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European Commission

Beyond PLANCK

Deliverable 6.4: Final astrophysical sky model products

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Work Package WP6 – Component separation

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Revision History

Version	Authors	Date	Changes
1.0	Kristian Joten Andersen Hans Kristian Eriksen Trygve Leithe Svalheim Ingunn Kathrine Wehus	November 25th, 2020	Initial Version

Contents

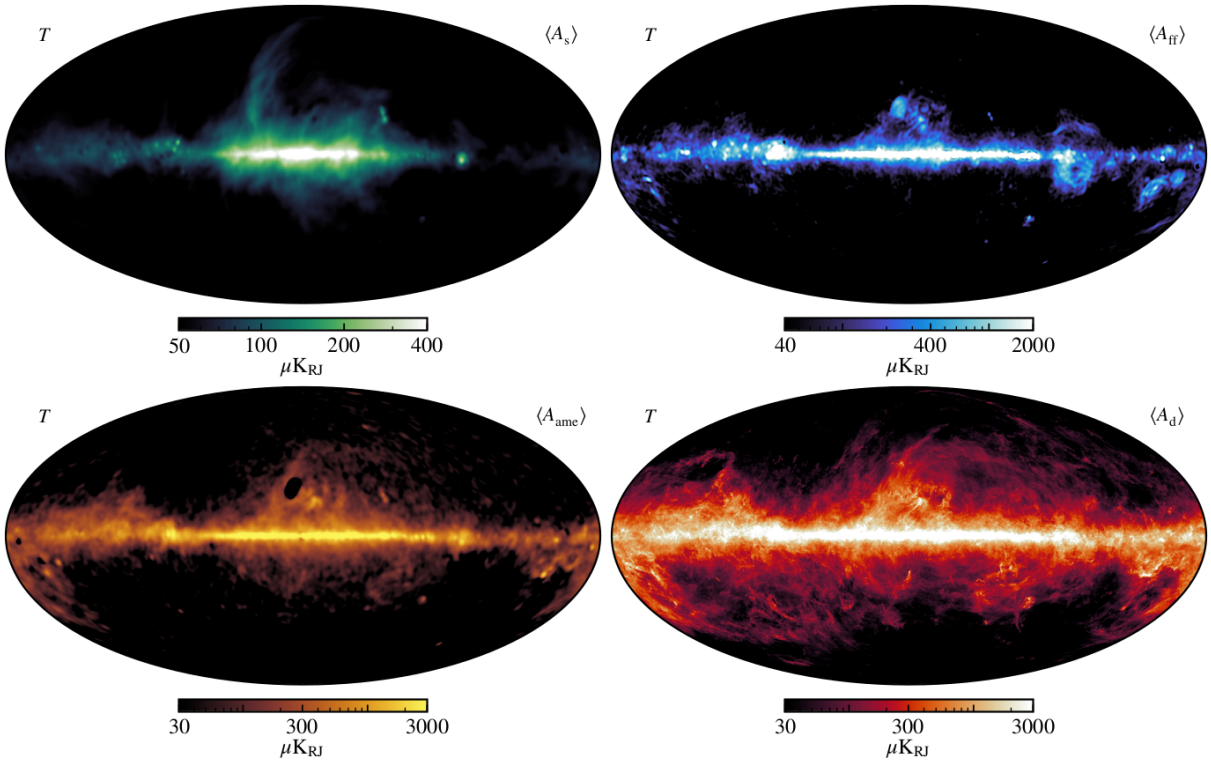

Figure 1: Foreground amplitude intensity maps as estimated with the BeyondPlanck pipeline. From top to bottom and left to right, the four panels show 1) synchrotron, 2) free-free, 3) AME, and 4) thermal dust emission.

1 Overview

Astrophysical component separation represents the computational heart of the end-to-end Bayesian Gibbs sampler implemented by the BeyondPlanck collaboration, as this is where the low-level time-ordered data connect to high-level cosmological parameters. The importance and complexity of this particular analysis step becomes obvious when inspecting the Commander source code: While the various TOD sampling steps account for about 6000 lines of code, the component separation steps account of 14.000 lines of code.

The BeyondPlanck sky model includes four five main foreground components, namely synchrotron, free-free, AME, and thermal diffuse emission, as well as compact sources. These are the only ones to which Planck LFI is primarily sensitive. In comparison, components such as Zodiacal light, cosmic infrared background, or Sunyaev-Zeldovich fluctuations are either too faint at frequencies below 70 GHz (Zodi and CIB), or affect too small scales to be relevant for LFI (SZ).

The explicit parameteric sky model that is fitted to the current data set in intensity therefore takes the following form,

$$
\begin{aligned}
\boldsymbol{s}_{\mathrm{RJ}} = &\left(\boldsymbol{a}_{\mathrm{CMB}} + \boldsymbol{a}_{\mathrm{quad}}(\nu)\right) \frac{x^2 e^x}{(e^x-1)^2} + \\
&+ \boldsymbol{a}_{\mathrm{s}} \left(\frac{\nu}{\nu_{0,\mathrm{s}}}\right)^{\beta_{\mathrm{s}}} + \\
&+ \boldsymbol{a}_{\mathrm{ff}} \left(\frac{\nu_{0,\mathrm{ff}}}{\nu}\right)^2 \frac{g_{\mathrm{ff}}(\nu; T_{\mathrm{e}})}{g_{\mathrm{ff}}(\nu_{0,\mathrm{ff}}; T_{\mathrm{e}})} + \\
&+ \boldsymbol{a}_{\mathrm{sd}} \left(\frac{\nu_{0,\mathrm{sd}}}{\nu}\right)^2 \frac{f_{\mathrm{sd}}\left(\nu \cdot \frac{\nu_{\mathrm{p}}}{30.0\,\mathrm{GHz}}\right)}{f_{\mathrm{sd}}\left(\nu_{0,\mathrm{sd}} \cdot \frac{\nu_{\mathrm{p}}}{30.0\,\mathrm{GHz}}\right)} + \\
&+ \boldsymbol{a}_{\mathrm{d}} \left(\frac{\nu}{\nu_{0,\mathrm{d}}}\right)^{\beta_{\mathrm{d}}+1} \frac{e^{h\nu_{0,\mathrm{d}}/k_{\mathrm{B}}T_{\mathrm{d}}} - 1}{e^{h\nu/k_{\mathrm{B}}T_{\mathrm{d}}} - 1} + \\
&+ \sum_{j=1}^{N_{\mathrm{src}}} \boldsymbol{a}_{j,\mathrm{src}} \left(\frac{\nu}{\nu_{0,\mathrm{src}}}\right)^{\alpha_{j,\mathrm{src}}-2},
\end{aligned}
$$

where each term is described in detail by Andersen et al. (2020). In polarization, only the first, second and fifth rows are included in the model; see Svalheim et al. (2020).

Figure 1 shows the resulting posterior mean maps from this process, while Figure 2 shows the polarized synchrotron emission amplitude (top) and spectral index (bottom).

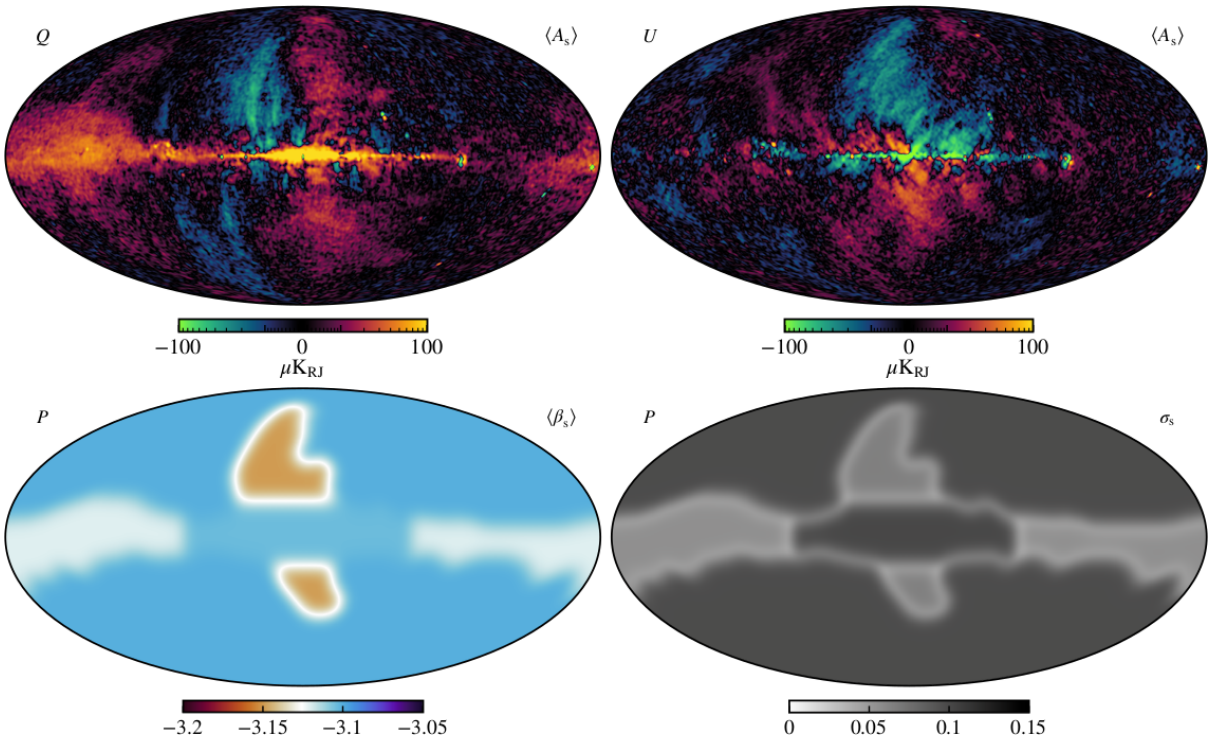

Figure 2: Polarized synchrotron amplitude Stokes Q and U (top left and right) parameters, and spectral index and its uncertainty (bottom left and right), as estimated with the BeyondPlanck pipeline.

2 Products and documentation

The BeyondPlanck astrophysical sky model is described by Andersen et al. (2020) for intensity and by Svalheim et al. (2020) for polarization, both in terms of algorithms and products. The full data set is already available from the project home page (http://beyondplanck.science), and main products will also be hosted by Planck Legacy Archive (PLA; http://pla.esac.esa.int) after the papers have been accepted for publication.

A total of six independent Markov chains have been produced, each including 200 samples. We estimate that about 50 samples in each chain must be rejected due to burn-in, leaving a total of 900 good samples for science analysis. (AME is a special case for which the burn-in period is significantly longer, and in this particular case only 300 samples are retained for scientifici analysis.) The total data volume of each chain file is 329 GB, for a total of about 2 TB of data across all six chains. In addition to the actual chain files, which do represent the main product of the entire analysis, we provide posterior mean and standard deviation maps for each component in a standard Healpix format.

Documentation is available at http://docs.beyondplanck.science.

3 References

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