The Bandmerged Planck Early Release Compact Source Catalogue

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Introduction

The Planck Early Release Compact Source Catalogue (ERCSC[1]) provides highly reliable sources detected at 9 frequencies ranging from 30 to 857 GHz in the first 1.6 full-sky survey maps of Planck. It thus offers a unique opportunity for studying these sources, both Galactic and extragalactic, in a previously under-explored frequency domain. In the ERCSC, source detection and characterization were done independently in each Planck band. Here we provide a value-added bandmerged catalogue of the sources in the ERCSC, to facilitate the study of spectral properties of Planck sources by the scientific community. The two main challenges in the merging process are: 1) different resolution across the bands (from 33' at the lowest frequency to ~ 4' at the highest frequency) which causes source confusion; 2) the broad frequency coverage that induces complication due to the interstellar medium (ISM) emission. We describe below the bandmerge algorithm, with emphasis on the confusion processing. We also utilize this catalogue to probe CO emission at high galactic latitudes.

Bandmerge Algorithm[2]

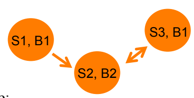
1. Cross-Band Matching

For a detection in one band (seed), we search all the other bands (candidates) for matching detections within ½FWHM of the beam size of the band with lower resolution. Each of the 9 bands is processed as seed band once. We save, for each detection, up to three pointers per band to any qualifying matches in all other bands, arranged in ascending order of positional offset.

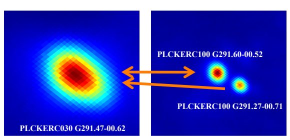
2. Confusion Processing

Case A: Inconsistent chain

Model:



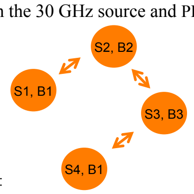
Example:



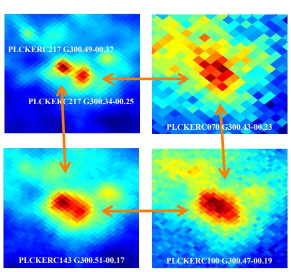
In regions of high source density, inconsistent chain can develop where source S1 in band B1 finds source S2 as the preferred match in band B2, but source S2's first-choice match in B1 is source S3. We approach inconsistent chains by looping over all source records, examining any first-choice pointers to see if its first choice points back. If not, we follow the chain until a reciprocal relation is found, break the previous link, and elevate any existing 2nd (or 3rd) choice pointer to 1st (or 2nd) choice. We then repeat the process on the updated source records until only reciprocal linkages remain. In the example here, PLCKERC100 G291.60-00.52 and PLCKERC030 G291.47-00.62 are found to be the preferred match to each other, we therefore keep the link between them and break the one between the 30 GHz source and PLCKERC100 G291.27-00.71.

Case B: Excess linkage

Model:



Example:



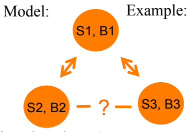
Inconsistencies can still exist after all linkages have been made reciprocal. Source S1 in band B1 can have a reciprocal relationship with a detection S2 in band B2, which has a reciprocal relationship with source S3 in band B3, which has a reciprocal relationship with a different source S4 in band B1. In the ERCSC merging, excess linkage often happens when one source detected at a lower resolution band resolves into multiple sources at higher resolution bands. We break the links between the unresolved detections and the resolved ones, and separate them as different entries in the bandmerged catalogue. In the example here, we would list the 70, 100 and 143 GHz sources as one entry, with a note pointing to the two components at 217 GHz that are listed as two separate entries.

Case C: Linkage rejection

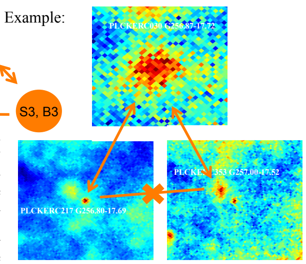
Linkage rejection refers to the scenario where source S1 in band B1 is matched to both source S2 in band B2 and source S3 in band B3, but S2 and S3 are not matched to each other. The main causes for this problem in the ERCSC merging are: 1) Different matching radii are used for every 2 bands during cross-band linkage; 2) When one source resolves into multiple components, ERCSC detects one component at one band and another at a different frequency. The fact that S2 and S3 are indirectly linked gives some credibility that they may be the counterparts to each other. We therefore test the unlinked detections with a 1FWHM matching threshold, and link them if they pass the larger threshold and inspection of the source images confirm they are not different components of the same source.

Case D: Cirrus confusion

Model:

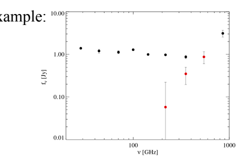


Example:



At Planck 353 to 857 GHz bands, the ISM contribution gets stronger and Galactic cirrus can sometimes be confused with a compact source. We identify a cirrus feature by selecting sources that show large discrepancies between the ERCSC bandfilled flux densities at 217 to 545 GHz (red circles in the example) and the bandmerged flux densities at the corresponding frequencies (black circles), and further selecting the ones with an EXTENDED flag at 857 or 545GHz but are compact at 217 or 353 GHz. We finally inspect source images from the Planck IRSA Archive[3] to confirm robust matches and separate the incorrect associations.

Example:



The Bandmerged Catalogue

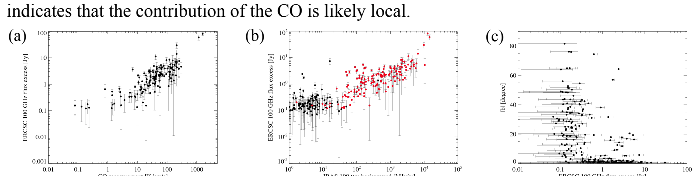
Table 1. Bandmerged ERCSC Content

Column Name	Description
NAME	Source name
GLON	Galactic longitude [deg]
GLAT	Galactic latitude [deg]
NBAND	Number of Planck bands with detection
FLUX	Flux density [mJy] in the Planck bands
FLUX_ERR	Flux density error [mJy] in the Planck bands
ERCSC_NAME	Name of the source in the ERCSC
NOTE	Indicate an entry in the notes file if set to 1

The final bandmerged ERCSC has 15191 sources; among them 79 are found to be detected at all nine frequencies. The source name and positions are based on the detection with the highest resolution in each chain. Upon publication of this paper, this catalogue will constitute the ERCSC entries in the NASA Extragalactic Database (NED).

Probing CO At High Galactic Latitudes?

The ERCSC 100 GHz flux measurements are contaminated by CO emission because the CO J = 1 → 0 line at 115 GHz falls in the band pass of the Planck 100 GHz channel. Using the bandmerged catalogue, we select 482 sources with detections at 70, 100 and 143 GHz bands. A simple interpolation of the 70 and 143 GHz fluxes at 100 GHz enables us to estimate the flux excess due to CO. We compare the flux excess with measurements from the Galactic CO survey map[4] in (a) and IRAS 100 μm background in (b), and show that it correlates well with both. This suggests that we can use this excess to study the distribution of CO at high galactic latitudes. We plot in (c) the distribution of this excess in our sample at different galactic latitudes. Below ~ 0.3 Jy, the values do not seem to change much with latitudes, which indicates that the contribution of the CO is likely local.



[1] Planck Collaboration 2011, A&A, 536, A7 [2] This algorithm is developed based on the technical document "Bandmerging Spitzer Point sources" by J. W. Fowler (http://irsa.ipac.caltech.edu/data/SPITZER/docs/dataanalysistools/tools/bandmerge/bandmerge_technical.pdf.) and modified to suit the specific needs of the ERCSC.
[3] The Planck IRSA archive can be accessed at http://irsa.ipac.caltech.edu/Missions/planck.html. [4] Dame, T. M., Hartmann, D., & Thaddeus, P. 2001, ApJ, 547, 792.