

## The Marseille-CFHT Focal Reducer with a PUMA Mode in General Use

A new focal reducer, on lease from the Observatoire de Marseille, is now available in general use at CFHT for the next three years. It is better adapted to spectrographic uses than the CFHT "Palila" focal reducer because:

- its chromatic aberrations, especially in the blue, are smaller
- it does not correct the comatic aberration at the F/8 Cassegrain focus of the telescope (and hence does not give comatic images of a slit)

It uses either a F/2.25 or a F/3 camera on the 45mm diameter exit pupil, and any of the present CFHT CCD detectors.

Carpenter grisms are used to get spectra. We have presently two such grisms: B400, centered at 5200Å and giving a dispersion of 230 Å/mm for the 100mm F/2.25 camera; O600, centered at 6000 Å and giving a dispersion of 160 Å/mm at f/2.25.

The useful spectral range is approximately 4000 Å to 7500 Å. Monochromatic images are very good over the whole 75mm diameter field (8.5 arc min diameter) at F/8. Chromatic aberrations, however, are still too large for a perfect focussing at 5500 Å, they give a transverse blur of 100μ diameter at the two edges of the spectral range. A new dedicated collimator is being ordered and it is expected that this aberration will be eliminated by early 1989.

The instrument uses under computer control a four position filter wheel (75m diameter filters) and a four position grism wheel: two positions receive GRISMS, the two others are open. A calibration box contains two spectral lamps (usually Ne and Ar) and a continuum lamp for flat fielding and slit/mask positioning.

The only presently commissioned use is the multi-holes PUMA mode:

It uses a Mark I punching machine, initially developed by an Observatoire de Toulouse team as a visitor instrument. A computer controlled routine selects ~15 to 40 objects from a direct CCD frame (without dispersion). This coordinate file is used to punch holes or slits 300 μm in width (2"2 on the sky) on a thin metallic wafer, which is placed by hand in the telescope focal plane. An additional CCD image of the backlit mask is then used to get a very precise alignment ( $\pm 0.1$ ) between the hole and the objects. The whole procedure lasts ~20 minutes (see Fort et al., SPIE proceeding vol. 627, 1986 for details). Using the TH1 CCD, it should be possible to obtain spectra S/N ratios in the continuum of 10 for  $M_R=21.5$  objects in 3 exposures, each 1.5 hr long.

A long slit mode will shortly be tested, and hopefully be commissioned for the second semester 1989. It presently uses a 40mm long (5 arc min) variable width slit. A "video game" technique will be used to put the object on the slit with a very good accuracy.

This focal reducer also has an integral field capability but, at present, is only a "visitor" mode (Observatoire de Marseille and Observatoire de Lyon). In this mode, referred to as 'TIGER', ~60 spectra for each 0.7 arcsec pixel are produced in a field with dimensions of roughly 4x6 arcsec. Spectral dispersion is the same as in the other, more classical, modes.

Operation of the instrument is fully computer controlled (except for initial adjustment, positioning of the PUMA mask and opening of the slit). Potential observers are nevertheless warned that the operation is still quite complex. Dedicated macros are being written however e.g. for focusing, offset pointing, calibration procedures and considerable progress is expected in the next two years

*G. Monnet*

## General Availability of the CIRCUS IR Camera

Interest in infrared imaging with array cameras is increasing rapidly within the CFHT community. Two team instruments from France have already had successful runs at CFHT: Obs. de Lyon 32x32 HgCdTe and Obs. de Paris-Meudon 32x32 InSb (CIRCUS). The University of Rochester 58x62 InSb array will have a four night run in July, and CIRCUS will return for its third run at CFHT in November (11 nights). In fact, of all the instruments to be used at CFHT this semester, only three (coudé spectrograph, CCD's for imaging, FTS) will be used more than IR cameras!

The CIRCUS camera (Caméra Infra-Rouge à Courtes longueurs d'ondes pour Utilisation au Sol) has been developed by the Département de Recherches Spatiales (DESPA) of l'Observatoire de Paris-Meudon. The team responsible for the project is headed by Daniel Rouan. The camera uses a 32x32 InSb array with a CID readout. More details on CIRCUS and an account of its first run at CFHT can be found in the previous issue of the Bulletin (No. 18, 1988 First Semester). The basic characteristics of the camera are recapitulated in the table below.

One year ago CIRCUS was made available to the French community as a common-user instrument. Support for observing runs was provided by the DESPA team under an agreement with INSU. The team have now very generously offered to make the camera available to all three CFHT communities beginning in first semester 1989. Observers wishing to use CIRCUS are invited to submit proposals in the usual manner. Those planning to do so are asked to contact

the CFHT Director as soon as possible so that we can provide additional information on the camera's characteristics and operational procedures. Proposals to use the camera will be reviewed for scientific merit and technical feasibility according to our normal practice. CFHT and the DESPA team will make their best effort to support as many highly-ranked proposals as possible, but because of the special circumstances it may be necessary to limit the number and timing of runs. Observers are asked to be as flexible as possible in their requests.

R. McLaren

**Table 1: CIRCUS Characteristics**

Detector material	InSb		
Operating temperature	4 K (LHe)		
Format	32x32 array (5 dead pixels)		
Pixel size	0".5x0".5 at CFHT		
Geometrical Filling Factor	72%		
Effective Quantum Efficiency	20% @ 3.5µm 8% @ 2µm		
Overall system read-out noise	1800 e <sup>-</sup> r.m.s.		
Charge storage capacity	2x10 <sup>6</sup> e <sup>-</sup> /pixel		
Maximum integration time	600 seconds		
Response uniformity	σ = 10%		
Filters	J (1.25 µm) H (1.65 µm) K (2.2µm) L (3.6 µm) M (4.8 µm) CVF* (R=60, 2.2-5.5 µm)		
* Circular variable filter			
Band	Limiting Magnitude	N	Tmax
J	22.6	60 (a)	60
H	21.1	60 (a)	60
K	20.6	60 (a)	60
L	17.3	18,000 (b)	0.2
M	15.7	36,000 (b)	0.1

Limiting magnitudes for 1 hour equivalent integration with S/N = 1. The noise (3300e<sup>-</sup>) is the "spatial" noise, based on a sky-minus-sky image. N represents the number of co-added frames necessary to obtain an integration time of 1 hour. Integration time per frame (Tmax, in seconds) may be limited by either dark current (a) or background emission (b).

## CFHT FILTER LIST

In an ongoing effort to keep an accurate record of all the CFHT interference filters we are publishing this list of available filters. They are grouped in different sets according to their use : Comet, Mould BVRI, DDO, Corion and General Purpose. The central wavelength, band width (full width at half maximum), maximum transmission and the dimensions are given for each filter with the F ratio (when available) at which the CW and BW are specified and the date of purchase. The central wavelength, band width and peak transmission are specified for an ambient temperature of 0°C.

A small shift in the central wavelength and in the band width can be expected when using a filter specified for a collimated beam, in an F/4 or F/8 beam. The relation between the shift and the angle is given by :

$$\lambda' = \lambda_0 \left[ 1 - \frac{\theta^2}{4 n^*{}^2} \right]$$

where θ is the half cone angle of the incoming beam, and n\* is the effective index of the filter. This term is dependant on the substrate, the dielectric materials and the number of layers used. For interference filters used in the visible the effective index varies between 1.8 and 2.35 with a value around 2.0 commonly obtained.

The band width is affected by the incident beam angle in the following manner:

$$(BW')^2 = BW^2 + \left[ \frac{\lambda^2 \lambda_0}{2 n^*{}^2} \right]^2$$

where BW' and BW are the resulting and original band width respectively.

The peak transmission is also affected according to this relation:

$$T = \frac{T_0}{1 + \left[ \frac{2(\lambda' - \lambda_0)}{BW} + \frac{\lambda_0 \theta^2}{BW n^*{}^2} \right]^2}$$

The position of the transmission peaks will also shift linearly toward longer wavelengths with an increase in temperature, the magnitude of the shift depends largely on the material. For materials commonly used in the visible region of the spectrum, the shift is of the order of 0.003% per °C.

At this time the filter wheel used for CCD imaging will only accept 50.8 mm square filters no thicker than 6.0 mm. All those filters that will not fit in FOCAM are in italics in the table.

A binder containing this list with the transmission curve of each filter will be kept in the Waimea library and at the summit at all times.

S. Béland