FINAL REPORT FOR GRANT NAG5-7533 (= UA FRS 308320)

SUBMITTED TO: The National Aeronautics and Space Administration
Office of Space Science
Solar System Exploration Division
NEO Observation Program

TITLE: **Mosaic of CCDs to Survey for Asteroids and Comets**

ORGANIZATION: The University of Arizona
Lunar and Planetary Laboratory

PERIOD REPORTED ON: 1998 August 1 - 2002 March 25.

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OVERVIEW

Spacewatch searches for asteroids and comets ranging in location from near-Earth space to regions beyond the orbit of Neptune. We are studying Earth-approaching asteroids, main belt asteroids, comets, Centaurs, and TNOs, as well as the interrelationships of these classes and their bearing on the origin and evolution of the solar system. Spacewatch is described at *http://www.lpl.arizona.edu/spacewatch/index.html.*

The Spacewatch Project has been discovering Earth-approaching asteroids (EAs) steadily and has used the results aggressively to estimate the statistical properties of the EA population. This grant funded Spacewatch to develop and implement a mosaic of CCD imaging detectors for the 0.9-m telescope, to increase that telescope's rate of coverage of sky area while preserving its limiting magnitude.

Description:

To increase the area of sky covered by the 0.9-m telescope, we are paving its focal plane with a mosaic of four CCDs. The mosaic will be installed on the 0.9-m Spacewatch Telescope, rather than the 1.8-m, for practical reasons. To keep down the cost of the mosaic of CCDs it is important to use small pixels. To cover enough sky with small pixels it is necessary to have a short focal length. The pixels of the chosen CCD are 13.5 microns square, so an effective focal length of 2.8 meters is required for the image scale of 1 arcsec per pixel (to which our software is tuned and which is required for our limiting magnitude). This focal length can be achieved more readily with the smaller of our two telescopes because on the 0.9-m telescope it does not produce too fast an f/number for the large lenses needed to correct and flatten the field of view. The URL *http://www.lpl.arizona.edu/spacewatch/09mosaic.html* illustrates the change in the optical configuration of the telescope. The mosaic of four edge-buttable CCDs will cover a solid angle of 2.9 square degrees, about nine times larger than the 1991-vintage 2Kx2K CCD we have been using. The geometry of the mosaic layout is incompatible with drift scanning, so all observations with the mosaic will be stares. Scotti's many years of recoveries of comets include considerable experience with "stare" imaging as faint as V=23, and Larsen has developed and used "stare" imaging software at the 1.8-m telescope as well. Pointing of the 0.9-m telescope would be reset during the 9 seconds the CCDs are being read out, resulting in an efficient use of telescope time.

The CCDs will be operated to the same limiting magnitude of V=21.7 we have been reaching, to allow us to discover all of the same classes of moving objects, but more of them. The mode of operation with the mosaic will be to accumulate 150 sec of exposure on each image area and return to each area three or four times over 90 minutes. Each 150 sec exposure will probably be accumulated with three exposures of 50 sec, each followed by a high speed 9 second readout. The exposures will be dithered slightly in position to minimize the effects of cosmic rays, bright stars, and flat field noise and to determine the direction of motion of EAs that are moving fast enough to leave trails during single exposures. Thus we will search the sky with the mosaic of CCDs to the same limiting magnitude as before, but at least six times faster. This is a conservative estimate, including telescope resetting time and CCD readout time, and is based on the use of four looks (12 exposures) at each region instead of the minimum required of three. Four looks might be needed in case the "stare" imagery has more pixel-to-pixel flatfield noise than scans, and four looks will cut the number of false detections, an important factor when such large areas are being observed.

We expect to make about 300 detections of EAs per year with the mosaic, most of which will be too faint to have been detected by other surveys. Not all of the detections will be different objects, of course, if we revisit our regions more than once within a lunation to extend orbital arcs.

Status of Effort to Date:

For this project we took delivery of four of Marconi Applied Technology's (formerly EEV, Inc.) 2048x4608 three-side buttable grade-one CCDs. The CCD cryostat and the lenses for the field corrector are also in hand. The design of the electronics to control and read the four CCDs is done and an eight-layer printed circuit board has been made and is being populated now. FLEX 10K family chips are being used to control the CCDs. All serial and parallel clocking patterns, as well as control of analog to digital conversion system clocks will be generated by programming the FLEX 10K devices. The Fibre Channel communications standard with Cypress CY7B923/33 HOTLink transceivers will interface with the FLEX 10K devices. The entire system will be run under the Linux operating system.

The cell for the new primary mirror has been fabricated by the LPL Machine Shop. The cell for the field correction lenses has been fabricated and anodized and is being assembled with the lenses. The one remaining large item for this upgrade is the new front end tube assembly for the 0.9-m telescope that includes a new spider for the prime focus instrument package with tip, tilt, and focus actuators. It will be finished in May.

The mirror blank for this upgrade to the 0.9-m telescope was especially designed for low thermal inertia, light weight, and high stiffness. It was spin-cast in August 2001 and sent to the opticians, who first fine-ground the back and sides and chamfered the corners. The mirror is now resting on 18 hydrostatic support points located at the same places as those in our new mirror cell. The opticians have been working on the front surface for a month now and have completed the aspherization grinding. They are also busy getting a tower and interferometer ready for final testing and figuring which will start in April. They expect to finish the mirror by the end of April. The company who will deposit a protected silver coating on the mirror has been sent a PO so they will be able to start as soon as they receive the mirror from the opticians. A spare blank for this telescope mirror has also been procured.

Downtime and conversion of the 0.9-m telescope is scheduled for the summer thunderstorm season, in time for observing with the mosaic of CCDs in the fall of 2002.