THESIS

# The Pursuit of Non-Gaussian Fluctuations in the Cosmic Microwave Background

## (宇宙背景放射における非ガウシアンゆらぎの追求)

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# Abstract


We present theoretical and observational studies of non-Gaussian fluctuations in the cosmic microwave background (CMB) radiation anisotropy. We use the angular bispectrum and trispectrum, the harmonic transform of the angular three- and four-point correlation functions. If the primordial fluctuations are non-Gaussian, then this non-Gaussianity will be apparent in the CMB sky.

Non-linearity in inflation produces the primordial non-Gaussianity. We predict the primary angular bispectrum from inflation down to arcminutes scales, and forecast how well we can measure the primordial non-Gaussian signal. In addition to that, secondary anisotropy sources in the low-redshift universe also produce non-Gaussianity, so do foreground emissions from extragalactic or interstellar microwave sources. We study how well we can measure these non-Gaussian signals, including the primordial signal, separately. We find that when we can compute the predicted form of the bispectrum, it becomes a "matched filter" for finding non-Gaussianity in the data, being very powerful tool of measuring weak non-Gaussian signals and of discriminating between different non-Gaussian components. We find that slow-roll inflation produces too small bispectrum to be detected by any experiments; thus, any detection strongly constrains this class of models. We also find that the secondary bispectrum from coupling between the Sunyaev–Zel'dovich effect and the weak lensing effect, and the foreground bispectrum from extragalactic point sources, give detectable non-Gaussian signals on small angular scales.

We test Gaussianity of the *COBE* DMR sky maps, by measuring all the modes of the angular bispectrum down to the DMR beam size. We compare the data with the simulated Gaussian realizations, finding no significant signal of the bispectrum on the mode-by-mode basis. We also find that the previously reported detection of the bispectrum is consistent with a statistical fluctuation. By fitting the theoretical prediction to the data for the primary bispectrum, we put a constraint on non-linearity in inflation. Simultaneously fitting the foreground bispectra, which are estimated from interstellar dust and synchrotron template maps, shows that neither dust nor synchrotron emissions contribute significantly to the bispectrum at high Galactic latitude. We thus conclude that the angular bispectrum finds no significant non-Gaussian signals in the DMR data.

We present the first measurement of the angular trispectrum on the DMR sky maps, further testing Gaussianity of the DMR data. By applying the same method as used for the bispectrum to the DMR data, we find no significant non-Gaussian signals in the trispectrum. Therefore, the angular bispectrum and trispectrum show that the DMR sky map is comfortably consistent with Gaussianity.

The methods that we have developed in this thesis can readily be applied to the *MAP* data, and will enable us to pursue non-Gaussian CMB fluctuations with the unprecedented sensitivity. We show that high-sensitivity measurement of the CMB bispectrum and trispectrum will probe the physics of the early universe as well as the astrophysics in the low-redshift universe, independently of the CMB power spectrum.

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