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ROBOTIC OPERATION OF THE DAO 1.2-M TELESCOPE AND MCKELLAR SPECTROGRAPH

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RESUMEN

El telescopio de 1.2m DAO ha sido utilizado exitosamente para obtener espectros astronómicos de modo robótico desatendido durante una década y aproximadamente 2/3 de las noches programadas en el telescopio son utilizadas de esta manera ahora. La disponibilidad de este tipo de operación robótica ha impulsado la tasa de subscripción del telescopio por aproximadamente 50% desde que los usuarios del telescopio ya no tienen que viajar a Victoria para llevar a cabo sus programas de observación. Se presenta un resumen del sistema robótico y algunos detalles de su operación.

ABSTRACT

The DAO 1.2-m telescope has been successfully used to obtain astronomical spectra in unattended robotic mode for a decade and approximately 2/3 of the nights scheduled on the telescope are now used in this fashion. The availability of such robotic operation has boosted the telescope's subscription rate by approximately 50% since telescope users no longer have to travel to the DAO in order to conduct their observing programs. An overview of the robotic system and some details of its operation are presented.

Key Words: telescopes — instrumentation: spectrographs

1. THE DAO 1.2-M TELESCOPE AND COUDÉ MCKELLAR SPECTROGRAPH

The Dominion Astrophysical Observatory (DAO) is located just north of Victoria, BC, on beautiful Vancouver Island on the west coast of Canada. The Observatory operates two optical telescopes: the 1.8-m Plaskett telescope and the 1.2-m telescope. The 1.2-m telescope has been successfully used for robotic observing for almost 10 years. The telescope is used at the Coudé focus with high-reflectance coatings for the second through fifth mirrors to optimize throughput. Three mirror sets have Super Blue multi-layer dielectric (3500−5500 Å), Enhanced Aluminum (3500 Å − near IR) and Enhanced Silver (5000 Å − IR) optics and are rapidly interchangeable and self-aligning. At the telescope focus an image slicer is used to squeeze more light through the spectrograph's narrow entrance aperture, thus increasing the throughput. There are three wavelength- and resolution-optimized image slicers to choose from.

The light collected by the telescope goes to one of two very stable spectrographs located in a thermally isolated room. A wide range of dispersions is available, from 2.4 Å/mm to 41 Å/mm with resolutions ranging from 0.07 to 1.2 Å($R = 3,000 - 70,000$). The detector, a 4K × 2K SITe CCD, is on a closed-cycle cryogenic cooler and operates for months without maintenance.

2. ROBOTIC OPERATION

The 1.2-m telescope can be operated in either observer on-site, remote, or robotic mode. In remote mode observing with the telescope can be done remotely from any computer in the world that has access to the Internet. In robotic mode, the telescope opens automatically and executes a series of observations. No interaction is required after execution of the robotic script by staff, although progress can be monitored remotely either by using Virtual Network Computing (VNC) to access the telescope computers or through the Web. DAO telescope status and environmental data are available on the DAO website.

The dome and the dome shutters are computer controlled. The dome position is automatically corrected from time to time in order to keep the dome slit in front of the telescope while it is observing. The telescope and the dome can be monitored remotely with the dome camera.

Telescope pointing and tracking are also computer controlled. The telescope pointing model gives typical pointing errors of 10″ RMS. Automatic object acquisition and guiding is done using a fast Ethernet AVT camera with a field of view of 1′. The

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magnitude limit for this camera is V = 12.5. A current limitation of the system is that the closest object to the center of the field of view is acquired. Automatic acquisition permits multiple targets to be observed on the same night. The guide camera also provides a feedback for the guiding system that performs active guiding by translating the f-number reducer lens on an X-Y stage. The current system makes corrections up to 7 times per second. There are plans to upgrade the system so that it can run at up to 30 Hz. Slower corrections are off-loaded to the telescope drives. A flux meter behind the image slicer is used to optimize the amount of light going into the spectrograph. A simple, low amplitude dithering algorithm is employed.

There are safeguards in place to ensure safe unattended telescope operation. The telescope and the dome are equipped with various safety limit switches. A rain sensor mounted on the dome forces the dome shutters to close if the weather deteriorates. The sensor is heated to prevent false triggers from condensation. A weather station installed near the dome also prevents the dome from opening (or closes it) if the humidity or wind speed exceeds predefined thresholds. The thresholds are set not to compromise telescope safety but at the same time to ensure that not more than 10% of clear nights are lost.

The DAO all-sky camera software now supplies cloud cover information and suggests when to observe. The algorithm searches the all-sky camera images for clouds/patchy clouds/cirrus and returns "OBSERVE" or "DO NOT OBSERVE". This will soon be integrated with the robotic script in order to add more intelligence to the robotic system. As an example, the dome could be re-opened if conditions improve late in the night.

Telescope operation is controlled by a shell script with a text file as the only command line parameter. The text file is generated from a user-supplied target list submitted to a Web script and can be modified before being executed. It provides the opening time and the calibration sequence. The user can specify either an exposure time or desired accumulated flux meter count level for each target.

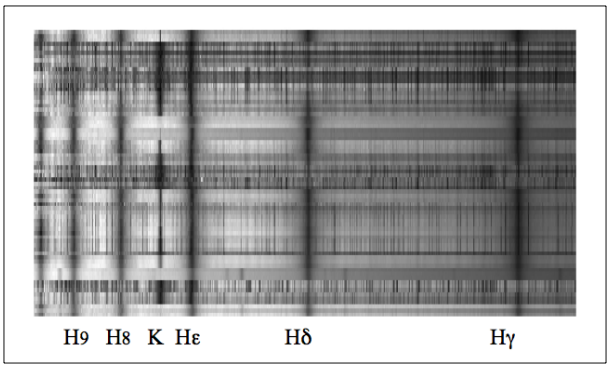

Fig. 1. A set of 70 spectra of 24 stars obtained during one night of unattended robotic observing with the 1.2-m telescope. Each row in the image is an individual spectrum.

The data collected is transferred to the Canadian Astronomy Data Centre's (CADC) DAO Science Archive. This includes science and calibration spectra, environmental data, and all-sky camera images. The archived data is typically available to the PI within about 10 minutes of acquisition.

A set of IRAF scripts is available for data reduction including radial velocity measurements. Figure 1 shows reduced spectra of 24 stars observed during one night of robotic telescope operation. The magnitude range of the stars is V = 5 to 8.

Here are some of the projects carried out in robotic mode:

- Stellar ages for Gemini Planet Imager target selection
- Ground-based spectroscopy in support of MOST microsatellite campaigns
- Possible carriers of diffuse interstellar bands
- Long-term and rapid variability of Be stars.

We are now using what we have learned with the DAO 1.2-m telescope to enable robotic operation of the DAO 1.8-m Plaskett telescope.