CCDs IN AN EDUCATIONAL ENVIRONMENT

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Abstract

Wellesley College has recently installed a liquid-cooled Photometrics Nubus CCD camera on the Sawyer 24-inch telescope. The small field with a long focal length telescope requires excellent pointing and new finder charts. We can easily observe 16th magnitude stars. Students and faculty are participating in research on variable stars, supernova photometry, and asteroid research.

Wellesley College is a liberal arts undergraduate college for women. We have a separate astronomy department and a major in astronomy. The four members of the astronomy faculty are all active in research, but have not previously used the Whitin Observatory facilities for our research.

We have 6-inch and 12-inch Alvin Clark refractors and a 24-inch Boller and Chivens refractor in our campus facility, Whitin Observatory. The 24-inch was upgraded in the fall of 1991, with recoated mirrors, a new, remotely controlled drive, and remote focus and dome control. We also purchased a complete U, B, V, R, and I filter set and an automated filter wheel. The pointing of the 24-inch telescope was previously limited by the size of the readout dials to about one-half degree. Now it is good to within a few arc seconds. Historically, the telescopes have been used only for teaching, with visual observing of planetary and deep sky objects done by students and the public. We have also done some photographic photometry with a 4-inch astrograph mounted on the 24-inch tube and a Cuffey Iris Photodensitometer.

About two years ago, we joined with Colgate, Haverford, Middlebury, Swarthmore, Vassar, Wesleyan, and Williams Colleges to form the Keck Northeast Astronomy Consortium funded by a generous grant from the W. M. Keck Foundation. Each school purchased a Photometrics CCD camera and Digital or Sun workstation. On our first night of observing with the Wellesley camera, we found we could obtain beautiful images of the Ring Nebula and the Sombrero Galaxy in only two minutes. However, the field of view on the CCD, with our focal length of 324 inches, is only about 4 minutes of arc. It was fairly easy to find objects which are bright enough to see in our C-8 guide telescope, but the pointing was inadequate for the faint star fields of most of the variable stars we wished to observe. Even after we added a Lumicon wide field adaptor to increase the field to 8 arc minutes, finding faint stars could take students up to two hours.

One problem with a CCD camera is that the images take up a great deal of computer disk space. Each of our 512 by 512 images occupies one-half megabyte. A four-hour observing session can easily generate over one hundred images filling fifty megabytes of space. Each night it is necessary to take at least four flat fields for each filter you plan to use, darks, and biases for calibration, as well as the desired object images. The flat fields are used to scale the images to correct for variation in gain of each pixel in the images. We are using the National Optical Astronomy Observatory program IRAF (Image Reduction and Analysis Facility) to process our images and do the photometry.

In spite of these problems, four students did independent projects using the CCD camera during the 1990-91 academic year: one on asteroid light curves and three monitoring variable stars. We are currently using the brighter stars in the field as comparisons, and plotting all the differential magnitudes against time to watch for variation in the comparisons.

We have begun to monitor LO Aurigae and VX Ursae Majoris. The *General Catalogue of Variable Stars* (Kholopov *et al.* 1985) lists LO Aur as a Mira with an unknown period and brightness range 12.1-16.3 visual magnitude. VX UMa is listed as a 215-day Mira with photographic magnitude 11.7-(14.5. I became interested in these stars because they both have water maser emission which exhibits interesting behavior. I hope to study whether the variability in the maser features has any correlation with the optical data. Figures 1 and 2 show the differential magnitudes between the comparisons and each variable star obtained to date. Both stars dimmed during the period of observation. In both cases, plots of the differential magnitudes for the comparisons are comparatively flat, as shown in Figures 3 and 4.

During the fall of 1991 the 24-inch drive was replaced; the pointing is now adequate to find the field of interest immediately. The new filter wheel box has a wide field lens giving us a field of about 8 arc minutes. We will continue to use the telescope for teaching our Observational Astronomy courses. Planned exercises range from photography of the sun and moon, CCD imaging of deep sky and solar system objects, CCD photometry (including finding extinction and transformation coefficients and taking and measuring images of open clusters to make H-R diagrams), and spectroscopy.

In addition to using the telescope for teaching, we will also be participating in the Keck Consortium collaborative research programs of monitoring extragalactic supernovae, variable stars, asteroids, and Pluto. We have received some grant money from the National Science Foundation to pay students to participate in the observing research projects. We are in the process of determining the transformation coefficients for our new filter set and training students to use the telescope, the CCD acquisition program, and the IRAF analysis program.

References

Kholopov, P. N. *et al.* 1985, *General Catalogue of Variable Stars,* Fourth Edition, Moscow.

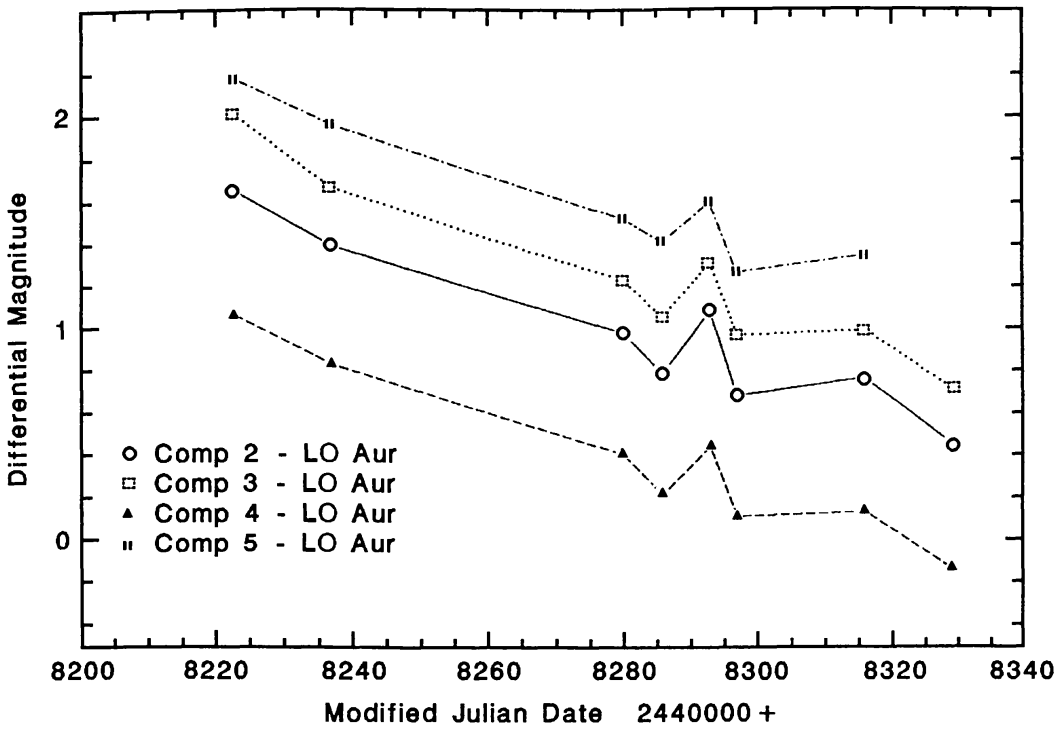

Figure 1. The differential light curve with an R filter of LO Aur from observations taken with the Whitin Observatory CCD camera.

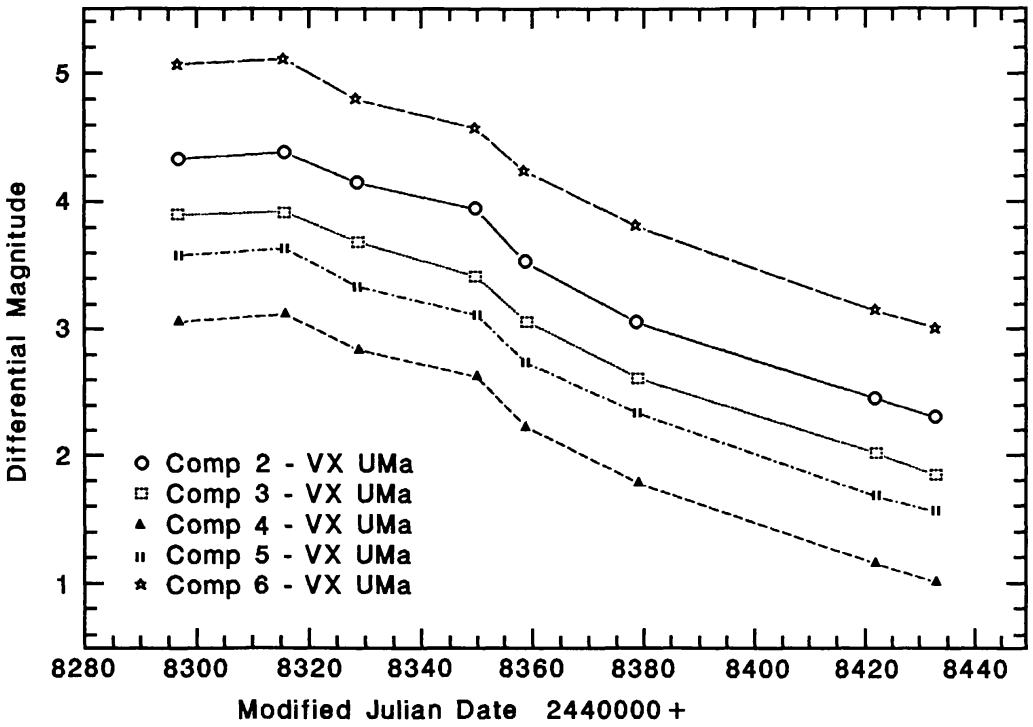

Figure 2. The differential light curve with an R filter of VX UMa from observations taken with the Whitin Observatory CCD camera.

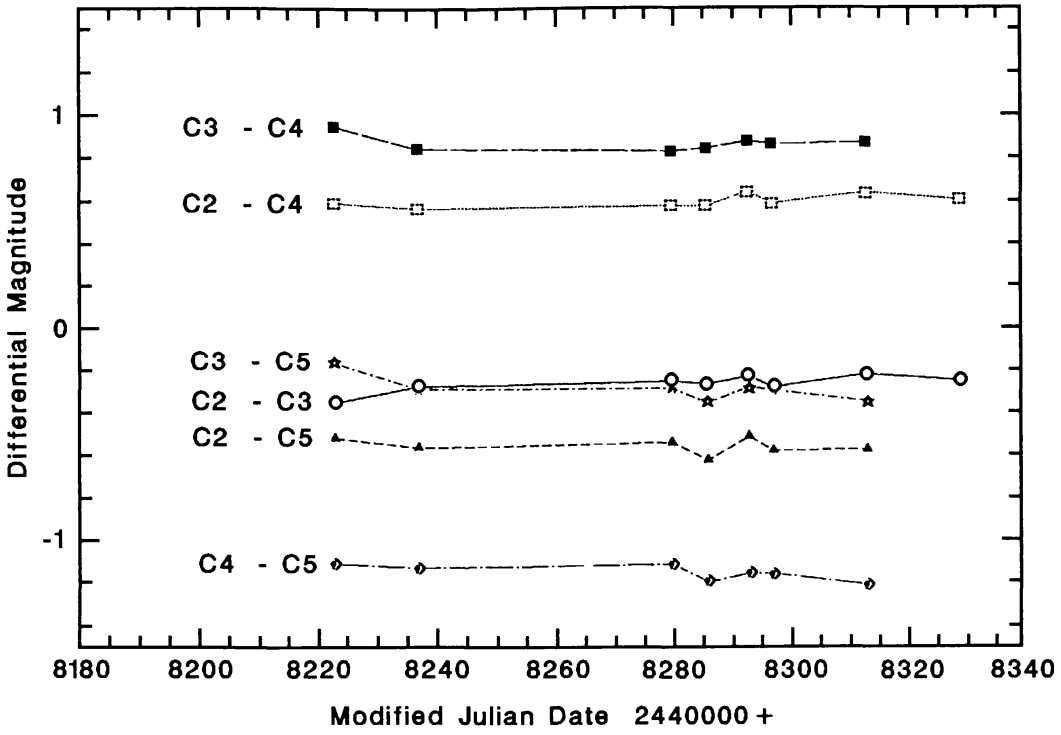

Figure 3. The differential magnitudes of the comparison stars for LO Aurigae.

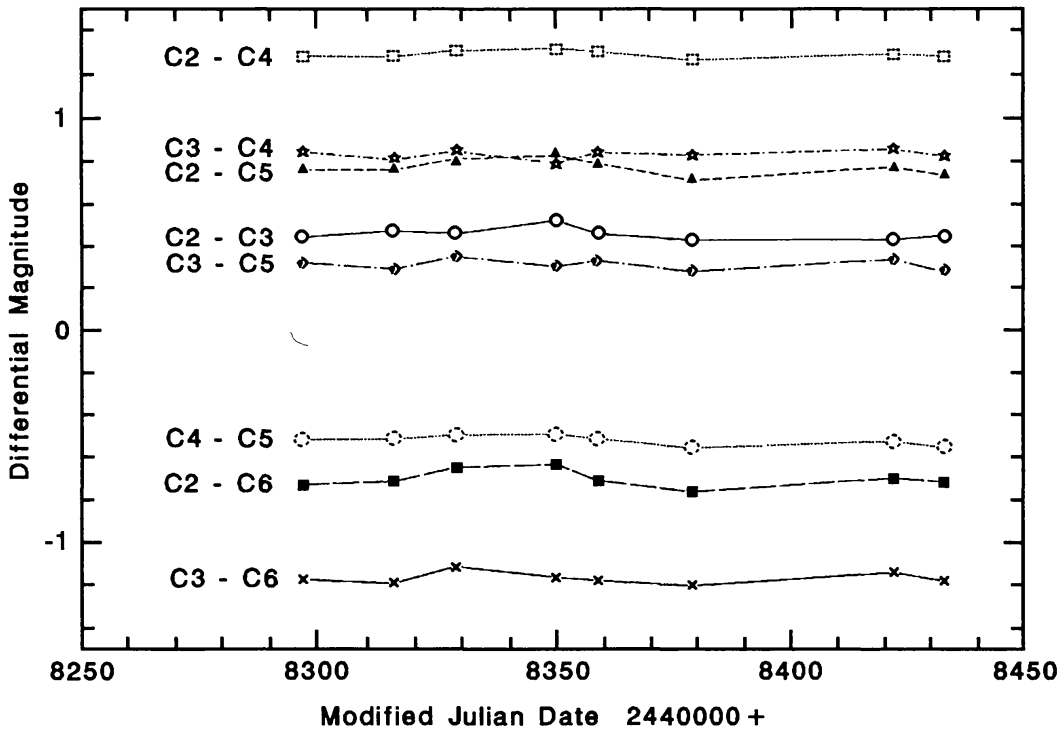

Figure 4. The differential magnitudes of the comparison stars for VX UMa.