Title: Short Period Spectroscopic Time Series Observations of CVs Using Small Aperture Telescopes:

Project Summary:

Observe and record photometric and spectroscopic variations of CVs using a network of amateur astronomers with small aperture telescopes, medium format CCD imagers, and low resolution spectroscopes.

The goal is to observe CVs between outbursts when the larger professional telescopes are busy with other projects. Even a modest sized network will be able to perform comprehensive observations of target systems for extended periods. In the process, this project will result in both the acquisition of new scientific insights related to the life cycle of cataclysmic variable, and encourage and nurture an attitude of inclusion among students, citizen scientists, and the professional community.

Project Description:

Using only photometry, much can be inferred about the nature of the accretion disk around the White Dwarf (WD) primary of a Cataclysmic Variable (CV) binary. This is particularly so if the orbital plane of the binary is closely in line with the observer. On the rare occasion that observers find a CV in nova, spectroscopic measurements of the events (Iijima, J. 2002) have been very illuminating, revealing much about the composition of the CV as it tears itself apart; succumbing to the violence of a runaway thermonuclear reaction initiated on the surface of the WD.

Between nova outbursts, many CVs continue to exhibit considerable variation in magnitude. Some nearby CVs, for example TT Ari (Stanishev, V. 2004), have very short period variations in luminosity during quiescence. They often demonstrate periodic and non periodic variations that are not consistent with the orbital period of the binary pair. Presumably, there are multiple sources contributing to this changing luminosity. Quite likely, the interplay of these sources will be evident in the changing spectroscopic signature of the CV; a signature that could change over the period of just minutes. This is data that we want to collect and analyze.

Using a GRISM spectroscope (wedge prism & diffraction grating), a CCD imager can record low resolution spectrographic images of all the stars in its field of view, along with their photometric data. (See Figure 1.) Each image would include the data of the target star system and the necessary comparison star data. A series of these images can be used to accurately plot the luminosity change along with the spectroscopic variations of the target system. Using only the small telescopes (20 cm to 30 cm aperture) commonly available to amateur astronomers, CVs down to 14^{th} magnitude can be ovserved and recorded in this way. And even with spectrographic resolution of only 20 to 25 angstroms per pixel, it should be possible to use the spectrographs to track the changes in the larger absorption and emission bands.

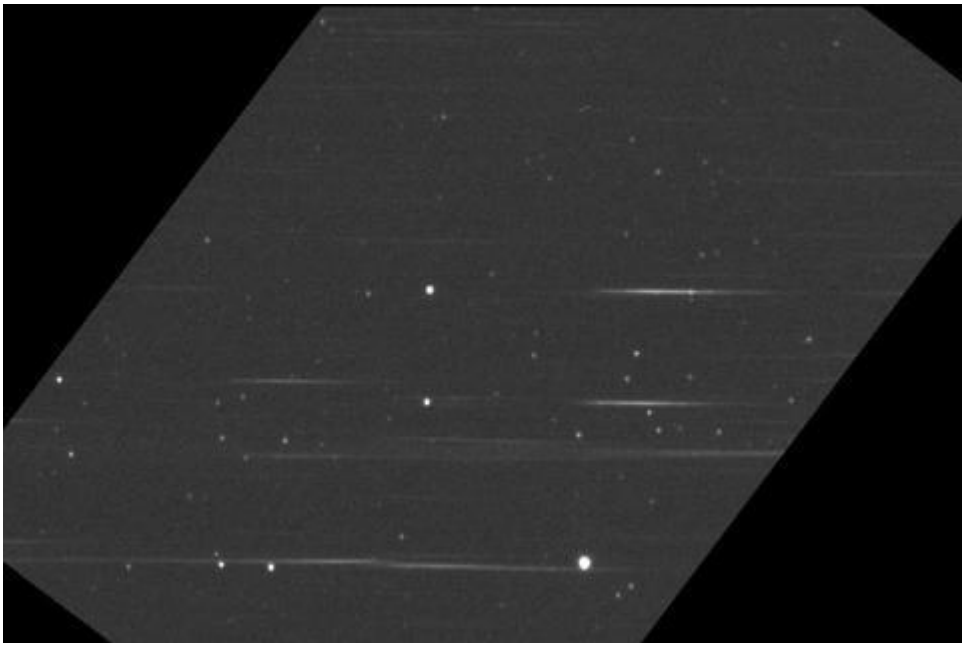

Figure 1.

Taking these time series observations will require a great deal of observation time. And observation time is hard to come by at professional observatories. But by utilizing a network of citizen scientists, many star systems can be observed and monitored in detail. Both raw and processed data can be easily shared, and the accumulated data can be used to better understand the dynamics of CVs, and to design more detailed observations to explore specific behaviors of the observed systems.

Goals of the Project:

1. Design, build and test GRISMs to best match the CCD imagers available to the amateur community. Although there are dozens of commercially available CCD imagers used by amateur astronomers, they are mostly based on just four sensor chips. It should therefor be necessary to test only a few configurations to verify suitable GRISM designs. These designs and the associated formulas will be make available for any observer interested in joining this research.
2. Select and observe several typical CVs in the 7^{th} to 14^{th} magnitude range. Individual exposure time should be less than 15 min. per image to provide adequate time series resolution. Determine the limitations of this technique and the best candidate stars for continued observations. (e.g. TT-Ari, V831-Cas)
3. Proceed to make photometric and spectroscopic observations of suitable CVs, collecting observations from multiple observers to obtain continuous coverage of the observed systems through multiple orbital cycles.
4. Establish the communications infrastructure (e.g. web sites, on-line networks, mailing lists) to encourage and support other citizen scientists to participate in and contribute to this research.
5. Through web content, publications, and personal presentations, increase the awareness among amateur astronomers and the general public of the contributions that common people can and do make to science.

Limitations of the Project:

The long term goals of this research is to better understand the nature of the fluctuations in luminosity of CV systems during quiescence, and possibly the mechanisms of angular momentum transfer in the gases of the WD accretion disk. The immediate and limited goal of this project is to acquire initial observational information, refine the observation techniques based on evaluation of the initial data, and then create a network of citizen scientists to continue the observations. Subsequent observations and analysis will be part of an ongoing use of this network, but more detailed observations and analysis would be the subject of future proposals.

Resources:

Alan A. Bedard , Primary Investigator (PI)

Charles Bedard, Consulting Mathematician

Digital-SF Observatory Foundation, a non-profit corporation with observatory facilities located near Cle Elum, Washington. Facilities include:

- Observatory building with 10ft dome, attached control room and adjoining outbuilding.
- 203mm f/6.3 Schmidt-Cassegrain Telescope with 80mm f/5 Guide scope and computer guided mount.
- Various imagers including Nikon D50, SONY ICX429 based CCD imager with thermoelectric cooling, and an un-cooled CCD imager for auto guiding.
- Software and computers for telescope control, auto guiding, camera control, image processing (photometry), and spectrographic measurements.

Existing Internet Infrastructure, including:

- Digital-SF.com (primary domain)
- Yahoo Group / digital-sf_photometry

Current Budget:

The current facilities are leased to the Digital-SF Observatory Foundation for $1 a year. This includes all utilities and maintenance costs. Travel expenses incurred by the PI on local trips to promote amateur astronomer involvement are defrayed by the PI. There is no budget for out of state trips or capital improvements.

Project Budget: [redacted]

The proposed project budget is based on the stated goals, and will provide support for at least a calendar year.

- Equipment (Line D) – CCD Imager based on Kodak 1603 sensor. Needed to improve accuracy and resolution of observations over existing Foundation equipment and to evaluate the GRISM design for medium format CCD imagers used by other observers. $[redacted]
- Travel (Line E) – Attend Society for Astronomical Sciences Symposium, Big Bear, CA. Promote involvement with project by other astronomers and astronomy groups. Present initial findings and analysis for peer review. $[redacted]
- Participant Support (Line F) – Stipend for PI to help defray cost of time spent specifically on the project and miscellaneous personal expenses, such as travel costs to and from the Foundation's observatory. $[redacted]
- Materials (Line G1) – Miscellaneous optics; diffraction gratings, wedge prisms, filters. $[redacted]
- Consultant Services (Line G3) – Fee for mathematical services performed by Charles Bedard, M.S. Statistical Mathematics ($50 per hour). $[redacted]
- Computer Services (Line G4) – Domain hosting and Internet access ($40/month). $[redacted]

References:

Iijima, J. 2002. The spectrum of the recurrent nova U Scorpii during the 1990 outburst. Astronomy & Astrophysics 387, 1013-1021.

V. Stanishev, V. Zamanov, R. Tomov, N. and Marziani, P. 2004. Hα variability of the recurrent nova T Coronae Borealis. Astronomy & Astrophysics 415, 609-616.

Biographical Sketches:

Alan Bedard

- Associate of Arts and Science, Technical Communications
- Project Management Certificate
- Nuclear Physics: Navy Nuclear Power Program
- Ten years observational astronomy
- Twenty years Technical Writer
- President of Board, SLWCC (a 501c non-profit), 2nd year.
- Director, Digital-SF Observatory Foundation (a 501c non-profit), founder

D. Charles Bedard

Master of Science, Statistical Mathematics