PROCEEDINGS OF SCIENCE

HFI L2 DPC destriping and mapmaking modules

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The data processing of the data from the High Frequency Instrument (HFI) of the Planck mission will use several modules. Destriping is expected to play a central role in the mapmaking stage. This paper outlines two existing HFI l2 DPC destriping modules together with estimations of their performances. MOKAPIX is a temperature data destriping tool based on scanning redundancies on the sky. We have developped another modules, BOGOPIX , based on the same philosophy, to perform simultaneously destriping and relative intercalibration.

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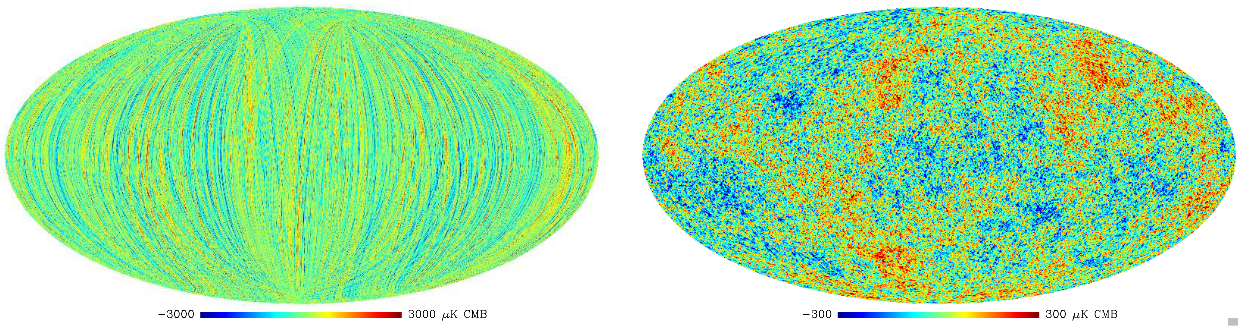

Figure 1: Example of sky maps obtained before (left) and after(right) destriping the PBR with MOKAPIX

1. Introduction

Data from High Frequency Instrument will be analysed in several steps. The noise affecting these bolometric data is expected to present a $1/f^{\alpha}$ spectrum ($\alpha \sim 2$) with a knee frequency of $f_{knee} \sim .06Hz$ and a white component of $\sigma_{white} \sim 0.1mK_{RJ}$ (at 143 GHz). After time ordered information (TOI) cleaning and filtering, the HFI DPC will take advantage of the Planck redundant scanning strategy : circles will be scanned ~ 60 times before moving the spin axis of the payload, at a 1 rpm speed. Each group of circles will be combined, forming rings, also labelled PBR (Phase Binned Rings). At the moment, a simple ring-making module has been used, based on the nearest grid point algorithm. More elaborate modules will be implemented. In addition to data size reduction, ring-making will also increase the signal-to-noise ratio for these compacted data. The noise affecting these PBR is expected to be white, the $1/f^{\alpha}$ component introducing in addition offsets from one PBR to the other. The aim of the HFI L2 destriping modules is then to determine and subtract these offsets from the PBR. In this study we have been evaluating temperature data destriping modules which could be used in HFI DPC pipelines.

2. MOKAPIX

The MOKAPIX algorithm makes uses of the redundancies of the Planck scanning strategy. An underlying HealPix sky map is defined. Our algotithm relies on the general hypothesis that the sky signal is constant in each pixel of this map. Each measurement M_{ij} of the i-th PBR may be decomposed as $S_k + O_i$ where S_k is the sky signal in the corresponding pixel k. MOKAPIX determines the offsets O_i by minimizing the χ^2 :

$$\chi^2 = \sum_{k(pixels)} \sum_{i(Ring)\, j(Phase)} (M_{ij} - S_k - O_i)^2$$

with the external constraint: $\sum O_i = 0$. Two minimization schemes have been implemented : the exact solution, which enables us to determine as well the offset covariance matrix, and a (much faster) iterative method through conjugate gradient. An example of destriped map is shown on

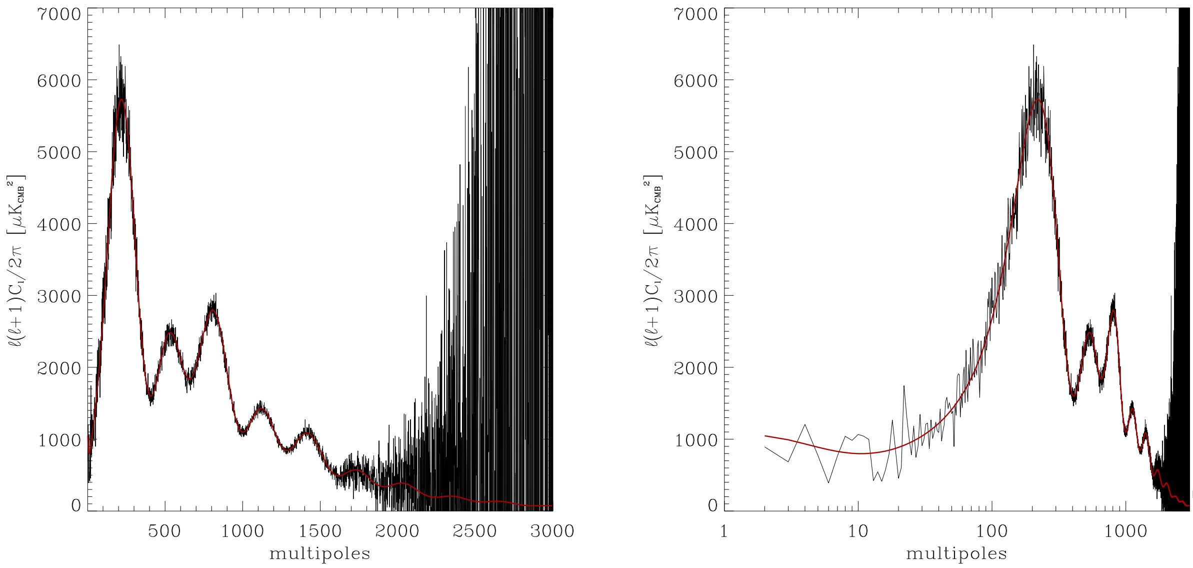

Figure 2: Example of power spectra reconstructed using MOKAPIX , in linear (left) and logarithmic (right) ℓ scale

figure 1. MOKAPIX has been implemented in the HFI DPC L2 architecture, and is fully compliant with the MPI process coordinator (ProC). It is able to deal simultaneously with data from several channels at the same frequency. Destriping data equivalent to one year (i.e. 8870 rings) for one channel takes 15mn of CPU on machines like Magique-II or In2p3 CC batch workers (for a serial job).

3. BOGOPIX

Following the same guideline, we have also implemented another module, BOGOPIX , capable of determininig (relative) gains G_i and offsets O_i for each ring i. Each measurement is now written as : $M_{ij} = G_i * S_k + O_i$ As before, the sky signal is assumed to be constant in each pixel of the underlying map. BOGOPIX determines the offsets, gains and signal G_i, O_i, S_k (ring i, pixel k) by least-squared minimisation with the constraint : $\sum o_i = 0$.

We first linearized the problem to solve it iteratively. We look for signal and gain variations Δs and Δg with respect to a starting point (G^*, S^*, O^*):

$$Y = G^*S^* + G^*P\Delta s + S^*K\Delta g + KO$$

where K is the offset pointing matrix. We initialize the problem as follows :

$$O^{(0)} = 0 \,; G^{(0)} = 1 \,; S = \left(P^TP\right)^{-1} P^T$$

We determine O, Δg and Δs by minimizing the χ^2 :

$$\left\| Y - G^*S^* - KO^{(n)} - G^{(n)}P\Delta s - S^{(n)}K\Delta g \right\|^2$$

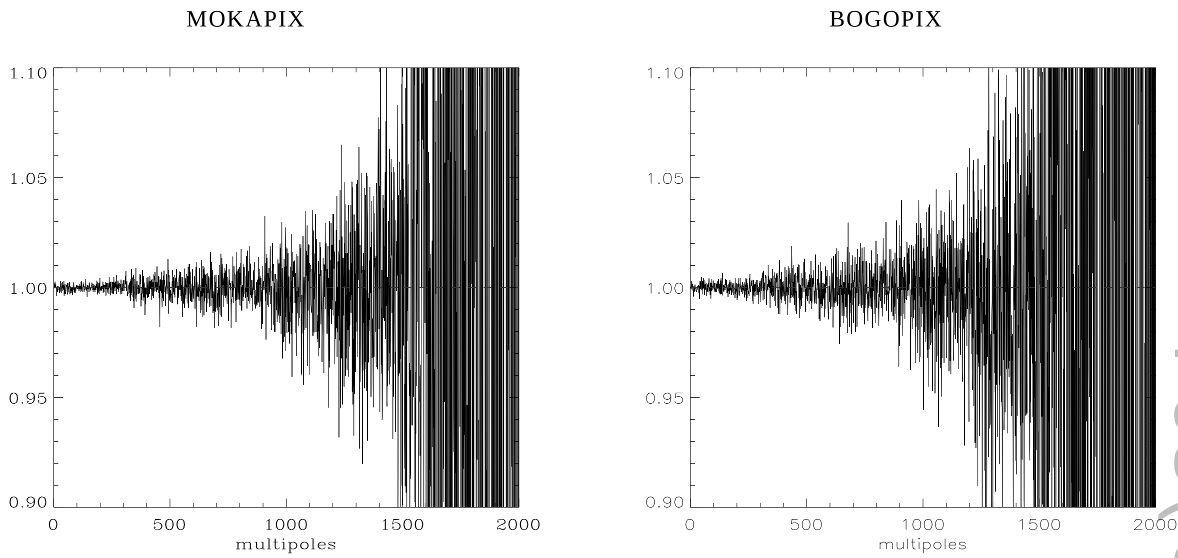

Figure 3: Transfer function for MOKAPIX (left) and BOGOPIX (right)

and update the offsets, signal and gains : $O^{(n+1)}$, $S^{(n+1)} = S^{(n)} + \Delta s$; $G^{(n+1)} = G^{(n)} + \Delta g$ The iterations stop when the χ^2 falls below an arbitrary convergence threshold.

BOGOPIX is integrated in the HFI L2 architecture, and MPI ProC compliant. It's parallelisation using MPI is not yet available however. Destriping 8870 rings takes $\sim$ 1 h of CPU time on our typical computing hardware. To use BOGOPIX on more realistic data (with e.g. a galactic component) care has to be taken to ensure to only use in the offsets and gain determination those pixel where the signal doesn't vary too much, by using a mask to skip the central regino of the galaxy for example.

4. Evaluation of performances

In order to evaluate the effect of our destriping modules on the CMB power spectra we use the LevelS softwares to grenerate data corresponding to one year of survey, for 4 143 GHz spiderweb bolometer channels. The sky signal was restricted at the moment to the CMB component. We coadded to this simulated sky signal realisations of simulated instrumental noise, including a $1/f^2$ component. $\sim$ 20 set of noise realisations were generated for each channel. PBR were reconstructed for the LevelS TOIs using HFI L2 modules. After destriping them we projected these data in HealPix maps (`nside`=1024). We finally reconstruct C_ℓ spectra using the Xspec HFI L2 module (M. Tristram, these proceedings). The averaged difference between the reconstructed C_ℓ spectrum and the input one is shown on figure 3, and measures the "transfer function" of our reconstruction procedure. These spectra show that up to $\ell \sim 1500$ our procedure do not distort the C_ℓ spectrum by more than 5%. Our results are mainly limited by the small number of noise realisation used up to now. More thorough studies as well as extension to polarized data are under way.