Expected principal component analysis of cosmic microwave background anisotropies

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Abstract

We implement and test an approach for measuring the primordial power spectrum of density perturbations given observations of the cosmic microwave background (CMB) anisotropy spectrum. In a broader sense we are interested in locating and exploring a solution to the general linear model equation, with the added complication of the presence of nuisance parameters. The method depends on exploiting the fact that the linear response of the CMB anisotropies with respect to the primordial power spectrum model parameters as well as the noise properties of the CMB detectors are both well understood. This puts us in the luxurious position of being able to pre-compute an accurate and useful representation of a Fisher matrix, from which a set of orthonormal power spectrum modes can be obtained. The full power spectrum mode plus nuisance parameter space can be integrated out using Markov chain Monte Carlo, and all the information concerning the primordial power spectrum is compressed onto a series of mode amplitudes which can then be easily compared with theoretical models. The idea of constructing an orthonormal model basis is certainly not a new concept in data analysis, rather this method merely highlights the link between data compression and statistical inference, and the increasing role of large-scale parallel computations for exploiting large data sets.