Finding Dusty Disks with Spitzer

**Goal:** Learn to use black body curves to predict the brightness of stars in the infrared and then compare their predictions to measurements from images obtained with the Spitzer Space Telescope.

**What to hand in** - Hand in a write-up of your lab results including
- An abstract summarizing your results
- An introduction describing the cluster IC 4665 and the purpose of the investigation
- A description of your procedure and the observations used (and sources)
- A description of your analysis procedures and plots, including error analysis. Include a plot of log (flux density) vs. log (wavelength).
- A discussion of your observations, identifying any stars with 24 micron excesses

An appropriate length is 3-5 typed pages, single spaced, 12-point font, with 1" margins, plus figures and tables. You may work with partners to obtain the data for the lab, but your analysis and writeup should be entirely your own. Be sure to review the general lab instructions on the "lab options" sheet.

**Background Science**
Planets orbiting stars other than the Sun are hard to find. They often orbit too close to their central stars and are too faint to see directly in the bright glare of the central star. Astronomers must use indirect means to detect the presence of planets around other stars.

The process of star formation leads to the formation of a disk of rocky or icy debris circling the central star. This debris disk may be similar to the large "asteroid belt" between the orbits of Mars and Jupiter in our own solar system. Planets disturb the orbits of bodies in the debris disk, causing collisions, which produce dust. Dust is expelled from the system in less than a million years. If dust is present around the star, then some source must be producing new dust. The presence of dust around a star is a strong indication of the presence of planets around the star.

Cool dust around other stars emits energy in the infrared portion of the electromagnetic spectrum that can be detected with the Spitzer Space Telescope. Stars with excess brightness at infrared wavelengths probably are surrounded by dust, and may well host extra-solar planets.

**Searching the Literature**
Use the WEBDA database of star clusters to determine the basic properties of the cluster IC 4665 (distance, age, chemical composition, reddening). WEBDA is a database of star clusters maintained at the University of Vienna ([http://www.univie.ac.at/webda//navigation.html](http://www.univie.ac.at/webda//navigation.html) or google "webda").
In the image of the cluster IC 4664 shown in the attached figure identifying the stars. The small (5' x 5') regions of sky imaged by the MIPS instrument on Spitzer are marked, and the stars in the center of each rectangle are the targets of this investigation.

The stars are identified according to the numbering scheme devised by astronomer Charles Prosser in 1993 (Astronomical Journal, 105, 1441). Prosser measured proper motions to determine which stars in the vicinity of the cluster are actually members and which are foreground or background stars. He also measured the magnitudes of the stars in three filters B, V, and I.

Obtain published BVI photometry for the 9 target stars from Webda or from Prosser (1993).

Obtain JHK photometry from the point source catalog of the 2MASS database at IPAC (http://irsa.ipac.caltech.edu/).

**Part 2 - Using the Data**

Use the BVI+JHK photometric data to predict the fluxes expected for the stars at 24 microns. Remember the Planck function on page 96 of the text and the Rayleigh-Jeans approximation on page 96. Several paths will work to convert magnitudes to flux densities. You can use the formulae on page 94 of the text, or the Spitzer on-line converter at http://ssc.spitzer.caltech.edu/tools/magtojy/.

You can use each filter (BVI+JHK) separately to predict what the flux should be at 24 microns, assuming a black body following the Rayleigh-Jeans approximation. The standard deviation of those predictions gives you an estimate of the uncertainty of the predicted 24 micron flux.

**Part 3 - Measuring Infrared Flux Densities**

Images of stars in IC 4665 were obtained with the "Multi-band Imaging Photometer for Spitzer" (MIPS) camera on the Spitzer Space Telescope. The images each cover a small patch of sky (a square about 5 arc minutes on a sky, and the target stars are located at the center of each image. The MIPS camera produces pictures with 183x202 pixels. The images were recorded at a wavelength of 24,000 nm (24 microns).

Obtain flux densities at 24 microns from the infrared images located in the directory /home/catyp/A304/Lab5. The fluxes in the images are calibrated in units of megaJanskys sr^-1. A Jansky is 10^{-26} watts per square meter per frequency interval, and you will need to convert your flux measurements to milli-Janskys (10^{-29} watts per square meter per frequency interval). The image scale of the MIPS images are 2.54" pixel^-1. (To convert the fluxes given by imexamine you will need to convert from megaJanskys to milli-Janskys, and then by the area of a pixel (steradians per arcsec^2).

**Part 4 - Finding Dusty Disks**

Compare the predicted 24 micron fluxes with those measured from Spitzer observations, and identify any stars showing excess flux at 24 microns.
## IC 4665 Targets

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