Pumping the Hydra CCD

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Historically, the Hydra CCD has been operated at a temperature of 150K. Because the thermal conduction of the cold finger from the Nitrogen to the dewar was not high enough, it was decided to pump the Nitrogen to achieve the low temperature required.

Although the system is workable, pumping the CCD causes some increase in operational cost (both monetary and in terms of mountain staff time and effort) and has occasionally proved cumbersome. There have been infrequent instances where the CCD has warmed during the night and caused loss of observing time.

Recently, the cooling system was upgraded, with new copper tubing and valves, but the upgrade has encountered some teething problems, with leaks, inadequate valves and the formation of ice plugs. In particular the last Hydra run in January was heavily affected.

We experimented with operating the CCD at the higher temperature of 160K, trading increased dark current for greater stability and operational simplicity. This worked well, with no significant problems reported during the most recent Hydra run. However, does this cause (as it should) an increase in the dark level and does this impact on the science being carried out with Hydra ?

In order to study this we measured the dark level at 160K and while cooling the chip (with pumping) to 150K. The gain setting used was #2, which gives a read noise of 3.0 e^- and gain 0.84 e^- per ADU. We were surprised to see an essentially constant dark level of about 4 counts/pix in 1800s exposures, or about 3.2 e^-/pix, irrespective of the CCD temperature. This was repeated with numerous variants, including with the CCD cap on (but not while pumping the system), disconnecting the LED cable, observing at night and with all surrounding lights off. This did not appear to make much difference, with the dark level remaining approximately constant.

Very careful study of the CCD dark current, paying very close attention to the exclusion of all stray light and parasitic electronic noise, in 2001, returned a dark current of about 1 e^-/pix per hour. The noise floor with this dark current is about 3.5 e^-. The currently measured dark level is 6.4 e^- per pixel per hour, several times larger than the low limit originally found. The noise limit in this configuration would be 4.3 e^-.

The level of dark current measured (and the previous values) would suggest that this is not so much dark current, as some stray charge or light leaks, coming from as yet unknown sources. While we need to make some effort to understand the source of the leaks, which appears to be internal to the CCD enclosure, since it is not affected by the cap being on or off, it is worth exploring whether the current dark level would affect current science.

The Hydra system is not very efficient, and observations are not usually attempted close to the read noise limited regime. With the availability of large telescopes, such observations are best carried out on a larger aperture, rather than having to struggle with instrumental effects. For a low resolution grating, the faintest source for which we can obtain a S/N 10:1 spectrum in 1hr of exposure has $B = 20.1$ (AB). The extra dark signal we find would reduce the S/N to 9.0, a loss of about 0.1mag of effective signal from the object. Most Hydra targets are considerably brighter than this.

Given the current regime in which Hydra science is done, Hydra can safely be operated at the 160K temperature without significant impact on the scientific outcomes, although particularly careful observers may wish to take darks as part of their calibrations routine. This also returns some significantly lower operational costs.