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ORIGINAL ARTICLE

Foreground removal from WMAP 7 yr polarization maps using an MLP neural network

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Abstract One of the fundamental problems in extracting the cosmic microwave background signal (CMB) from millimeter/submillimeter observations is the pollution by emission from the Milky Way: synchrotron, free-free, and thermal dust emission. To extract the fundamental cosmological parameters from CMB signal, it is mandatory to minimize this pollution since it will create systematic errors in the CMB power spectra. In previous investigations, it has been demonstrated that the neural network method provide high quality CMB maps from temperature data. Here the analysis is extended to polarization maps. As a concrete example, the WMAP 7-year polarization data, the most reliable determination of the polarization properties of the CMB, has been analyzed. The analysis has adopted the frequency maps, noise models, window functions and the foreground models as provided by the WMAP Team, and no auxiliary data is included. Within this framework it is demonstrated that the network can extract the CMB polarization signal with no sign of pollution by the polarized foregrounds. The errors in the derived polarization power spectra are improved compared to the errors derived by the WMAP Team.

Keywords Cosmology: cosmic background radiation · Methods: data analysis

1 Introduction

It is well established that the temperature anisotropies in the cosmic microwave background are a powerful tool to study the early phases of the evolution of the Universe. In addition, polarization measurements provide a new window into the physical conditions in that era. The polarization at large angular scales has the potential to provide information about the Universe when it was only 10^{-35} s old, and in addition, information about the ionization history of the Universe.

The CMB polarization probes the evolution of the decoupling and reionization phases. Rees (1968) predicted the polarization signal shortly after the discovery of the CMB by Penzias and Wilson (1965). Since then there have been considerable effort, both theoretical and observational to study this component. An excellent review can be found in Hu and Dodelson (2002).

Polarization measurements are normally given by the Stokes parameters Q and U, since they have straightforward noise properties. Since their definition depends on the chosen coordinate system, they are not well suited for quantifying the polarization anisotropies. In consequence, Q and U are transformed into E and B modes (E for the curl-free and B for the divergence-free components of the polarization field). The E and B mode formalism was introduced by Seljak and Zaldarriaga (1997), Kamionkowski et al. (1997) and Zaldarriage et al. (1997).

Fundamental symmetries in the production and growth of the polarization signal constrain the possible configurations of the CMB polarization. Scalar (density) perturbations give rise to T(emperature) and E modes, while tensor (gravitational wave) perturbations give rise to T, E and B modes. Both kinds of perturbations can produce polarization patterns in both the decoupling and reionization periods.

If the primordial inhomogeneities were Gaussian in nature, it follows (assuming linear theory) that CMB fluctuations are also Gaussian and fully described by the 4 cross power spectra TT, EE, BB and TE, while the TB and EB power spectra, from parity considerations, vanish (e.g.

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