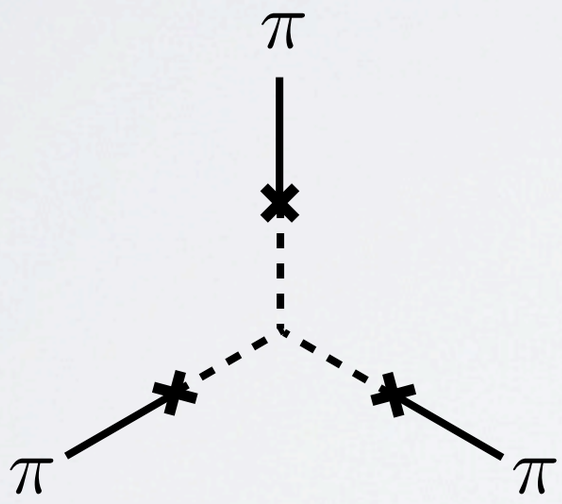

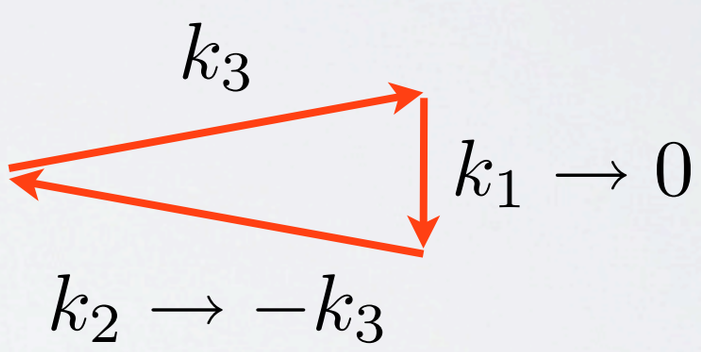

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effective field theory approach!

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effective field theory approach [Cheung et al '07]

time dependent background evolution during inflation

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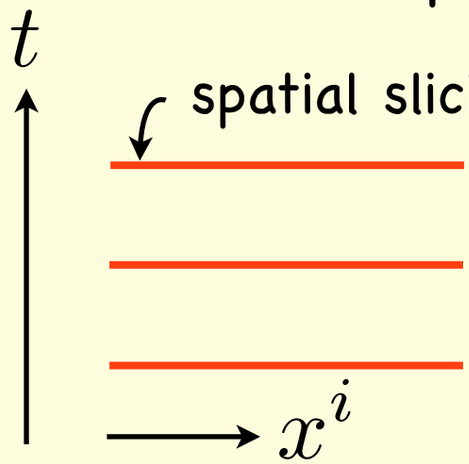

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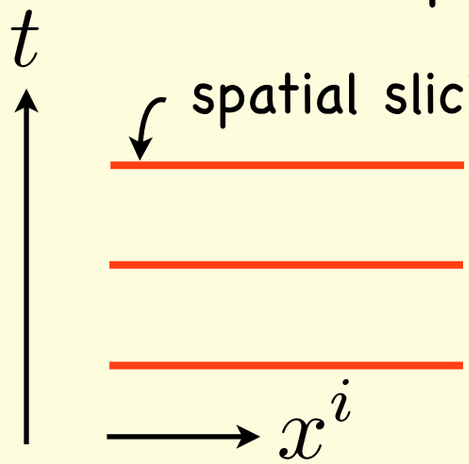

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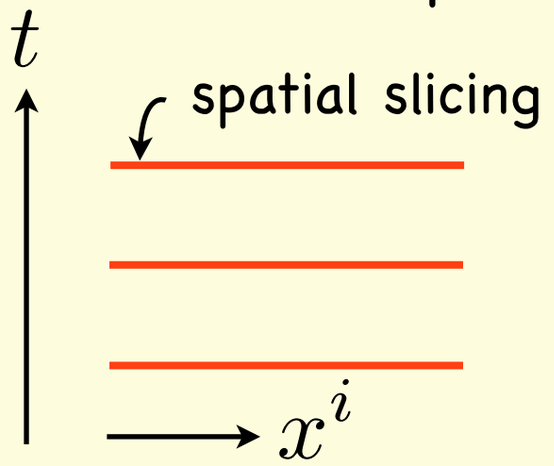

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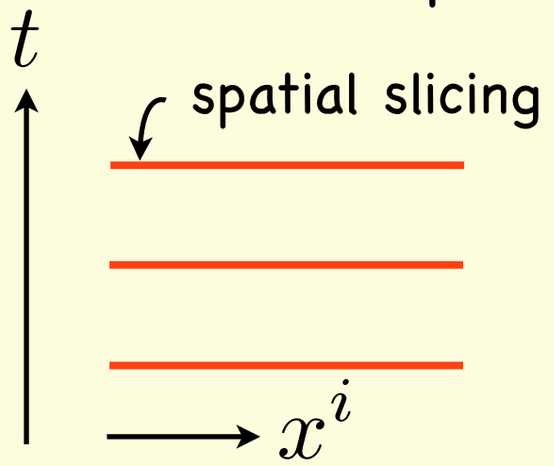

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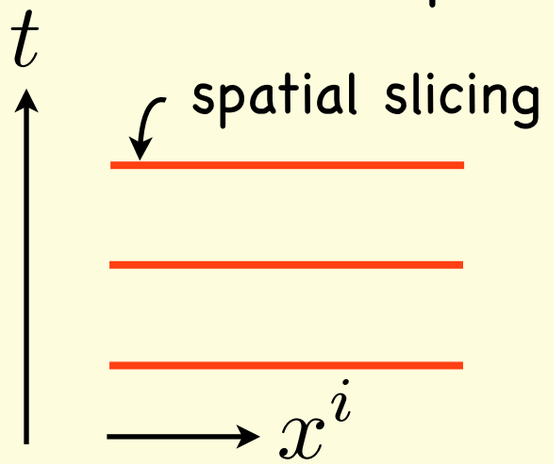

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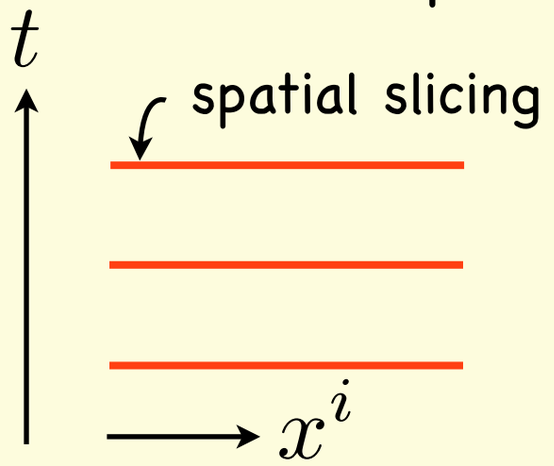

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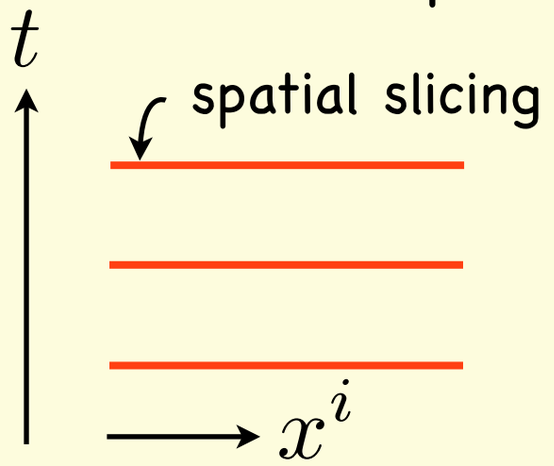

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advantages:
- systematic expansions in fluctuations and derivatives
- simplification in the dynamics of Goldstone boson π
- relations between physics and non-Gaussianities are clear!

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general action of quasi-single field inflation

relevant dof = three physical modes of graviton
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Stuckelberg method

$$S_{\rm mix} = \int d^4x\, a^3\left[-2\beta_1\dot\pi\sigma + (2\beta_2 - \beta_3)\dot\pi\dot\sigma + \beta_3\frac{\partial_i\pi\partial_i\sigma}{a^2} - \beta_1\left(\dot\pi^2 - \frac{(\partial_i\pi)^2}{a^2}\right)\sigma + 3\beta_2\dot\pi^2\dot\sigma - 2\beta_2\frac{\partial_i\pi\partial_i\sigma}{a^2}\dot\pi - \beta_2\frac{(\partial_i\pi)^2}{a^2}\dot\sigma + \dots\right]$$

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large non-Gaussianitis from mixings β_1 and β_2 — $\zeta \sim -H\pi$

Power spectrum

power spectrum

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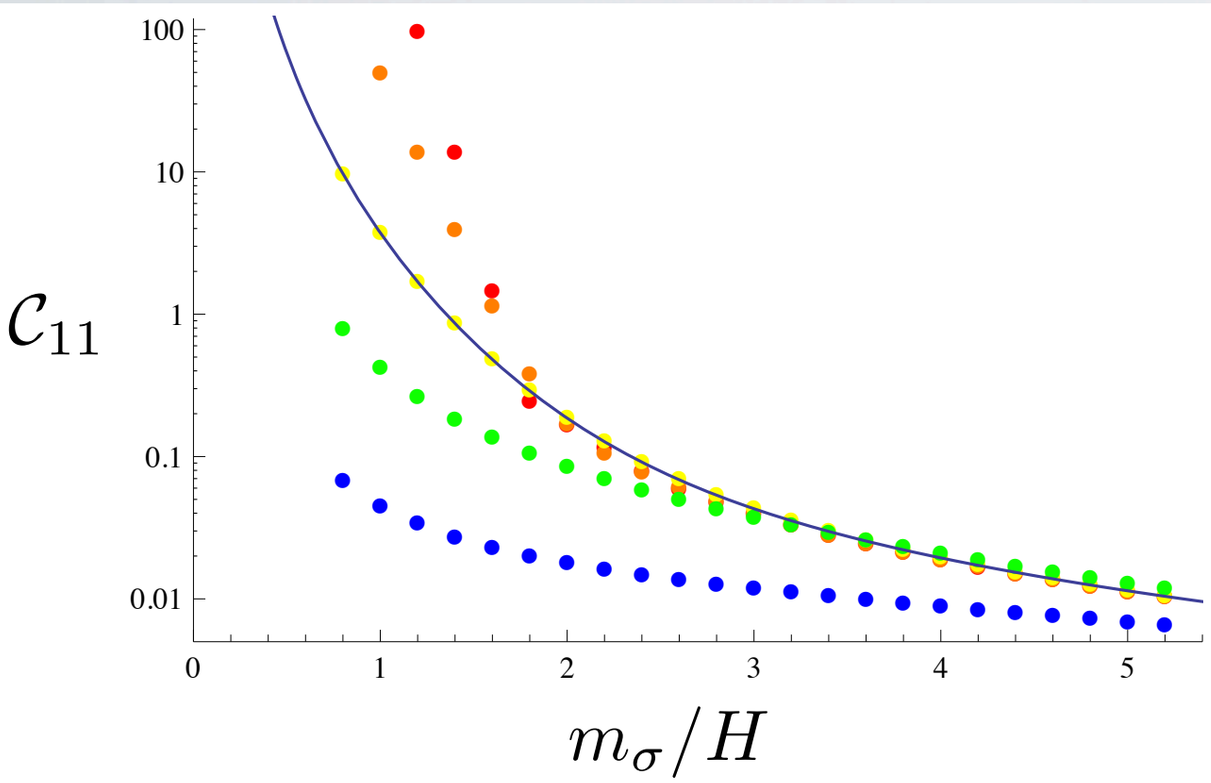
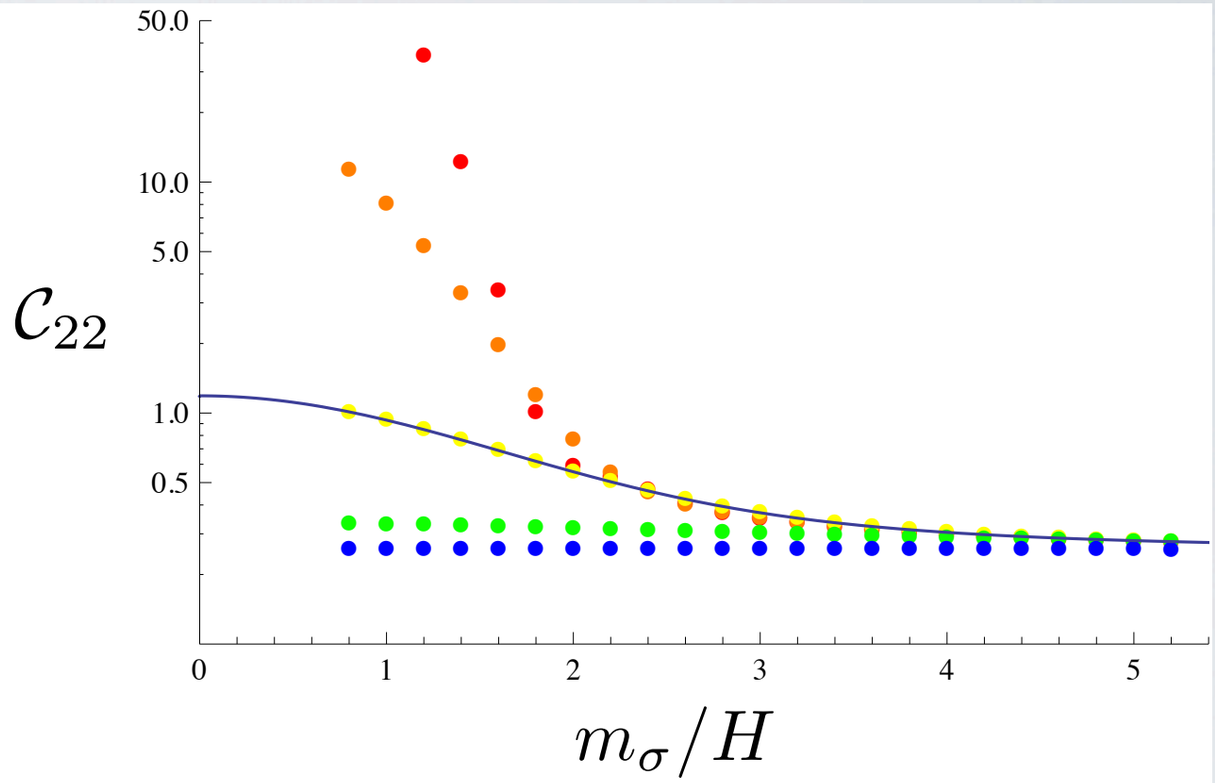
deviation from single field

$$\mathcal{P}_\zeta(k) = \frac{H^2}{8\pi^2 M_{\rm Pl}^2\epsilon\, c_\pi}\left[1+\frac{\pi}{4\alpha_\sigma^2}\frac{c_\pi^2}{M_{\rm Pl}^2(-\dot H)}\left(\frac{\tilde\beta_1^2}{H^2}\mathcal{C}_{11}+\tilde\beta_2^2\,\mathcal{C}_{22}+\tilde\beta_3^2\,\mathcal{C}_{33}\right.\right.$$
$$\left.\left.+\frac{\tilde\beta_1}{H}\,\tilde\beta_2\,\mathcal{C}_{12}+\frac{\tilde\beta_1}{H}\,\tilde\beta_3\,\mathcal{C}_{13}+\tilde\beta_2\,\tilde\beta_3\,\mathcal{C}_{23}\right)\right]$$

Power spectrum

$\mathcal{C}_{ij}(m_\sigma/H, c_\sigma/c_\pi)$ for fixed $r_s = c_\sigma/c_\pi$





The dots are numerical results for $r_s = 0.1$ (red), 0.3 (orange), 1 (yellow), 3 (green), and 10 (blue).

The curve is an analytic result for $r_s = 1$.

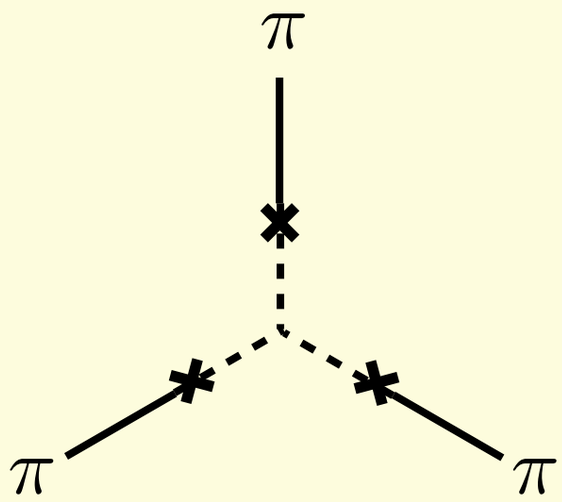
※ $\mathcal{C}_{22}$ does not vanish even in the heavy mass limit

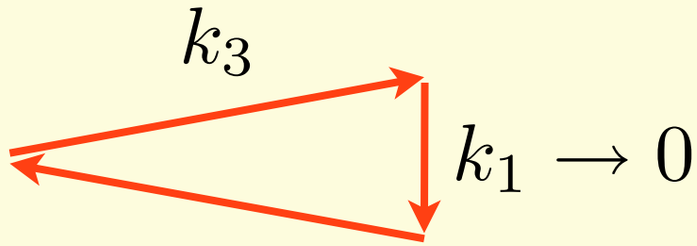
$\tilde{\beta}_2 \dot{\pi} \dot{\sigma}$

3pt functions

three point functions in the squeezed limit

- original models of quasi-single field inflation





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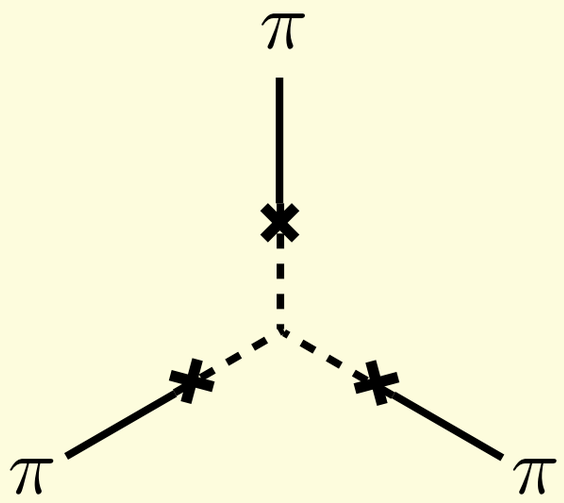

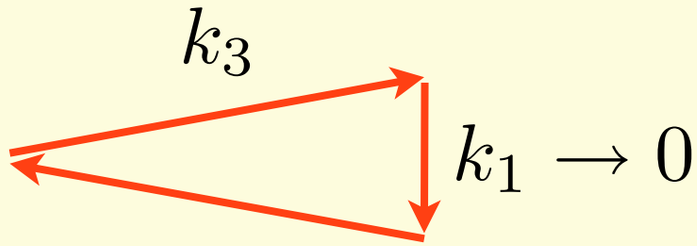

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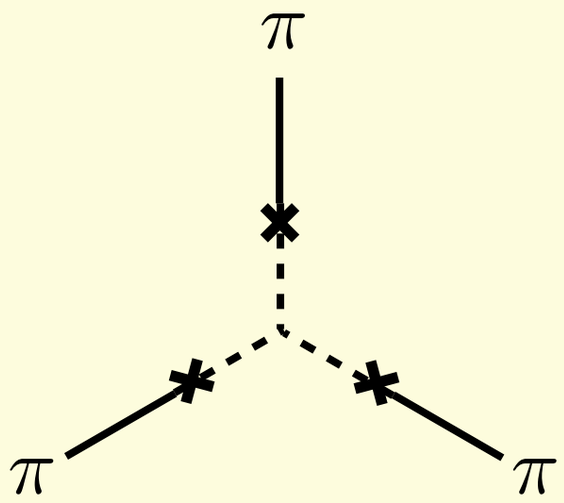

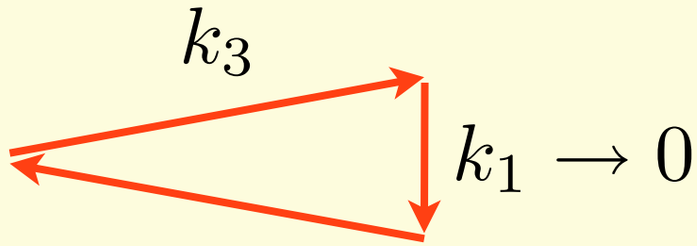

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① scaling does not depend on details of mixing

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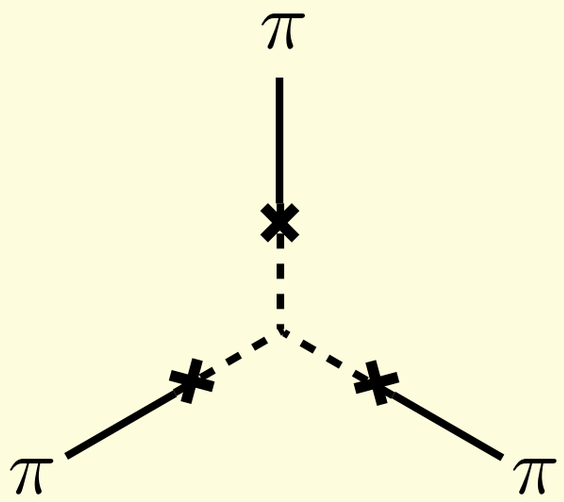

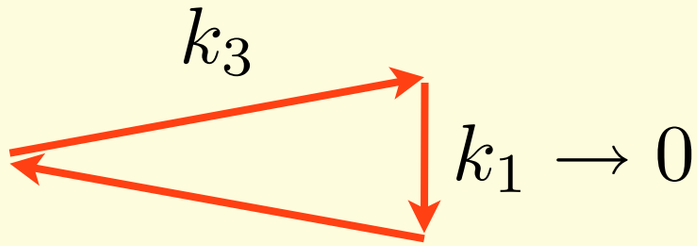

$k_2 \to -k_3$

$|k_2| = |k_3| = k,\ |k_1| = \kappa k$

$$\langle \pi_{k_1} \pi_{k_2} \pi_{k_3} \rangle \propto \kappa^{-3/2-\nu} k^{-6} \qquad \nu = \sqrt{9/4 - m_\sigma^2/H^2}$$

- for general mixing and cubic couplings

① scaling does not depend on details of mixing

② determined only from cubic interaction in the diagram

three point vertices	momentum dependence
$\dot\pi^3,\ \dot\pi\dfrac{(\partial_i\pi)^2}{a^2}$	$\kappa^{-1}k^{-6}$
$\dot\pi^2\sigma,\ \dot\pi\dot\sigma,\ \dot\pi\sigma^2,\ \dot\pi\sigma\dot\sigma,\ \dot\pi\dot\sigma^2,\ \ddot\pi\sigma\dot\sigma,$ $\sigma^3,\ \sigma^2\dot\sigma,\ \sigma\dot\sigma^2,\ \sigma\dfrac{(\partial_i\sigma)^2}{a^2},\ \dot\sigma^3,\ \dot\sigma\dfrac{(\partial_i\sigma)^2}{a^2}$	$\begin{cases}\kappa^{-3/2-\nu}k^{-6} & \text{for}\quad m_\sigma<\dfrac{3}{2}H\\ \kappa^{-3/2}k^{-6}\sin[i\nu\log\kappa+\delta_\nu] & \text{for}\quad m_\sigma>\dfrac{3}{2}H\end{cases}$
$\dot\pi\dfrac{\partial_i\pi\partial_i\sigma}{a^2}$	$\kappa^{-2}k^{-6}$
$\dfrac{(\partial_i\pi)^2}{a^2}\sigma,\ \dfrac{(\partial_i\pi)^2}{a^2}\dot\sigma,\ \dfrac{\partial_i\pi\partial_i\sigma}{a^2}\sigma,\ \dfrac{\partial_i\pi\partial_i\sigma}{a^2}\dot\sigma$	$\begin{cases}\kappa^{-3/2-\nu}k^{-6} & \text{for}\quad m_\sigma<\sqrt{2}H\\ \kappa^{-2}k^{-6} & \text{for}\quad m_\sigma>\sqrt{2}H\end{cases}$
$\dot\pi\dfrac{(\partial_i\sigma)^2}{a^2}$	$\begin{cases}\kappa^{-1/2-\nu}k^{-6} & \text{for}\quad m_\sigma<\sqrt{2}H\\ \kappa^{-1}k^{-6} & \text{for}\quad m_\sigma>\sqrt{2}H\end{cases}$

non-trivial scaling in the squeezed limit when mixing is relevant!

$$\nu=\sqrt{9/4-m_\sigma^2/H^2}\quad 0<\nu<3/2\quad\text{or}\quad \nu=\text{pure imaginary}$$

Summary and prospects

summary

applied EFT approach to QSI

- systematic expansions in fluctuations and derivatives
- simplification of action for π in decoupling regime
- relation between physics & non-Gaussianities is clear

calculated power spectrum for constant mixing

discussed scaling of 3-pt functions in squeezed limit

- sensitive to # of fields and their mass

also discussed effects of heavy particles, sharp turning

prospects

full non-Gaussianities, detectability, ...

EFT for sugra based inflation,

more on sharp turning, ...

THANK YOU!!