Quantitative and Qualitative Tests of the Early Universe

We live in exciting times for cosmologists. There is a plethora of cosmological experiments that allow us to reconstruct the earliest moments in the Universe and test our ideas on how the Universe came into existence. Current data appear to favor a model that produces adiabatic, scale free, Gaussian fluctuations with an amplitude of $10^{-5}$ in units of mK. Within the realm of cosmological models, it appears that such conditions are easily accomplished if we have a period of inflation driven by a single light field slowly rolling down its potential. In the first half of his talk, Dr. Meerburg will investigate the possibility to what extend our current observations would allow for a deviation from slow-roll: several class of models predicts that the fluctuation spectra will contain superimposed features on top of their slow-roll solution. He will discuss these models and explain a novel way of extract these features from the data, both in the power spectrum as well as in the bispectrum. The detection of B-mode polarization on large angular scales by the BICEP2 collaboration, and its possible primordial origin as the result of relic gravitational waves has invigorated the cosmological community. There has been much debate about the interpretation of the BICEP2 data, and this is an important issue that will be resolved with independent measurements and multi-frequency observations. The recent BICEP2/KECK and Planck 353GHz polarized map joint analysis has shown that at least a part of the BICEP2 and KECK signal is due to polarized dust. However, more importantly the observations have yielded renewed interest in constraining models of the early universe through their predictions of the spectrum of primordial gravitational waves and the testability of the inflationary scenario. One possible way to test the inflationary scenario is to verify or falsify the inflation consistency condition, which relates the amplitude of gravitational wave amplitude to its scale dependence; if tensors and scalars are sourced by the same mechanism, more power on small scales would violate the null energy condition and would suggest inflation is not responsible for the tensor modes. Much discussion has been aimed at how well we could do with future observations; in the second half of his talk Dr. Meerburg will present some results we have derived from combining current data, including the latest BICEP2/KECK and Planck Polarization data. He will show that constraints from ground based gravitational wave detectors (LIGO) and pulsar timing arrays (PTA) already constrain the posterior parameter volume significantly. In addition he will show that in order to consistently use the CMB data to constrain the inflation consistency condition we should include effects of the gravitational background density on the expansion history of the Universe.