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Planck 2015 results: X. Diffuse component separation: Foreground maps

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Abstract

Planck has mapped the microwave sky in temperature over nine frequency bands between 30 and 857 GHz and in polarization over seven frequency bands between 30 and 353 GHz in polarization. In this paper we consider the problem of diffuse astrophysical component separation, and process these maps within a Bayesian framework to derive an internally consistent set of full-sky astrophysical component maps. Component separation dedicated to cosmic microwave background (CMB) reconstruction is described in a companion paper. For the temperature analysis, we combine the Planck observations with the 9-yr Wilkinson Microwave Anisotropy Probe (WMAP) sky maps and the Haslam et al. 408 MHz map, to derive a joint model of CMB, synchrotron, free-free, spinning dust, CO, line emission in the 94 and 100 GHz channels, and thermal dust emission. Full-sky maps are provided for each component, with an angular resolution varying between 7.5 and 1deg. Global parameters (monopoles, dipoles, relative calibration, and bandpass errors) are fitted jointly with the sky model, and best-fit values are tabulated. For polarization, the model includes CMB, synchrotron, and thermal dust emission. These models provide excellent fits to the observed data, with rms temperature residuals smaller than 4μK over 93% of the sky for all Planck frequencies up to 353 GHz, and fractional errors smaller than 1% in the remaining 7% of the sky. The main limitations of the temperature model at the lower frequencies are internal degeneracies among the spinning dust, free-free, and synchrotron components; additional observations from external low-frequency experiments will be essential to break these degeneracies. The main limitations of the temperature model at the higher frequencies are uncertainties in the 545 and 857 GHz calibration and zero-points. For polarization, the main outstanding issues are instrumental systematics in the 100-353 GHz bands on large angular scales in the form of temperature-to-polarization leakage, uncertainties in the analogue-to-digital conversion, and corrections for the very long time constant of the bolometer detectors, all of which are expected to improve in the near future.

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Keywords

Cosmic background radiation, Cosmology: observations, Diffuse radiation, Galaxy: general, ISM: general, Polarization