## Identification and classification of excess infrared sources in the Spitzer Enhanced Imaging Product

## SIRXS Draft proposal

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## Abstract

*The SEIP Infrared Excess project (SIRXS) will identify those sources in the Spitzer Enhanced Imaging Products (SEIP) that exhibit infrared excess and describe the demographics of of those sources within the SEIP source population.*

## Background

This project examines infrared point sources in the Spitzer Enhanced Imaging Product (SEIP) and identifies those sources that are likely to include significant dust, as indicated by the presence of infrared radiation in excess of what would be expected from a main sequence star or galaxy not shrouded by dust. These objects are identified by analysis of the relative strengths of the source in five IR bands, as visualized on a color-color diagram.

*Blackbody curves and excess IR*

All matter radiates thermally. The radiation from a star’s photosphere may be reasonably approximated as blackbody radiation, with a spectrum described by Planck’s law.

If a star is surrounded by dust, the illuminated dust is heated as it absorbs the star’s radiation. The dust then also radiates, albeit at a lower temperature. The dust is significantly cooler than the star so its blackbody spectrum is shifted to comparatively longer wavelengths, with peak spectral radiance in the infrared.

If a detected source is, in fact, the combination of a star plus circumstellar dust, then the spectrum of that source will be a combination of flux from star and the flux from the dust. The curve of the cooler dust only makes significant contribution to the combined curve at wavelengths in the IR.

### Sources that exhibit excess IR:

Infrared excess has been used to identify potential targets of study since the discovery of a circumstellar shell around Vega by its infrared excess (Auman et al 1984).

There are four main categories of sources likely to exhibit excess infrared: young stars, evolved low- to intermediate-mass stars, active galactic nuclei (AGN), and interacting galaxies (ULIRGs). All four share the combination of a central source of energy with reprocessing by surrounding dust.

### Young stars:

Young stellar objects (YSOs) may be embedded in a circumstellar envelope or disc of primordial dust not yet expelled, or by a debris field caused by the collision of forming protoplanets. In either case, the surrounding material is heated by the star or protostar and the target may be expected to exhibit excess infrared. Excess infrared was used by a previous NITARP team to identify YSOs in bright-rimmed clouds. (Rebull et al 2013)

### Evolved stars

Low to intermediate mass stars eject 20 - 80 percent of their mass during the superwind phase at the the end of the asymptotic giant branch. During the superwind, dust forms in the ejecta. [[Lagadec and Zijlstra 2008](http://mnrasl.oxfordjournals.org/content/390/1/L59.full.pdf)]

The resulting circumstellar dust reprocesses the radiation from the star and re-emits in the infrared.

### Active Galactic Nuclei

Infrared excess has been demonstrated as a successful technique for identifying active galactic nuclei (AGN) (Stern et al 2005). Gas drawn from the surrounding galaxy forms a high-temperature accretion disk characterized by a blackbody spectrum peaking at ultraviolet wavelengths. It has been theorized that the disk may be enshrouded by a dusty torus of material also drawn from the surrounding galaxy. As it is heated, the torus reprocesses the radiation from the accretion disk by absorbing the optical and ultraviolet components and radiating in the infrared.

### Colliding galaxies

Ultraluminous infrared galaxies (ULIRGs) are interacting galaxies that exhibit exceptional intensity at infrared wavelengths.

Interaction between galaxies causes morphological distortion due to tidal forces [[Toomre & Toomre 1972](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#too)] and such distorted galaxies are are distinct from normal ones on the (U-B, B-V) diagram. [Larson & Tinsley 1978](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#lt78)provide evidence for a 'burst' mode of star formation associated with the violent changes associated with galactic interaction.

[Lonsdale, Persson & Matthews 1984](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#lon84) and [Joseph & Wright 1985](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#jow) showed that interacting galaxies result in massive infrared excess due to star formation, and that interactions leading to merger are associated with “superstarbursts,” or “burst of star formation of extraordinary intensity and spatial extent.”

## Scientific Goals

Sources of excess infrared will be examined using data from the Spitzer Enhanced Imaging Products (SEIP) catalog. SEIP constitutes a list of all point sources imaged by the Spitzer Space Telescope during its cryogenic mission. The SEIP source list of photometry from compact sources includes data from the four channels of IRAC (3.6, 4.5, 5.8, 8 microns) and the 24 micron channel of MIPS.

The full set of products for the Spitzer cryogenic mission includes around 42 million sources. Of those, approximately five million have high signal-to-noise ratio, and one million have high SNR in all five channels. We will use color-color diagrams to identify those sources with excess IR and generate a list of candidate sources. Candidate sources will be screened by visual examination of the original Spitzer images in which they appear.

Once the excess IR sources have been identified we will use color-magnitude diagrams to classify the sources as nearby dusty stars, or distant AGNs or ULIRGs.

## Expected Outcomes

The goal of SIRXS is to identify for future follow-up all previously unknown sources of infrared excess in the Spitzer catalog.

The result of the project will be a list of excess IR sources in SEIP. The list will be categorized by type.

It is not currently known how common such sources are within the Spitzer catalog. SIRXS will enable us to comment on the demographics of infrared excess objects in the in SEIP, and, more generally, estimate the likelihood of of a pointed mission serendipitously measuring previously unidentified IR excess sources.

## Archived Data

Source selection for this project was completed by the release of the SEIP. SIRXS will examine all the high-reliability point sources in the Spitzer archive.

## Instruments

Spitzer Space Telescope is an orbiting infrared telescope in an Earth-trailing orbit. Spitzer’s complement of instruments includes the InfraRed Array Camera (IRAC) and the Multiband Imaging Photometer (MIPS). IRAC has four cameras with broadband filters centered at 3.6, 4.5, 5.8 and 8 µm. MIPS has three cameras inside that image using three broad-band filters, centered at 24, 70, and 160 microns.

SIRXS will use all four IRAC channels, plus the 24 µm channel from MIPS.

## Education Goals

### Nobles astronomy workgroup

Noble & Greenough School students will be involved in the entire SIRXS process through an astronomy workgroup functioning within school activity time. Students will learn the necessary background literacy and skills necessary to access SEIP data, construct color-color and CM diagrams.

### Basis for future curriculum development aligned w experiential learning

Noble & Greenough School is developing a student research program as part of a school-wide initiative on experiential learning. SIRXS will serve as a template for student involvement in a research project. In cooperation with my department chair and biochemistry teacher, Jennifer Craft, PhD, and Caroline Odden, Observatory Supervisor at Phillips Academy, I will develop additional strands of astronomical research to continue to involve students after the completion of SIRXS.

### NES-AAPT

I will present the SIRXS project as a template for student involvement in research to the New England section of the American Association of Physics Teachers.

### NSTA

I will apply to present the the SIRXS project as a template for student involvement in research at National Science Teachers’ Association meeting in Chicago in 2015

### Open question on the process -- talk with Jody

## References

[Auman et al 1984](http://adsabs.harvard.edu/abs/1984ApJ...278L..23A)

[Joseph & Wright 1985](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#jow)

[Lagadec and Zijlstra 2008](http://mnrasl.oxfordjournals.org/content/390/1/L59.full.pdf)

[Lonsdale, Persson & Matthews 1984](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#lon84)

[Rebull et al 2013](http://iopscience.iop.org/1538-3881/145/1/15/article)

[Stern et al 2005](http://iopscience.iop.org/0004-637X/631/1/163/fulltext/)

[Toomre & Toomre 1972](http://ned.ipac.caltech.edu/level5/Sept06/Lonsdale/Lonsdale_refs.html#too)