Adapting Observations of WZ Sge Made With the Spitzer Space Telescope for Use in the Classroom

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Abstract: Scientists, students and teachers involved with the Spitzer Teacher Observing Program observed the eclipsing cataclysmic variable WZ Sge with the Spitzer Space Telescope. These observations yielded a light curve for WZ Sge in channels 2 (4.5 microns) and 4 (8 microns) from IRAC. Photometric observations were also made with the 0.9 meter telescope at Kitt Peak National Observatory, and light curves were constructed from these data as well. Data reduction of both the Spitzer and ground-based photometric observations completed by the students and analyzed by the team using IRAF. The scientific results of these observations will be presented in a separate poster. The teachers and students developed educational materials which convey the conceptual background necessary to interpret these light curves. We report on the development and piloting results from these materials, which include a physical 3D model of a CV, plotting and interpreting a light curve from Spitzer data, and simulating a light curve of a CV using a downloadable, paper based model. This work was supported by the Spitzer Science Center, the National Optical Astronomy Observatory, and the California Department of Education's Specialized Secondary Grant program.

Teachers and Students Visit the SSC

The objective of this project was to determine the properties of the cataclysmic variable star WZ Sge using Spitzer data and optical data. This interacting binary system is thought to exhibit an eclipse caused by a brown dwarf secondary passing in front of an accretion disk and its white dwarf core. Since the orbital period of this system is 81 minutes, we conducted a 90 minute Spitzer observation of the target to ensure we captured at least one complete eclipse phase cycle. This system is believed to be a semidetached binary, with the primary star being a non-magnetic white dwarf.

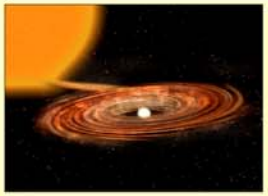
Data was collected from the Spitzer Space Telescope in the summer of 2007. We reduced the Spitzer data using IRAF and DS9 while at the SSC in October 2007. In addition, the data was then imported into an excel worksheet where the flux values were converted from Spitzer standard output to mJy. Light curves were created by plotting the time vs. flux in mJy.

As an additional check of the data, four comparison stars were selected near WZ Sge, and flux values, time, and phase cycle were recorded. Our goal was to make light curves and fit a function that would give some information as to how the detector response changed as a function of time. A significant change in response would require a correction factor be applied to the data. After analyzing the light curves it was determined lights curves for the comparison stars were flat, and no correction would be necessary.

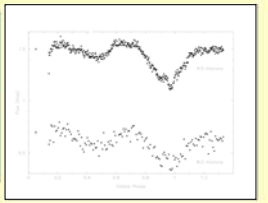
We also reduced optical data from four nights of observing at the 0.9 Meter Telescope at Kitt Peak. These images were collected by a team of RBSE teachers during their summer workshop. We reduced all four nights of data and constructed light curves, which clearly showed the eclipse event. We then compared the eclipse event at optical wavelengths with the eclipse event at 4.5 and 8 microns..

The data is being used to make a model of the WZ Sge system. Our hypothesis was that at 8 microns, the circumbinary disk would outshine other features within the eclipse and therefore produce a smooth light curve. However, our results showed a deep and wide eclipse, at both 4.5 and 8.0 microns, forcing us to rethink our understanding of WZ Sge, as well as the dynamics of accretion disks themselves. The data indicates that the system must be physically larger and more massive than what earlier models have predicted. The eclipse is more prominent at 4.5 microns than at 8.0 microns which may indicate some circumbinary disk, but not to the degree initially thought. This is the first mid infrared light curve of any CV, and it is the first research collaboration in some time which has resulted in astronomers having to significantly rethink what an accretion disk around a CV looks like.

What are we doing with our results?



LEFT: Left: Figure 1 - An artist conception of the current view of systems such as WZ Sge (NOAO/P. Marenfeld).
RIGHT: Light curves of the interacting binary WZ Sge at 4.5 and 8 microns. The 4.5 microns dataset is shown at its full resolution of 12 seconds per point while the 8.0 micron data have been binned by 3. The two points shown on the far left give the one sigma errors for each dataset (Howell et al).



BELOW: Teachers Jeff Adkins and Beth Thomas have developed classroom activities making use of our WZ Sge data. **RIGHT:** J.M. Santiago and Trevor Bennett of Deer Valley High School were able to create a 3-dimensional model of WZ Sge, and Matt Walentosky of Oil City High School is attempting to graphically model what is happening with WZ Sge. **COMING SOON:** More classroom activities and information will be posted on the Spitzer Wiki at http://coolwiki.caltech.edu.

Modeling the Data . . .