



## Instruments and Science Programs at Fresno State's Campus Observatory

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Fresno State's Campus Observatory opened in 2002 May, in back of the Downing Planetarium. It was built by Prof. Steve White and Fresno State student Art Cowley, and is the only observatory dome I've ever seen (on six continents) that doesn't leak! Steve and I recently considered moving the facility, because of the planned construction nearby of the Downing Planetarium Museum and the Science II building. We have now decided to leave it on planetarium grounds, since the whole point of a Campus Observatory is to be convenient to students. Besides, a second, remotely controlled 16-inch telescope is being built for us, which we plan to install at a dark site at 6100 feet near Shaver Lake, in the next year or two.

The Campus Observatory's telescope is a 16-inch Meade LX200, which we usually use at Schmidt-Cassegrain focus at  $f/10$ . Many of the instruments are by the Santa Barbara Instruments Group (SBIG), including an ST-8 CCD camera, an AO-7 Adaptive Optics guider, and a Self-Guiding Spectrograph, with its own dedicated ST-7XE CCD camera. We also have an Optec Temperature-Compensating Focuser (TCF), a Celestron  $f/6.3$  focal reducer for wide-field (15-arcminute) imaging with the ST-8, and an eyepiece projection system designed by Greg Morgan that can reach  $f/60$ . A homemade filter wheel (with a flip mirror) has broad-band UBVRI filters installed. Other 1.25-inch filters include a Custom Scientific clear (IR suppressor) and a 4.5-nm-bandpass hydrogen alpha filter, Orion color planetary and Moon filters, and an Orion Ultrablock Light-Pollution Filter, also called a nebular filter since it passes only hydrogen beta and the [O III] "nebulium" lines, often the strongest lines in nebulae. Eyepieces range from a 2-inch 55-mm (giving 74 power at  $f/10$ ) to a 1.25-inch 8-mm TeleVue Plössl (giving 512 power), together with an Orion VariPower 2-3x Barlow lens, and various adaptors, diagonals, and telescope tube balance weights.

A 70-mm Vixen guidescope can be mounted piggyback on the 16-inch telescope. With its 400-mm focal length, this refractor has a field of view 4 degrees in diameter with our 40-mm eyepiece. With the ST-8 this shrinks to "only"  $2.0 \times 1.3$  degrees, easily enough to image the entire Moon at once. An Astrovid 2000 CCD TV camera was bought for the guidescope, so Friday-night planetarium visitors can see the telescope's target on our 10-inch, 800-line Toshiba monitor, while waiting in line to see it through the eyepiece. The 70-mm can also be used as a sensitive finder scope, or as an offset guider for CCD imaging through the 16-inch, or with a CCD imaging through it while using the 16-inch as an oversized guidescope with our Meade Pictor 201XT CCD Autoguider. We also have two all-manual 35-mm film cameras, with 35-to-70-mm and 80-to-300-mm zoom telephoto lenses, which could be mounted piggyback or used through either telescope.

The 16-inch telescope's image resolution is between 1-2 arcseconds for 80% of the time, excellent for a facility not on a mountaintop. This is probably because of the dome's small 3-m diameter, unpainted aluminum skin, and being surrounded by grass, all good for thermal properties. Vibrations in the floor are not noticeable, even with 7 people in the dome, since the concrete slab is 18 inches thick. The Meade GO TO equatorial mount is on a permanent pier. It's easy to use, with practice: while not as accurate as a professional mount, it normally always slews to well within the 5-degree field of the 8x50 finder. Despite being on campus, the 16-inch telescope can image 19th magnitude stars in 1-2 minute exposures. (More precisely, the ST-8 at  $f/10$  can reach  $V = 19.0$  at  $S/N = 3$  in 120 s, and  $B = 18.6$ ,  $V = 17.1$ , and  $R = 16.8$  at  $S/N = 10$  in 240 s, of co-added 10-s exposures in an urban sky with no Moon and  $V = 3$  stars visible.)

Current science programs include:

(1) Target-of-opportunity observations of the eruptions of classical novae, by Greg Morgan. Greg has produced a paper for publication in a refereed professional astronomy journal, and plans a CVA presentation on spectroscopy later this year. Astronomers have been taking spectra of novae for over a century, but systematic study with sensitive, linear, digital CCD detectors only started in the 1990s. Only about two dozen novae have been observed in this way, and novae are idiosyncratic: every one we observe

will be an education. We intend to observe more novae, but this is a target-of-opportunity program: if no novae are having eruptions when we want to observe, we can't get data. Then again, summer is nova season, since they are concentrated in the Galactic plane and center, so we won't have to wait long!

(2) Searches for variability in stars, particularly in hot, high-gravity stars with cool companions that have undergone common envelope evolution. Common envelope evolution is how most close binary stars form, in which one star in an initially wide binary engulfs its companion star. One such suspected system is PB 7032, a hot subdwarf star that has unusual emission lines, possibly from the heated face of a cooler, close companion star, if one is present. Last fall, Fresno State grad student Scott Endler discovered that PB 7032 is variable: one night it was clearly two magnitudes fainter than on the other four nights Scott observed it. We plan detailed observations this summer, when PB 7032 emerges from behind the Sun, to determine the nature of this variability. If it's from eclipses by a companion star, PB 7032 would be the second-ever hot subdwarf known to have eclipses. With eclipses, we could measure the size and mass of this hot subdwarf, the stellar evolutionary link between the central stars of planetary nebulae and white dwarf stars.

These stellar variability searches are easy to schedule. Over 300 candidate stars are on my target list, enough for decades of work. They're all over the sky, so one could observe many on any clear night. To search for variability, take 8-10 unfiltered images per night of each star (and stars in the field around it), over 1-2 weeks. One could therefore do parts of this project of any size, limited only by ambition. Again, every close binary of this type we find will be important, since only about two dozen are now known. The target list is also a mixed bag, so it will probably lend itself well to serendipitous discovery of many stellar oddities. It's available online, at: [zimmer.csufresno.edu/~fringwal/comp2.3lis](http://zimmer.csufresno.edu/~fringwal/comp2.3lis).

(3) Searches for transits of extrasolar planets, in collaboration with Transitsearch.org, who post predictions of when planets may move in front of their parent stars, or transit (see [www.transitsearch.org](http://www.transitsearch.org)). This again is a target-of-opportunity program, but then such programs are well suited for a small observatory, since we don't have to compete with hundreds of other astronomers for telescope time. Two Fresno State students, Jesse Rorabaugh and John Prigge, detected the planet orbiting HD 209458 during 2003 Fall, proving we can observe these transits with our equipment. HD 209458b is the only planet known to transit its parent star that was discovered by Doppler shifting of its spectral lines. It is therefore the *only* extrasolar planet for which we definitely know its mass and radius: it really is a Jupiter, and it really is closer to its parent star than Mercury is to the Sun. Each transiting planet we find would be *important!*

Planned science programs include: (4) Searches for black holes lurking in old novae. I have promised this program to Michelle Beierle, who will arrive at Fresno State as a grad student this fall. If you're interested, please ask her if you can help. (5) Campaigns with the Center for Backyard Astrophysics. CBA is a global network of small telescopes dedicated to observing cataclysmic variable stars and their outbursts. (6) The Small Telescope Science Program in support of NASA's Deep Impact spacecraft, scheduled to make a crater in Comet Tempel 1 on 2005 July 4. An observing campaign on the comet will begin in September.

If you're interested in these programs, please read these books:

- *Cataclysmic Variables: How and Why They Vary*, by Coel Hellier (the whole book).
- Chapters 1-6, 8-9, and any other chapters that interest you of:  
*The Handbook of Astronomical Image Processing*, by Richard Berry and James Burnell.

We can always use more pretty pictures, too, which can be done at any time, preferably at New Moon. Many professional astronomers sneer at pretty pictures, but I find they're educationally useful. Show me someone who, through care and patience, has developed the skill to be able to get publishable-quality pretty pictures, and I'll show you an observer for whom taking nearly any kind of science data will seem easy. Few science programs require one to be as fussy as when getting a really good picture, many of which are now on our gallery page, at: [zimmer.csufresno.edu/~fringwal/gallery.html](http://zimmer.csufresno.edu/~fringwal/gallery.html).

If you are a CVA member and have your own ideas for projects, particularly if they describe a specific, plausible path from telescope to finished scientific objective, which we can do with the equipment we have now, please contact Fred Ringwald by e-mail at [ringwald@csufresno.edu](mailto:ringwald@csufresno.edu) or by phone at 278-8426.