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Combining *Planck* and *Herschel* to improve our view of the Milky Way

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Abstract. *Herschel* has revolutionized our ability to measure column densities (N_H) and temperatures (T) of molecular clouds thanks to its far infrared multiwavelength coverage. However, the lack of a well defined background intensity level in the *Herschel* data limits the accuracy of the N_H and T maps. We provide a method that corrects the missing *Herschel* background intensity levels using the *Planck* model for Galactic dust emission. Our method combines the *Planck* model on large angular scales with the *Herschel* images on smaller angular scales in the Fourier space. We apply our method to two test regions (Perseus & HiGaL 11) and further generate column density and temperature maps out of our results. Our method successfully corrects the *Herschel* images, including both the constant–offset intensity level and the scale-dependent background variations measured by *Planck*. We apply our method to synthetic observations of a simulated molecular cloud for validation.

1. Introduction

The *Herschel* (Poglitsch et al. 2010) Space Telescope photometers have surveyed large areas of the sky in the far-infrared. However, large portions of the data remain to be fully scientifically exploited. One obstacle to obtaining accurate column density and temperature maps is that the *Herschel* archive data have not yet received a full background correction. Obtaining such corrections is not trivial. In the case of the SPIRE images, the archive data have been partially corrected with a *Planck*–derived constant–offset, assuming average zero–level flux values (a single constant-offset correction over a given map, see SPIRE handbook), based on *Planck* (Planck Collaboration et al. 2014a) measurements. All these methods implicitly assume that the corrections to the *Herschel* intensity are independent of angular scale. However, this assumption is an over-simplification, specially for the shortest wavelengths of *Herschel*.

While the constant-offset corrections partially account for the missing background in the *Herschel* images, the *Planck* flux distribution may significantly vary within the image area, especially in cases where the maps are large and at shorter wavelengths. Therefore, both PACS and SPIRE images would benefit from a background correction that is capable of grasping the scale dependence of the background emission levels. The knowledge of these background levels are an obvious requirement to estimate the "actual" flux scale measurements in *Herschel* images.

We use the *Planck* all-sky dust model (Planck Collaboration et al. 2014b) to generate *Planck* flux maps at the same Herschel wavelengths and combined these data sets with Herschel in the Fourier space, keeping the information of the former at large scales and the

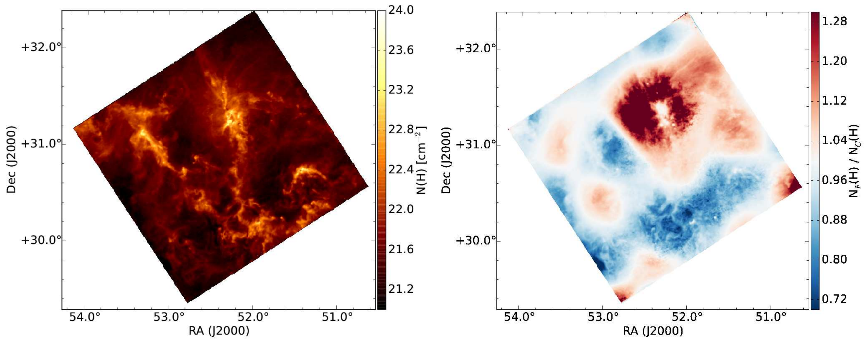

Fig. 1. *Top:* Logarithmic column density map of NGC 1333 obtained with our method. *Bottom:* Ratio of our column density map and the constant–offset column density map of NGC 1333.

latter at small scales. Here we present the basic steps of our method and its results, tested on Perseus and the HiGaL field at l = 11 deg.

2. The method

Our method makes use of the 2.5 level data products from the *Herschel* archive and the all-sky model of dust emission from *Planck*. We summarize here the main steps of our method. For a more detail description, we refer the reader to Abreu-Vicente et al. (2017):

1 With the *Planck* all–sky dust model we obtain SEDs for each sky pixel and convolve them with the *Herschel* filter responses (*Planck* fluxes).
2 We cross–calibrate the *Planck* fluxes from step 1 and the *Herschel* maps.
3 The *Herschel* and *Planck* fluxes are combined in the Fourier space weighted by Fourier–scale dependent functions whose aim is to keep *Herschel* (*Planck*) information at small (large) scales.

3. Results and conclusion

We apply the method to the two test fields and compare the results with the previously adopted constant–offset correction. We further post–process our "*HP–combined*" maps to obtain column density and temperature distributions, comparing them with their constant–offset counterparts.

We find significant differences ($\gtrsim$20%) over significant ($\sim$15%) areas of the maps, at low column densities ($N_{\rm H} \lesssim 10^{22}\,{\rm cm}^{-2}$) and relatively high temperatures ($T \gtrsim 20\,{\rm K}$). We apply our method to a simulated molecular cloud to validate it, showing that our method is accurate and better reconstructs the missing background emission than a constantoffset correction. Furthermore, our method is general and can be applied to any combination of datasets from telescopes with different resolutions.

We are currently applying the method presented here and in the paper to the whole Galactic plane to obtain the best large scale column density and temperature datasets of our Galaxy so far (Stutz, Abreu–Vicente in prep).

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