Report on the first 1.5-m fiber echelle run (May-June 2008)

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1 Details of the run

The Blanco echelle spectrograph was moved to the coudé room of the CTIO 1.5-m telescope and connected by fiber. The first light was achieved on April 18, 2008.

The first observing run started on May 19, 2008 and ended on June 15/16, 2008. The observers at the beginning of the run (till May 26) were D. Fischer, A. Tokovinin and G. Marcy, plus regular SMARTS observers J. Velasquez and M. Hernandez working on alternating 1-week shifts. On the second half of the run, the students H. Isaacson and J. Guedes took the data together with the SMARTS observers.

A web space has been created for the documentation on this instrument. The links to this URL, the instrument manual and the first report by D. Fischer are:

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http://www.ctio.noao.edu/~atokovin/echelle/index.html
http://www.ctio.noao.edu/~atokovin/echelle/ech_manual.pdf
http://www.ctio.noao.edu/~atokovin/echelle/ctio_report2008May26.pdf
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The main goal of this run was to take quasi-continuous data on the α Cen A and B stars with iodine cell, for the purpose of terrestrial-planet discovery. Processing of this data to determine the radial-velocity precision is underway. Calibration and experimental data (e.g. observations of the Moon) were also taken during the run. For the purpose of demonstrating the suitability of the spectrograph for general use, spectra of selected multiple systems and other objects were taken without iodine cell.

The observations were conducted during essentially all clear night hours, without major technical interruptions. Nights lost to weather were May 21-27 and May 31 to June 4 (12 total).

2 Efficiency

To estimate the system efficiency, the fluxes in the extracted spectra around 550 nm were compared with monochromatic fluxes from the observed stars above atmosphere. The gains of 1.38 and 1.27 el/ADU were measured by D. Fischer for the left and right amplifiers, respectively. The pixel size around 550 nm is 0.065 Å as determined by the wavelength solution (2-pixel resolution $R = \lambda/\Delta\lambda =$ 42000). Figure 1 shows the results, with a dotted line indicating 1% efficiency. The total efficiency is thus close to 1%, so a $V = 5^m$ star gives a flux of 116 el/pixel/s. A S/N=100 will be reached on a

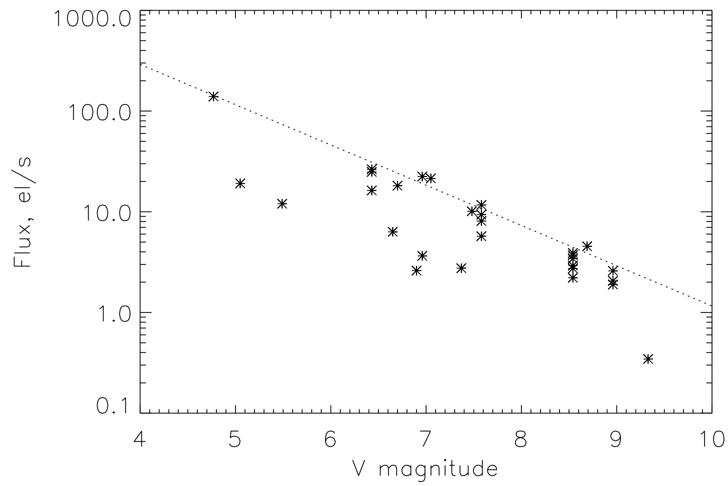

Figure 1: Detected flux near 550 nm (electrons per pixel per second) vs. star magnitude. The dotted line shows 1% total efficiency.

$V = 7^m$ star in a 10-min. exposure. Some stars show a reduced efficiency, presumably due to clouds, poor guiding, or bad seeing.

The data were taken with a 60-micron slit causing a 60% light loss, so an efficiency of 1.7% is expected with the fully opened 150-micron slit, giving spectral resolution $R \sim 25000$. The efficiency of this spectrograph at Blanco, as determined by the exposure-time calculator, was in the range 3% to 5%. For comparison, modern spectrographs have efficiencies from 8% to 20%. If a 10%-efficient spectrograph replaces the Blanco echelle, we will gain 2^m in the magnitude limit.

3 Identified problems and future work

3.1 Guiding

With the current system, a star is viewed on a monitor using the analogue TV camera. As the guide probe cannot be moved, guiding must be done manually, unless the fixed probe field captures a suitable star (this happens near the Galactic plane mostly). Stars of $V = 12^m$ and fainter are seen very well on the monitor, but disappear when centered in the fiber hole of $2.4''$ diameter. Currently, manual guiding on the TV screen is practical down to $V \sim 10^m$. On the other hand, bright stars saturate, causing problems for guiding and focusing. A neutral-density filter has to be inserted in the TV guider (by actuating the lever manually) to permit observations of α Cen.

The analog TV camera will be replaced by a digital CCD camera GC650 with a Gigabit Ethernet interface. A new dedicated PC will receive the signal, display it in real time and run a suitably adapted guider program to correct the telescope tracking. Changing the exposure time of the camera will enable dynamic range large enough to work without filters.

3.2 Condensation in the iodine cell

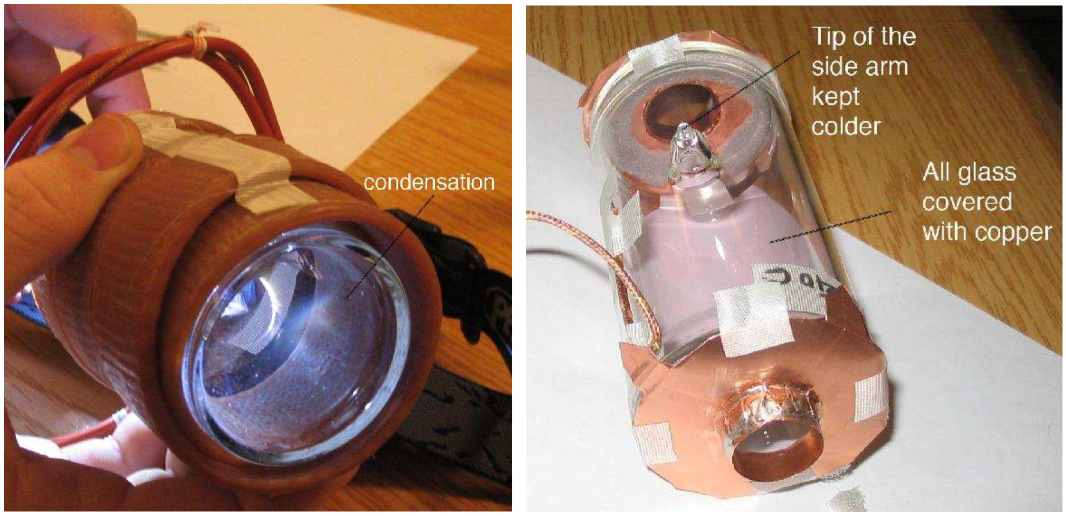

Figure 2: Condensation on the upper window of the iodine cell (left) and the copper-foil caps on the windows (right).

The iodine cell is heated to 55°C by a heater tape controlled by a single temperature sensor. Temperature gradients in the cell are inevitable because there is essentially no thermal conductivity in the system, while the heat is supplied in the non-uniform way. Foggy condensation was forming on either upper or lower windows of the cell, causing a significant flux loss by scattering. The problem was fixed temporarily by wrapping the cell in a copper foil, with the heater tape put outside (Fig. 2). Moreover, the tip of the side arm was made colder by wrapping it with another, un-heated piece of copper foil. The purpose is to provide a condensation site which does not affect the optical transmission. This solved the problem for the rest of the run. Note that such cells have never been operated in the vertical position before, at other spectrographs they were either horizontal or inclined, so a condensation on the wall could go un-noticed.

In the future, the cell should be placed in a heat-conducting container (e.g. made of aluminum). The heater and thermal sensor will stabilize the temperature of the container. A "cold finger" to the tip of the cell may still be necessary.

3.3 Dewar hold time

The CCD dewar has shown a strange behavior during this run. It was pumped in April. The hold time on May 19 was about 6 h, with a very fast temperature rise when the nitrogen was exhausted. The dewar was pumped again on May 21, and after this the hold time improved to > 12 h. It slowly degraded again, though. On the last night of the run (June 15/16), the dewar started to heat up 5.5 h after the refill, and heated from 84°K to 158°K in about 10 minutes.

A new CCD system is sought for this spectrograph. Meanwhile, it would be useful to collect historical record of the behavior of this dewar at Blanco. Regular pumping should be scheduled in future runs to keep the hold time longer than 6 h.

3.4 Thermal stabilization of the spectrograph

It is desirable to stabilize the temperature of the spectrograph for minimizing drifts and obviating the need of refocusing. The easiest solution appears to install a thermostat heater in the coude room, to maintain its temperature at about 20-25°C. The spectrograph itself will be isolated from the air by foam panels or something similar, so its temperature will be passively equalized by conductivity. The in-out motion of the iodine cell has to be motorized (it will no longer be possible to move the cell manually), but this is desirable anyway. A flow of the cold air from the CCD dewar will not affect the spectrograph directly, as it will pass outside the enclosure.

3.5 Finishing the electronics

Temporal power supplies for the quartz and Thorium lamps were used during this run. Definitive supplies will be installed in the electronics box (at the telescope). The lamps, prism motion, and cell motion will be controlled manually from the switch-box in the control room.