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Instrumentation for the IUCAA telescope

S.N. Tandon

IUCAA, Post Bag 4, Ganeshkhind, Pune 411007, India

Abstract. The IUCAA telescope would be a modern 2m aperture Cassegrain telescope for use by the university sector. It is planned to equip this telescope with a few general purpose optical and near infrared instruments. The first two instruments would be: a wide angle imager spectrograph for the optical band, and a near infrared imager spectrograph. These instruments would allow a quick changeover from imaging mode to the spectroscopic mode during the night; this would be very useful when the weather is unpredictable. In the future a two band optical imager would be acquired which would allow simultaneous observations in two bands, e.g. B and R, and hence the measurements of accurate colours even in the presence of some clouds. The details of these instruments would be presented.

1. Introduction

The IUCAA is planning to set up a two metre aperture optical telescope as a moderate but state of the art facility in the university sector, for optical and near infrared observations. In order to achieve a high efficiency of observing, while minimising the resources required at the observatory: a site has been chosen within a distance < 100 km from IUCAA, so that servicing of the telescope and other instruments can be done from IUCAA at short notice, and versatile focal plane instruments have been chosen so that a few instruments can be used for a variety of observations without a need for changeover.

The first instrument selected is an imager spectrograph for the optical band and the second is a similar instrument for the near infrared band; such instruments provide the possibility of a quick changeover from photometric observations to spectroscopic observations, and therefore partially cloudy night can be used optimally. In this paper the main features of the two instruments are presented. The presentation on these instruments is preceded by a brief description of the telescope and the site, and is followed by some suggestions for the instruments for future.

2. The telescope and the site

The main features of the telescope are aperture 2m, Ritchey-Chretien optics with f/3 primary and a f/10 Cassegrain focus, images < 0.5 arcsec in a field of 12 arcmin diameter; a corrector for the optical band gives images < 0.5 arcsec in a field on 40 arcmin diameter, alt-az mounting

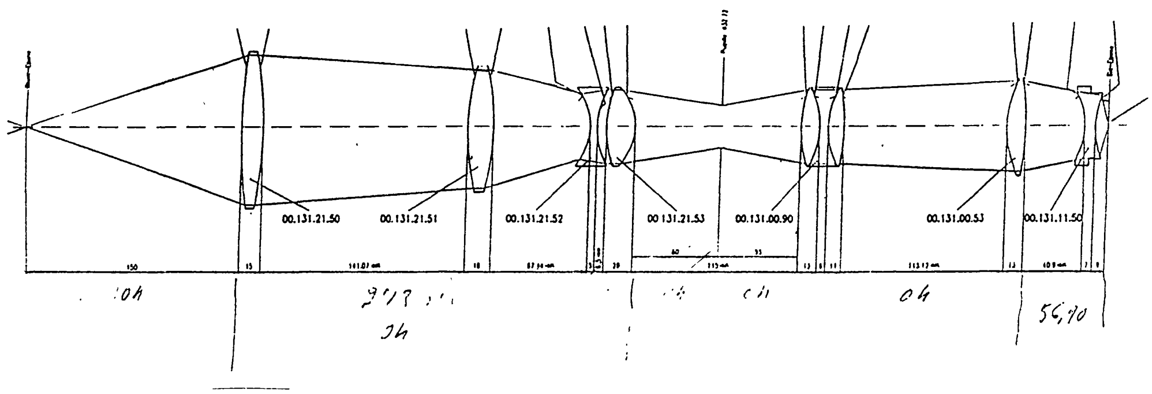

Figure 1. Optics of the imager spectrograph is shown. The telescope's focal plane is on the left extreme and the detector is at the right extreme; the total length is about 750mm. The first four lenses on the left are for collimation, and the lenses on the right of these makeup the camera. The filters and grisms are placed in between the collimator and camera — note the narrow waist of the light of the light beam in this part which minimises the size of grisms etc. (Ref.: Per Rasmussen, Copenhagen University Observatory, private communication).

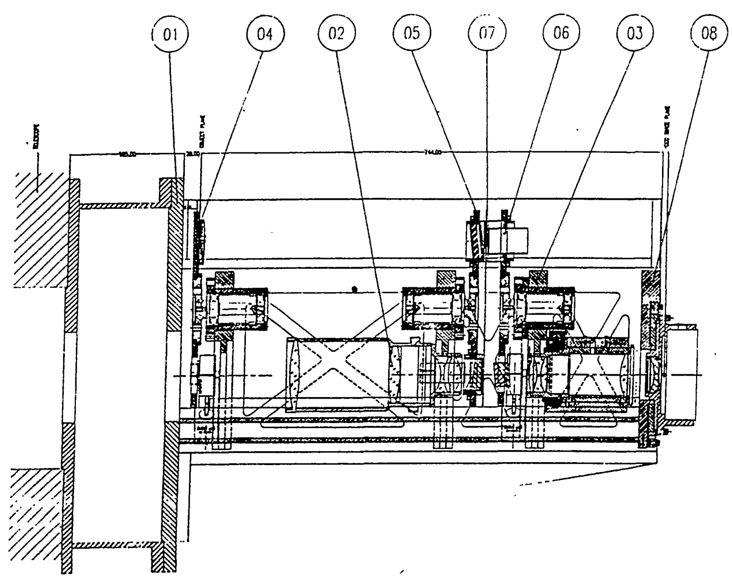

Figure 2. The mechanical structure of the imager spectrograph is illustrated. On the left, close to the mounting flange, the aperture wheel can be seen. The CCD dewar is at the extreme right, and the two wheels for the filters and grisms are placed between the collimator and the camera. (Ref.: Per Rasmussen, Copenhagen University Observatory, private communication).

with 2" pointing and autoguiding with a fixed CCD camera, instruments capacity: 1.5 m length along the axis and 500 kg mass.

The site is about 90 km from IUCAA at an altitude of 1000 m, located about 15 km west of the GMRT centre. The sky brightness is in range 21.2-20.7 mag per sq arcsec in the V band. The median seeing is ~ 1.5 arcsec during the winter and it is 2 arcsec during the summer. The number of spectroscopic nights is about 80% during the months of November to April and the number of photometric nights during the same months is about 50%. Extinction in the V band can be as low as 0.15 mag, but it could also be 0.4.

3. The instruments

i) Imager spectrograph for the optical band

The need for wide field imaging requires a focal reducer of high efficiency. It so happens that in order to have a focal reducer with small aberrations over a field of > 10 arcmin, the optics need to have the sequence of a collimator and a camera. The necessity of having a collimator makes the choice of an imager cum spectrograph very natural. Such instruments are fairly standard now, and a very popular design is based on an ESO instrument called EFOSC (see Buzzoni et al., ESO Messenger 38, 9). The optics and the mechanical structure of the instrument are illustrated in Figures 1 and 2 respectively. (Most of the details presented below are based on the information provided by Per Rasmussen of the Copenhagen University Observatory).

The optics would give a reduction of about two in the imaging mode, the aberrations would be < 0.5 arcsec in the wavelength range of 350-850 nm throughout the field of 10 arcmin × 10 arcmin, and the transmission would be in range 70% to 80%.

There would be three remotely controlled wheels in the optical path: a wheel at the telescope focal plane for selecting the aperture e.g. long slit, multislit, etc., a filter wheel and a grism wheel in the parallel beam between the collimator and camera. A set of filters and grisms would be used to choose the spectral resolution; to get higher resolutions echelle grisms could be used in combination with cross dispersing grisms (placed in the filter wheel). A possible selection of the grisms is listed below.

disp(Å/mm)	wavelength region	resolution at 5000 Å (one arc second slit)
147	blue	
208	visual	10Å
209	red	
93	blue	
100	visual	5Å
84	red	
30	echelle	1.5Å
413	blue X-disp	
310	visual X-disp	15Å
881	red X-disp	
34	echelle	

The top efficiency in each order of the echelles is around 40%. "Normal" grisms have efficiencies from 80% (the X-disperses with low dispersion) to 60% (the normal grisms with highest dispersion).

ii) Imager spectrograph for the near IR

This instrument is similar to that for the optical band but with the inevitable differences, necessary in view of the smaller size of the array and the need to keep the optical components within a dewar for minimising the thermal background. (Most of the details presented below are based on the information provided by Rene Doyon of the University of Montreal.)

A 1024×1024 HgCdTe Array with pixel size of 18 microns would be used to get a field of view of ~7'×7' with a reduction factor of ~2. The optical arrangement is shown in Fig. 3.

A normal grating and a echelle grating would be used for getting resolutions in the range of 1000-4000. A pupil plane between the grating and the camera would be used to block the background radiation; the same plane would be used to place the filters too, as the beam has a small waist here. The filters would be mounted on a set of two wheels.

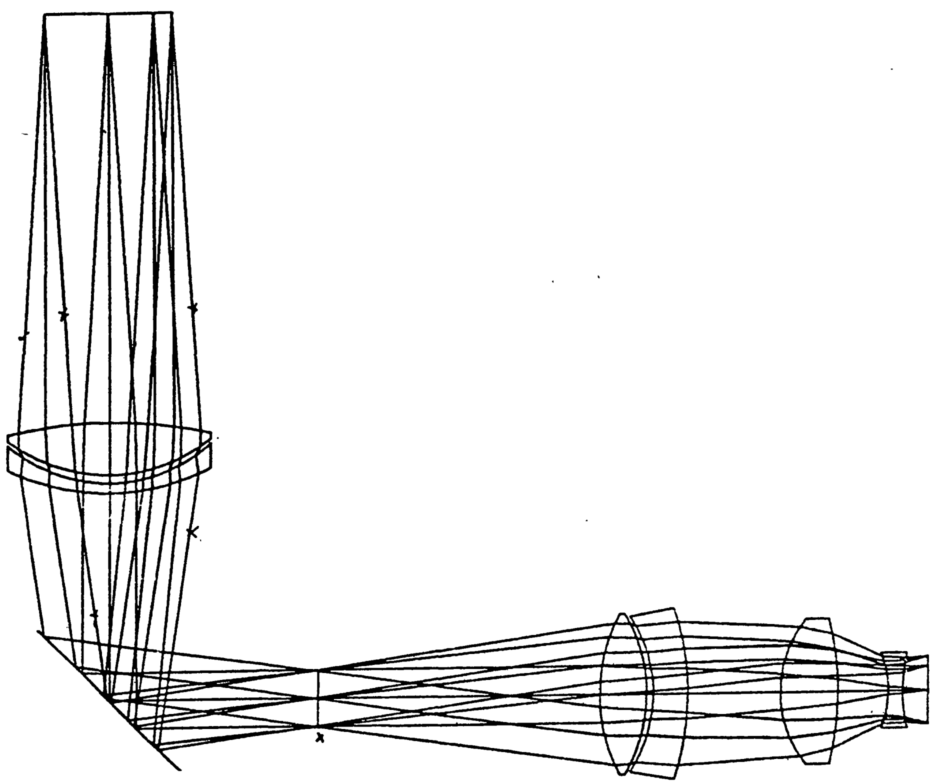

Figure 3. Optics for the near IR imager spectrograph is illustrated. The telescope's focal plane is shown on the top, and the detector is on lower right corner. The beam is deflected at the left hand bottom, by a mirror, in the imaging mode; the mirror is replaced by a suitable grating in the spectroscopic mode. The filters can be replaced on the right of the mirror, where the beam has the minimum diameter. (Ref.: Rene Doyon, University of Montreal, private communication).

4. Future instruments

An obvious extension of the optical instrument would be a two band imager, which can be used for simultaneous imaging of a large (> 10'×10') field in B or V and R or I simultaneously. This instrument would need two independent camera lenses and a set of beam splitters (see Fig. 4). Thus the instrument would be fairly large and expensive, but it provides the possibility of very accurate colour mapping even in the face of unsteady extinction. Depending on the experience with the first imager - spectrograph the utility of such an instrument would be reviewed in the future.

The large carrying capacity of the Cassegrain station offers the possibility of mounting a large optical - infrared instrument which can be put into the desired mode in a few minutes. Such an approach not only provides the possibility of adjusting the observations to the changing weather, but it also would involve minimal effort in changing the instruments and adjusting them for the runs. The design could be in a modular form so that the optical module and the infrared module could be serviced independently.

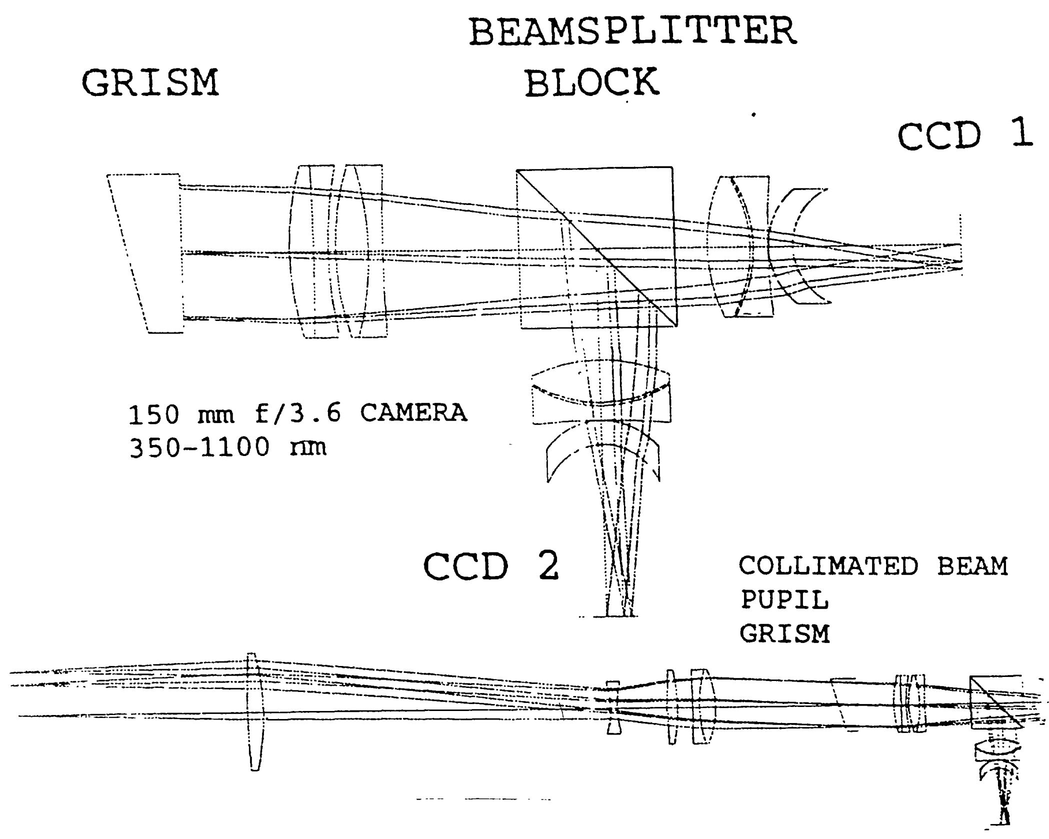

Figure 4. Optics for a two band imager spectrograph is illustrated—note that the beam splitter can be used as an order sorter in the spectroscopic mode. (Ref.: Peter Conroy, Mt. Stromolo Observatory, private communication).