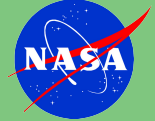


Classification of Compact Submillimeter Sources in the *Planck* Archive



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Abstract

The *Planck* satellite is a third-generation, space-based, cosmic microwave background (CMB) experiment with greater resolution and broader frequency range than its predecessors, COBE and WMAP. The completion of the first high-sensitivity submillimeter all-sky survey in April 2010 allows a unique opportunity to study the classes of astronomical sources that are foregrounds to the CMB. This project classifies sources in the *Planck* Early Release Compact Source Catalog (ERCSC) which have not been identified previously. In an effort to avoid the effects of confusion from the high density of sources in the Galactic plane, we confined our study to $|b| > 20^\circ$. Due to the $\sim 5'$ resolution of *Planck* data and resultant uncertainty in the positions of sources, we used WISE 12- μm and 22- μm data to determine accurate positions and an estimate of the far-infrared (FIR) color temperature of the sources. Other catalogs, including Akari, IRAS, Sloan and 2MASS, were also searched to pinpoint the counterpart of the source and obtain their spectral energy distribution (SED). The SED was used to constrain the origin of the FIR emission and provide further clues as to the nature of the sources. Of the 57 selected objects, $\sim 16\%$ were classified as stars while 12% were galaxies; pre-stellar cold cores or ISM with temperatures between 10K and 20K were also seen. Teachers and students from four schools were active participants in the data analysis process to bring authentic research into the classroom.

Procedures

- Search the *Planck* Early Release Compact Source Catalog (ERCSC) for unidentified compact sources at 857 GHz and outside the Galactic plane $|b| > 20^\circ$.
- Search WISE All-Sky Survey 12- μm and 22- μm catalogs to identify short-wavelength counterparts of the *Planck* source.
- Build a Spectral Energy Distribution (SED) for each source including Akari, IRAS, Sloan and 2MASS data.
- Estimate the far-infrared color temperature of the sources by fitting a modified blackbody to the SED.
- Use the temperature and Sloan/2MASS morphology to constrain the origin of the FIR emission and determine the nature of the source.

PLCKERC G244.76+54.92 Star-Forming Galaxy

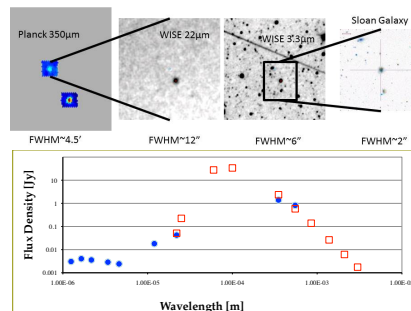


Figure 1. Multi-wavelength cutouts of unidentified *Planck* 350- μm source (PLCKERC G244.76+54.92) classified by us as a star-forming galaxy at $z \sim 0.07$. The WISE 22- μm data help pinpoint the location of the source which can then be associated with objects in other catalogs. Also shown is the full SED, which suggests a far-infrared color temperature of $\sim 40\text{K}$ and reveals the 1.6-micron stellar bump.

PLCKERC G194.50+42.07 Red Supergiant Star

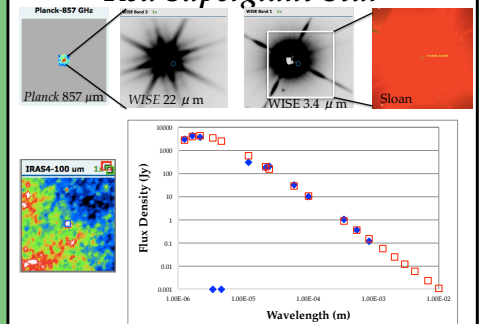


Figure 2. Multi-wavelength cutouts of *Planck* 350- μm source (PLCKERC G194.50+42.07) classified by us as a star (RS Cancri). WISE data help pinpoint the location of the source which can be associated with objects in other catalogs. Also shown is the full SED, which suggests the far-infrared color temperature of $\sim 2400\text{K}$ with a peak at 1.6 microns.

PLCKERC G208.54+33.28 Planetary Nebula

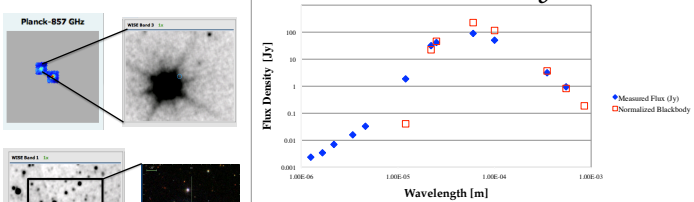
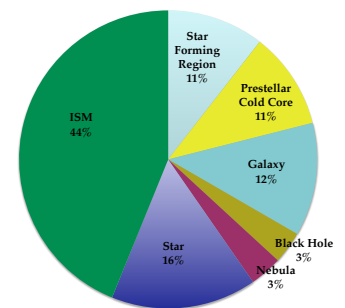


Figure 3. Multi-wavelength cutouts of a *Planck* 350- μm source (PLCKERC G208.54+33.28) classified as a planetary nebula (Abell 66). The WISE data pinpoint the location of the source which can be associated with the objects in other catalogs. Also shown is the full spectral energy distribution, which suggests the far-infrared color temperature of $\sim 77\text{K}$ (emissivity = 1) with a peak at 60 microns.

Results

Classification	Number in Sample (n=57)
Star-forming Region	6
Pre-stellar Cold Core	6
Galaxy	7
Star	9
Interstellar Medium	25
Black Hole	2
Nebula	2



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