21cm bispectrum

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Formalism

Definition

\[ \langle \delta T_b(k_1) \delta T_b(k_2) \delta T_b(k_3) \rangle = \delta(k_1 + k_2 + k_3) B(k_1, k_2, k_3) \]

○ equilateral type

\[ |k_1| = |k_2| = |k_3| = k \]

○ squeezed type

\[ |k_1| = |k_2| = k, |k_3| = k_c \quad (k > k_c) \]

○ folded type

\[ k_1 + k_2 - k_3 = 0 \]
Scale dependency

10 realizations \( |k_1| = |k_2| = |k_3| = k \) (equilateral type)
Redshift dependency

Squeezed type 21cm bispectrum has three peaks. This type is different from other types of bispectrum.

correlation between long and short wavelength modes.

We can get the information on local non-linearity in real space.

**equilateral**
\[ k_1 = k_2 = k_3 = 1.0 \text{Mpc}^{-1} \]

**folded**
\[ k_1 = k_2 = 1.0 \text{Mpc}^{-1}, k_3 = 2.0 \text{Mpc}^{-1} \]

**squeezed**
\[ k_1 = k_2 = 1.0 \text{Mpc}^{-1}, k_3 = 0.1 \text{Mpc}^{-1} \]
Decomposition

\[ \delta T_b(x) = \overline{\delta T}_b(1 + \delta_{x_H}(x))(1 + \delta_m(x))(1 + \delta_\eta(x)), \]

\[ \eta = 1 - \frac{T_\gamma}{T_S} \]

\[ B_{\delta T_b} = (\overline{\delta T}_b)^3 [B_{\delta m\delta m\delta m} + B_{\delta_{x_H}\delta_{x_H}\delta_{x_H}} + B_{\delta_\eta\delta_\eta\delta_\eta} \]
\[ + (\text{cross correlation terms}) \]
\[ + (\text{higher order terms})]. \]
The component of 21cm bispectrum

\[ k_3 = 1.0 \text{Mpc}^{-1} \]

\[ \frac{k_1}{k_3} - \frac{k_2}{k_3} \text{ plain unnormalized} \]

**Decomposition**

Decomposition of 21cm bispectrum into matter, spin temperature and neutral fraction fluctuations as function of wave number. We can see what configuration and what component is dominant.

We may subtract the information of each component by using the dependence on configuration.