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Deliverable 6.5: Joint Planck LFI and WMAP dipole estimate

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Work Package WP6 – Component separation

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Revision History

Version	Authors	Date	Changes
1.0	Loris Colombo Hans Kristian Eriksen Harald Thommesen Ingunn Kathrine Wehus	November 25th, 2020	Initial Version

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Experiment	Amplitude [μK_{CMB}]	Galactic coordinates l [deg]	Galactic coordinates b [deg]	Reference
COBE[a,b]	3358 ± 23	264.31 ± 0.16	48.05 ± 0.09	Lineweaver et al. (1996)
WMAP[c]	3355 ± 8	263.99 ± 0.14	48.26 ± 0.03	Hinshaw et al. (2009)
LFI 2015[b]	3365.5 ± 3.0	264.01 ± 0.05	48.26 ± 0.02	Planck Collaboration II (2016)
HFI 2015[d]	3364.29 ± 1.1	263.914 ± 0.013	48.265 ± 0.002	Planck Collaboration VIII (2016)
LFI 2018[b]	3364.4 ± 3.1	263.998 ± 0.051	48.265 ± 0.015	Planck Collaboration II (2020)
HFI 2018[d]	3362.08 ± 0.99	264.021 ± 0.011	48.253 ± 0.005	Planck Collaboration III (2020)
NPIPE[a,c]	3366.6 ± 2.6	263.986 ± 0.035	48.247 ± 0.023	Planck Collaboration Int. LVII (2020)
BeyondPlanck[e]	**3359.5 ± 1.9**	**263.97 ± 0.09**	**48.30 ± 0.03**	Section 9.5

Table 1: Comparison of CMB Solar dipole estimates derived from different datasets and with different methods. The bottom row shows the BeyondPlanck estimate, which is the first estimate that uses both Planck LFI and WMAP data.

1 Overview

The Solar CMB dipole plays an essential role in CMB analysis, because its spectrum is known to follow that of a near-perfect blackbody with a temperature of T=2.7255 K (Fixsen 2009), and it is the single brightest variable signal on the sky between 30 and 300 GHz. As such, it represents the ideal calibrator for CMB satellite experiments.

However, its amplitude and direction are intrinsically unknown, since these parameters depend on the Sun's velocity through space relative to the CMB monopole, and this has no connection to fundamental physics. These parameters must therefore be estimates directly from the same dataset as used for calibration. The only reason this is possible is because of the Earth's annual motion around the Sun, which induces a second and independent dipole, and the amplitude of this dipole is known from basic physics, since Earth's relative velocity with respect to the Sun is known to very high precision.

Before BeyondPlanck, each satellite experiment has produced its own independent estimate of the Solar dipole, as reported in Table 1; see BeyondPlanck collaboration (2020) for full details. BeyondPlanck is the first effort to analyse Planck LFI and WMAP jointly, and thereby produce a more robust estimate of this essential quantity. As expected, the new dipole amplitude takes a value (3359.5 µK) that lies between the Planck (3364 µK) and WMAP (3355 µK) estimates.

Perhaps equally important as the central values of these parameters, however, are the uncertainties. The BeyondPlanck estimates are the first ever to not include an ad-hoc "systematics" contributions, but these are rather simply the posterior standard deviations produced directly by the Markov chain.

2 Products and documentation

The CMB dipole is not a separate product as such, but rather an integrated component of the general CMB sky map. The relevant Gibbs chains for these CMB sky maps are available at http://beyondplanck.science, and documentation is available at http://docs.beyondplanck.science. A detailed discussion of the scientific results is presented by Colombo et al. (2020)

3 References

BeyondPlanck I. Global Bayesian analysis of the Planck Low Frequency Instrument data, BeyondPlanck Collaboration, 2020, A&A, submitted, [2011.05609]

BeyondPlanck XII. CMB constraints, Colombo, L. P. L., 2020, A&A, in preparation