Educational Aspects of Searching for Variable Stars in the Mid-IR Sky

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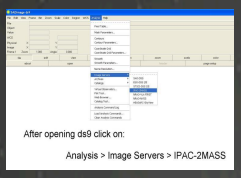
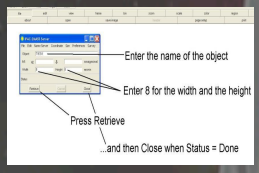
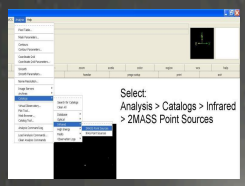
ABSTRACT: Using archival Spitzer Space Telescope Infrared Array Camera (IRAC) data, our team of students, educators and astronomers designed and carried out a program to discover new variable stars in mid-infrared (3-8 micron) wavelengths. Our educational goal was to learn, and then disseminate, methods to (a) utilize various image processing software tools and (b) subsequently analyze and display gathered data in a meaningful form in order to identify variable stars. We processed a total of 6447 images in three target fields, examining a total of 242 stars for this project, finding one star that has not previously been identified as a variable. Photometric data were produced for each point source and those data were used to create light curves and brightness vs. standard deviation curves. Our target fields were taken from Spitzer observations of exoplanet transits, which utilized comparatively long, uninterrupted sequences of IRAC observations. This poster will illustrate how students and teachers learned to use imaging software to gather and display photometric data for targets in this project, and created tutorials to enhance the use of these tools in astronomy classrooms. This work was supported by the NASA's Spitzer Science Center and NOAO (National Optical Astronomy Observatory).

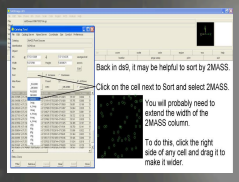
DS9 : Astronomical Data Visualization Application

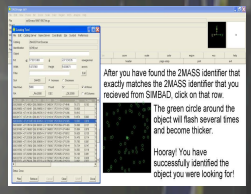


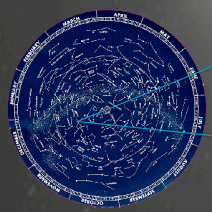


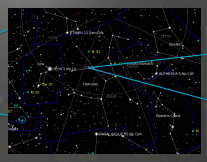


Now we'll open SIMBAD in an internet window to find the unique 2MASS identifier for TrES4. SIMBAD is an astronomical database for objects lying outside the solar system.

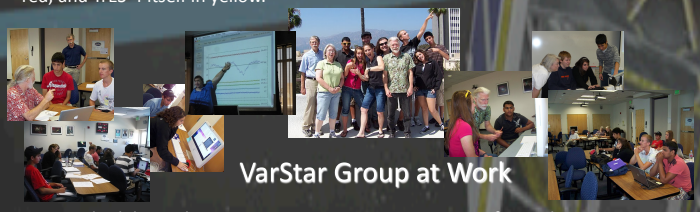








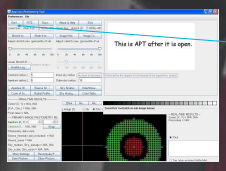
This diagram shows the location of the variable star we discovered in regards to the celestial sphere. With a Right Ascension of 268.260302 and a Declination of +37.220394, the star can be found in Hercules, near the "shoulder" closest to Vega. The specific field containing the star is TrES-4; the discovered variable is circled in red, and TrES-4 itself in yellow.



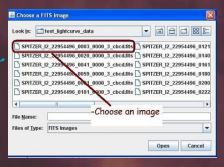
VarStar Group at Work

Our goal while at the Spitzer Science Center was to perform photometry on Spitzer images and present the results in a meaningful form, allowing us to identify possible variable stars in the infrared. Students were divided into three groups, each examining one of the three target fields (TrES-2, Hat-P-b, TrES-4) on channels 2 and 4. We applied apertures of 3 and 5 pixels using IRAF to reduce the data. We then used "Readspit" to produce light curves and check for variability. Plots for each field were also created using mean brightness vs. standard deviation (sigma plot) to direct us towards possible variables. An aperture of three pixels was selected based on the lower standard deviation. From the reduced data, light curves were made in Excel to search for possible periodic variables. Of the one star believed to be a variable, IRAF/PDM was used to determine the period. Phase folding was also utilized to confirm the period as well as assess the photometric errors. NITARP V-1 is indeed a variable star with a period of .084 days.

Aperture Photometry Tool (APT)

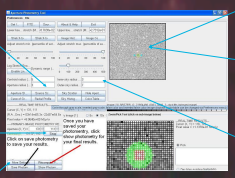


To access images click on Get Image.



Navigate through the folders to retrieve the Image.

Aperature controls the number of pixels used to determine luminosity (red squares).



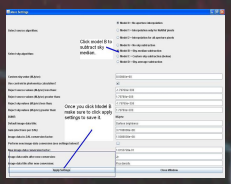
The chosen image appears here.

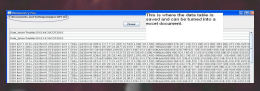
To find the source intensity click the chosen star.

Once you have your chosen star, click snap to center your image.

Inner and outer sky radius set the inside and outside limits of the background subtraction (green donut).

We chose Model B, sky median subtraction, then clicked apply settings to subtract background noise.

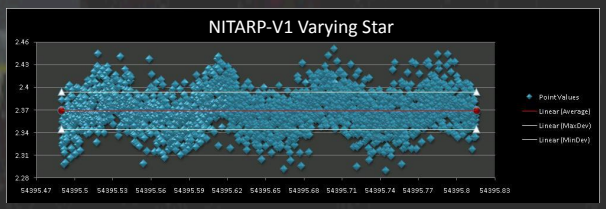


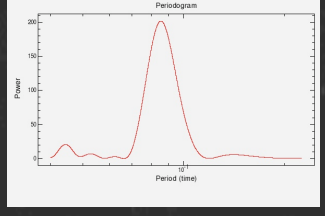


This is an example of an APT data table which we used to produce light curves in Excel.

Photometric Data

Using photometric measures for individual stars produced by IRAF, we were able to use Excel to produce light curves showing a stars' flux density over time. Some stars revealed false variations, that is variability caused by having a location in the image blended with other stars, near the edge of the images, or other instrument signatures. We carefully examined the data for NITARP-V1, our only confirmed variable star.





We found the same periodicity for V1 in all four Spitzer channels. The figure above shows the light curve of NITARP-V1 phased on its period of 0.084 days. The figure to the left shows a power spectrum for NITARP-V1 revealing the period present in our Spitzer data.

Also see the poster "Scientific Aspects of Searching for Variable Stars in the Mid-IR Sky", R. DeCoster et al. this meeting.

We gratefully acknowledge funding via NASA Astrophysics Data Program funds and NASA/IPAC Archive Outreach funds.