A Search for Faint Sources of Infrared Excess in the SEIP Catalog

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Abstract

The Spitzer Enhanced Imaging Products catalog (SEIP) contains over 42 million sources, many of which were serendipitously imaged as a part of other projects and so have never been individually examined. The SEIP also contains the largest sample of sources detected at 24 microns fainter than 8th magnitude. Finding an excess of infrared radiation in a source's spectral energy distribution can indicate the presence of dust, which is often an indicator of an interesting evolutionary phase. So the SEIP provides a unique opportunity to find IR excess objects at 24 microns that would not have been detected in other surveys. This study built upon the work of three previous studies of infrared excess sources found in the SEIP, finding fainter objects than those surveys had been able to identify. After using the SEIP to identify sources with infrared excess at 24 microns with a signal to noise ratio greater than 5, the sources were crossmatched with the Gaia database, excluding any sources without a Parallax/Parallax_Error ratio greater than 3. Additionally, sources outside of the Galactic plane were selected as the focus of the investigation. Of the 19,540 sources with Gaia distances, 2,350 had a Parallax/Parallax_Error ration greater than 3. Of these, 269 sources were greater than 1 KPC from the Galactic plane. This dataset was cross checked with SIMBAD (Set of Identifications, Measurements, and Bibliography for Astronomical Data) to eliminate 31 known sources of infrared excess. These 238 sources were then inspected visually to ensure that the fluxes of the identified sources were free from contamination by nearby objects. This catalog of 103 new visually-vetted sources includes 99 with infrared excess, which will provide a rich opportunity for further study by current and future infrared telescopes.

Background

Stars are close to having a blackbody spectral energy distribution (SED) curve (see top panel of Figure 1 below). Stars that have greater measured flux in the infrared range compared to a blackbody are said to have an infrared excess (see middle panel below). This excess infrared can be caused by a debris disk or shell around young stellar objects or evolved stars. The bottom panel shows the SED for a source with a gap between the star and a debris disk or dust belt.

Spitzer Enhanced Imaging Products catalog (SEIP) includes an archive of data from the Spitzer Space Telescope's Infrared Array Camera (IRAC) which has measured the flux of sources in four channels (3.6, 4.5, 5.8, 8 microns) and also contains data from the Multiband Imaging Photometer (MIPS) channel at 24 microns. Infrared excess can be detected by plotting the ratio of these fluxes on a color-color diagram (see Figure 7). In order to find sources that would not have been detected by the Wide Infrared Survey Explorer (WISE), we selected for the SEIP 24 micron magnitude to be greater than 8.

Further, we were intrigued by sources outside of the Galactic plane since stars found there with an infrared excess are likely to be in an unusual evolutionary phase.

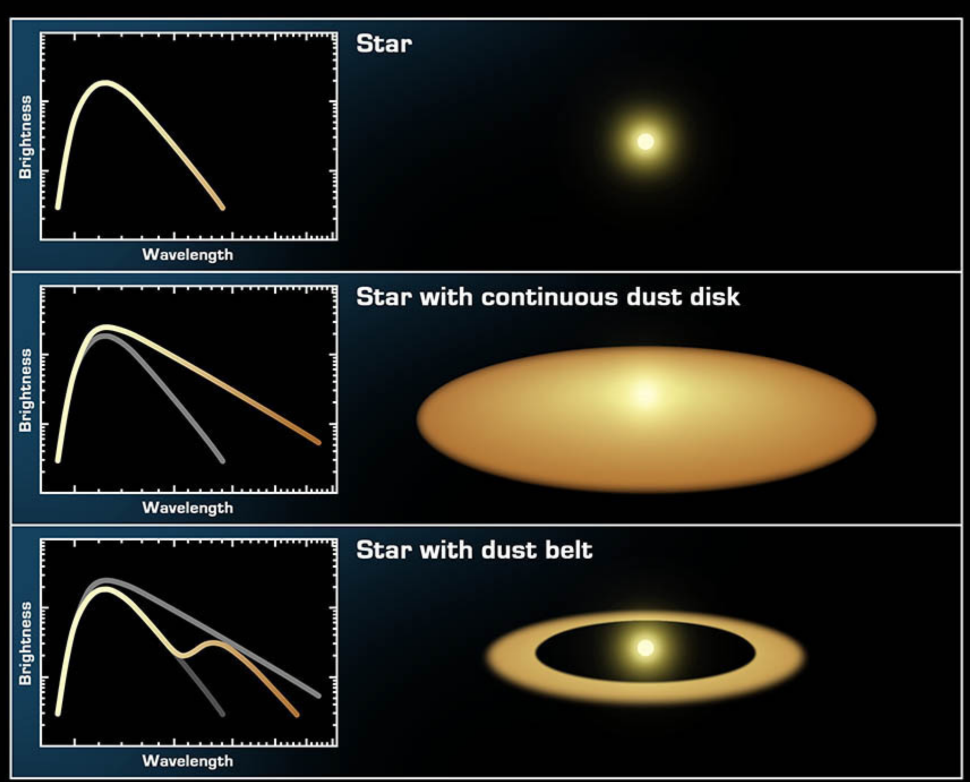

Figure 1: Credit: NASA/JPL-Caltech/T. Pyle (SSC)

Procedure Summary

1. **SEIP Search**: SNR >5 for IRAC I1, I2, and MIPS 1, and MIPS 1 > 8 mag ; 508,384 sources (Figure 2)
2. **Gaia Crossmatch**: Parallax/Parallax_Error >3; 2,350 sources (Figure 3)
3. **Check for sources already in SIMBAD; Select new sources Outside of Galactic Plane** (>1 kpc): 238 sources (Figure 4)
4. **Visually Vetting**: 103 sources (Figure 5 and Figure 6)
5. **Color-Color Diagram**: 99 sources with infrared excess (Figure 7)
6. **Color-Magnitude Plot**: main sequence and giants (Figure 8)

We gratefully acknowledge funding via NASA Astrophysics Data Analysis Program.

Procedure

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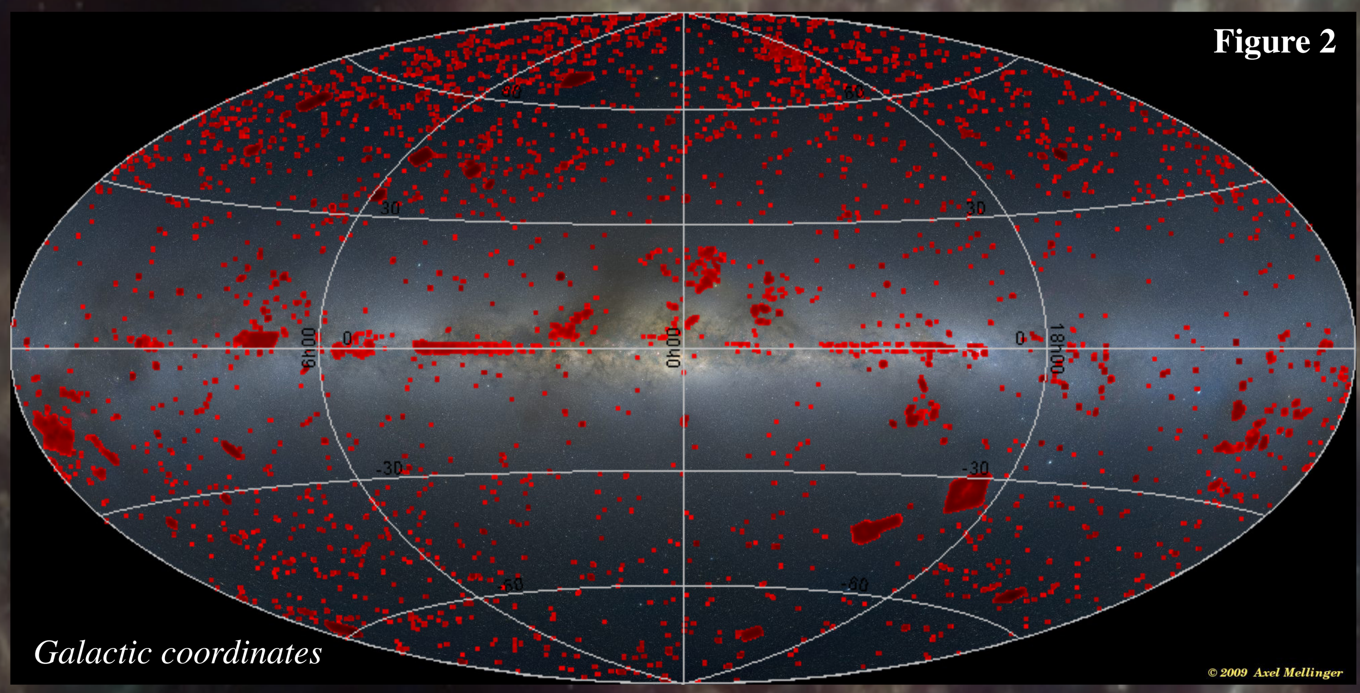
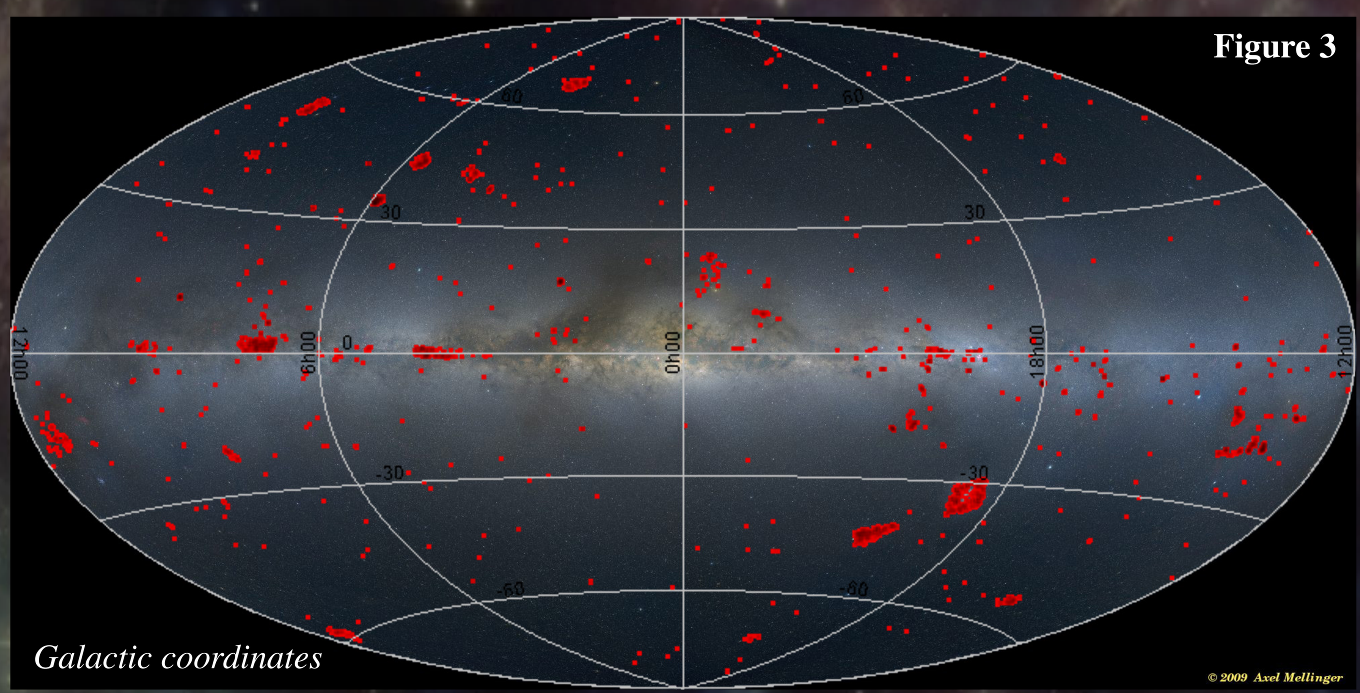
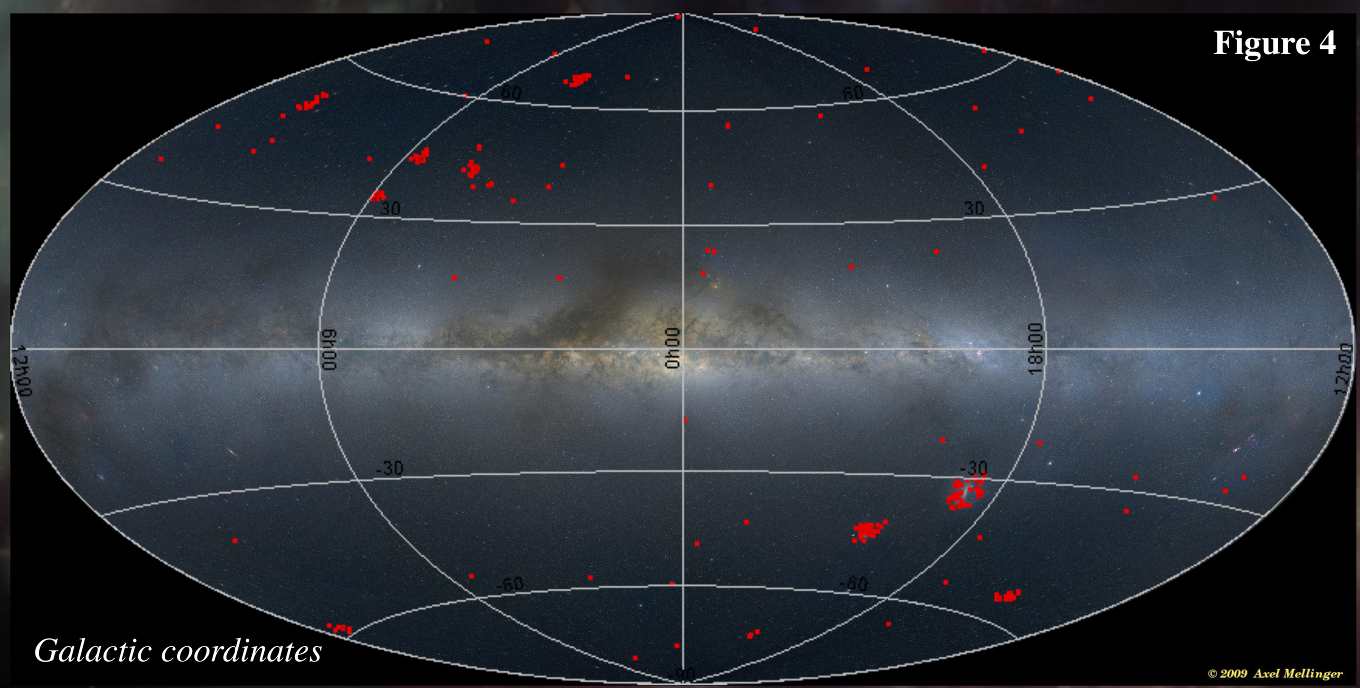


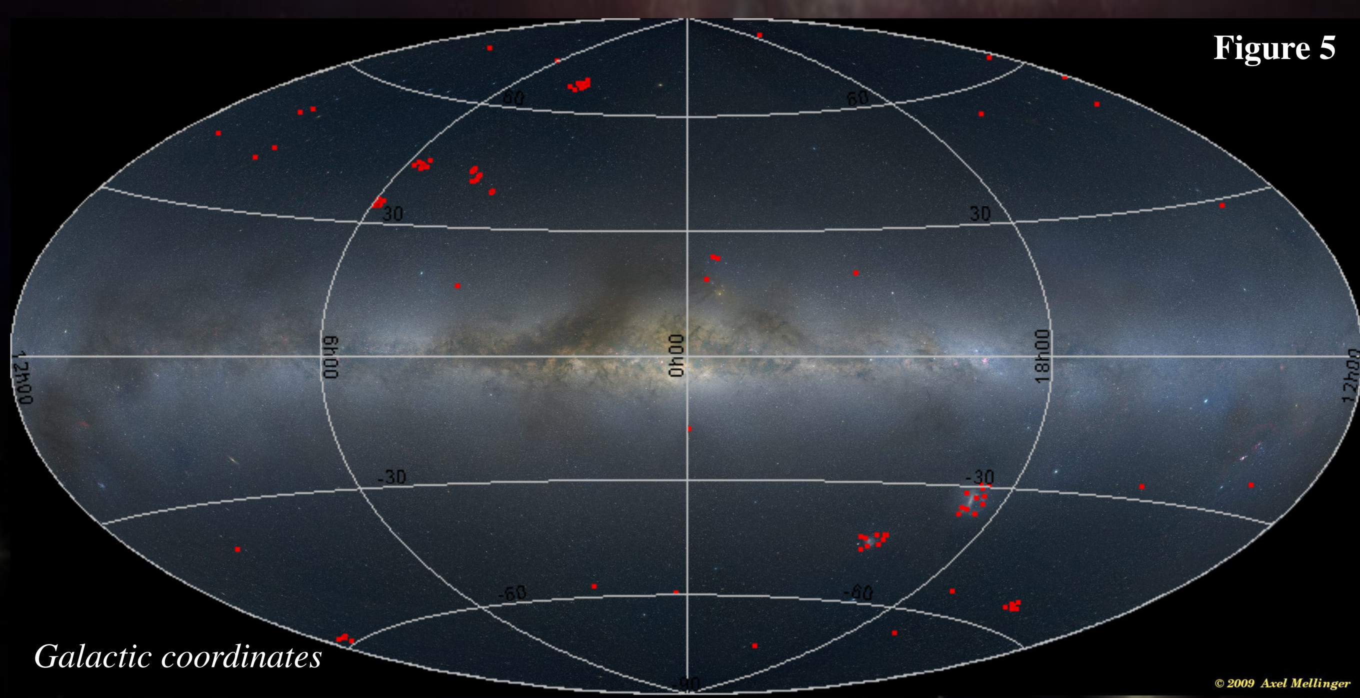
2. Gaia Crossmatch: Parallax/Parallax_Error >3; 2,350 sources



3. Check for sources already in SIMBAD
Select new sources Outside of Galactic Plane (>1 kpc): 238 sources

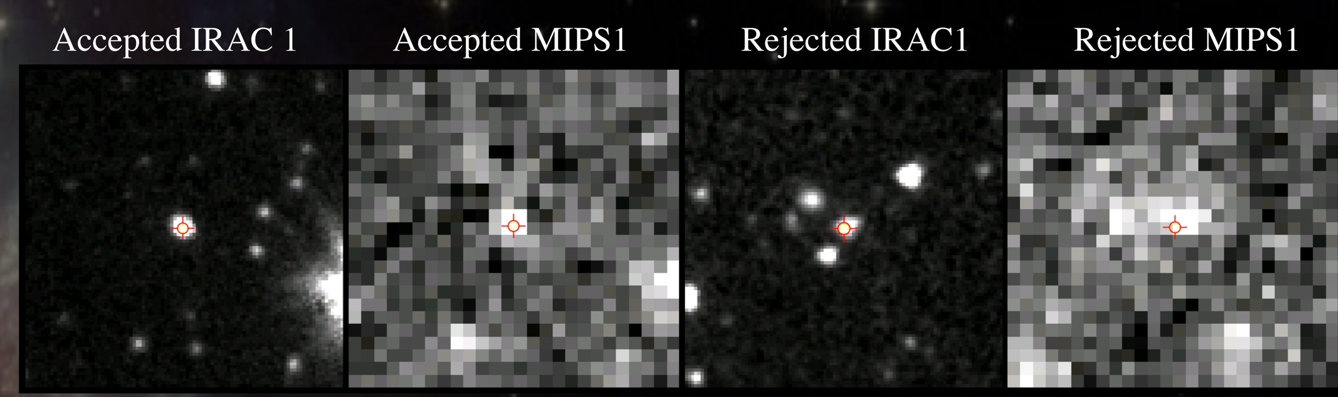


4. Visually Vetting: (see Figure 6 for samples) 103 sources

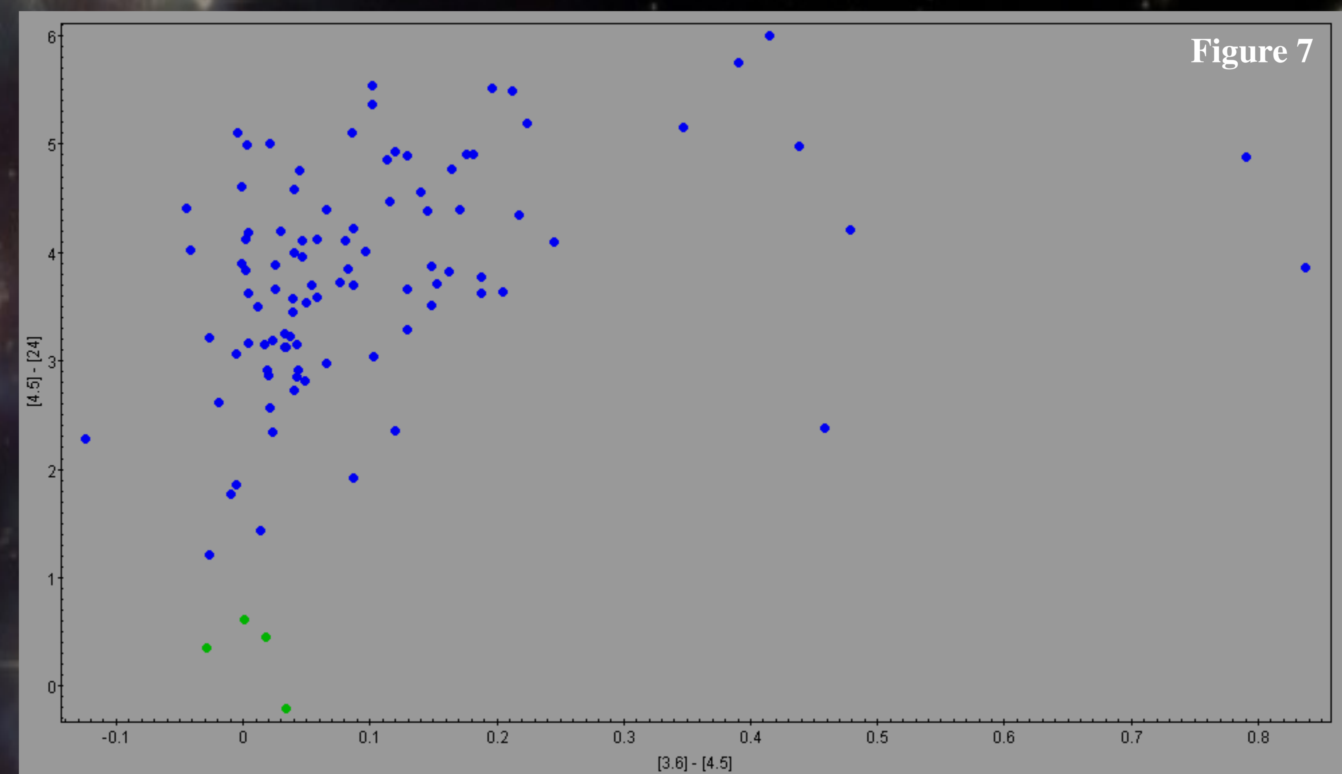


[Step 4 continues at the top of the right column]

Step 4 continued: Vetting Samples **Figure 6**

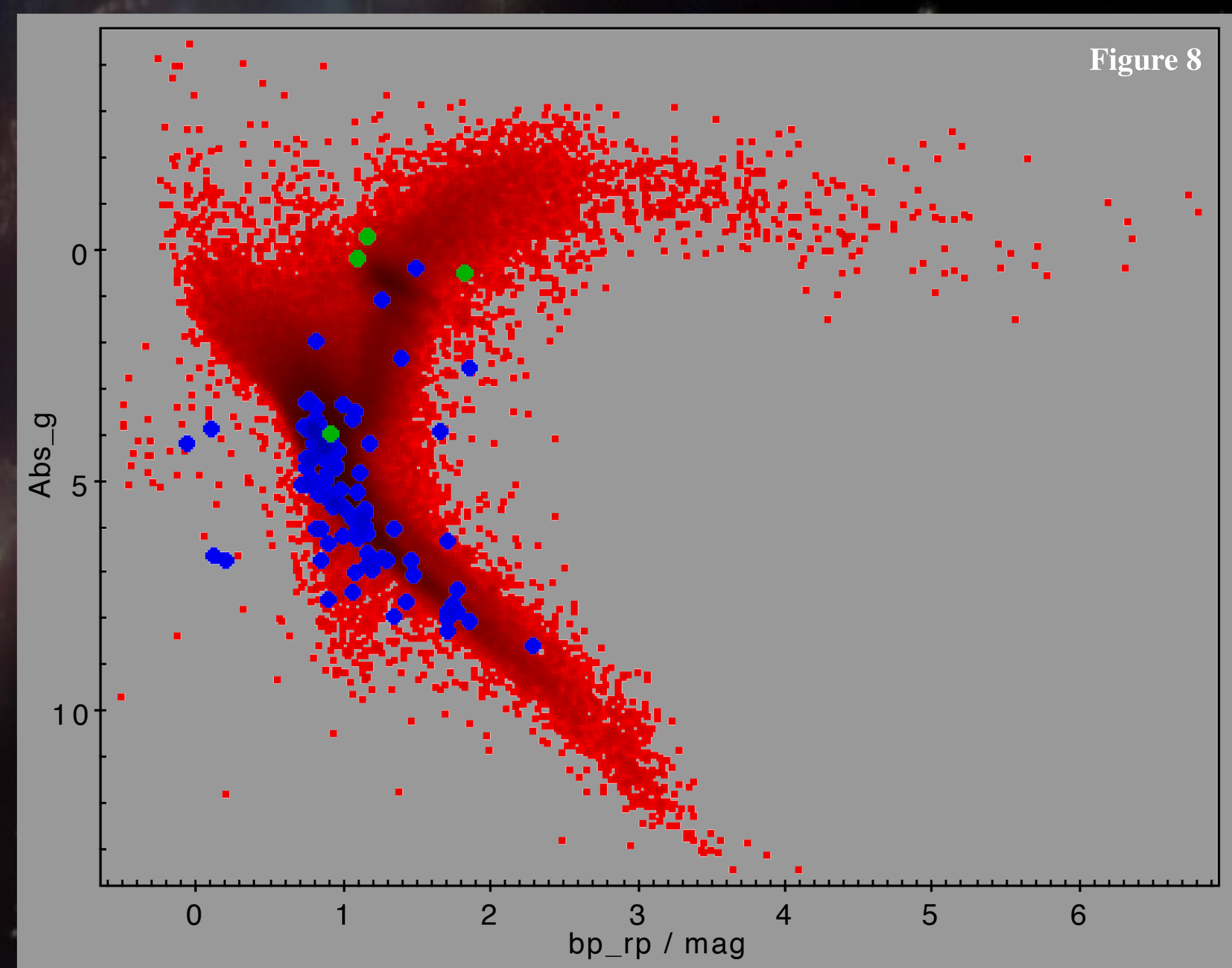


5. Color-Color Diagram: 99 sources with infrared excess



Color-color diagram of IRAC 1-2 versus I2-MIPS1 (Vega Magnitudes). Blue dots show excess infrared. Green dots show no excess infrared.

6. Color-Magnitude Plot: main sequence and giants



Color-magnitude diagram of the final sources. Blue dots show excess infrared. Green dots show no excess infrared. Red dots represent a sample HR diagram using Gaia data. This plot is using the Gaia b, g, and r filters.

Conclusion

After limiting the SEIP search to sources that have signal to noise ratio greater than 5 in IRAC channels 1 & 2 and MIPS 1, a Parallax/Parallax_Error ratio greater than 3, found at least 1 kiloparsec from the Galactic plane, and visually vetting them for validity, a total of 99 infrared excess sources. It was interesting to note that most of the sources seem to be on the main sequence. It was also interesting that many of the sources we eliminated in the visual vetting process were due to the source being off-center in the MIPS 1 channel. This catalog of new sources will provide an excellent opportunity for future study.

Galactic Coordinates Image Credit: *Axel Mellinger, A Color All-Sky Panorama Image of the Milky Way, Publ. Astron. Soc. Pacific 121, 1180-1187 (2009)*

Background Image Credit: Cassiopeia A Supernova Remnant; NASA/JPL-Caltech/O. Krause (Steward Observatory)