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Near Infrared PICNIC Imager (NIPI) for IUCAA Telescope

A. Deep*, A. N. Ramaprakash, S. N. Tandon, R. Gupta, M. P. Burse, P. A. Chordia, H. K. Das, S. Engineer, A. A. Kohok, V. B. Mestry
Inter University Centre for Astronomy and Astrophysics, Pune - 411 007

Abstract. In this paper we present the current status of development of the Near Infrared PICNIC Imager (NIPI), which will be the first near-IR instrument on IUCAA telescope. When used at one of the Cassegrain side ports of the telescope, it gives a plate scale of 0.8 arcsec per pixel at the PICNIC detector array with a field of view of 2.5 arc minutes. It offers imaging capabilities in J, H and K filter bands, with the reimager optimized in H-band for which almost 90encircled energy of a point source is contained in a pixel. Hardware and software for infrared readout are being developed at IUCAA.

Keywords : PICNIC - near infrared - imager - IUCAA Telescope

1. Introduction

The Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune is setting up a 2 metre optical-near infrared telescope at a site called Giravali, about 80kms NE of Pune (Das et. al. 1999). The telescope will have a 2 metre aperture f/3 primary of Astro-Sital, and a Ritchey-Chretien optics to get a final focal ratio of f/10 at the Cassegrain focal station. This station will have a direct port as well as four side ports. We have already acquired an imager-spectrograph (IFOSC) for the optical band ($3500A^{\circ} - 8500A^{\circ}$) which will be the main work-horse instrument mounted at the direct port. The details of the telescope as well as the instrument are given in a seperate article in this issue.

The primary goal of the development of NIPI - Near Infrared PICNIC Imager, is

*e-mail:adeep@iucaa.ernet.in

Wavelength Range	1 - 2.5 μm
Cell Pitch	40 x 40 μm
Scale at the Detector	0.8 arcsec/pixel
Working Temperature	77K
Dark Current	$< 1\ e^-/s$
Readout Noise	15 e^-
Full Well Capacity	2 - 5 x $10^5 e^-$

(a)

Band	sky brightness ($arcsec^{-2}$)	sensitivity (mag.)
J	16.0	21.55
H	13.9	20.22
K	12.2	19.10

(b)

Table 1. (a)Salient properties of the PICNIC detector (b) Sensitivity estimates for NIPI under typical observing conditions

to utilize the near infrared ($1.0\mu m - 2.5\mu m$) capabilities of IUCAA Telescope from the outset. Initially we plan to use a three-slot filter wheel having J, H and K as the three filters. NIPI has a demagnification of 0.5 thereby increasing the a plate scale to 20"/mm and reducing the final focal-ratio to 5. The camera will be equipped with a 256 x 256 HgCdTe IR PICNIC array from Rockwell International Corporation. This detector has been obtained on a long term loan from the Institute of Astronomy, Cambridge, UK. The field of view of the instrument will be about 2.5 arc minutes.

PICNIC is an upgrade of the well known NICMOS3 array. In table 1(a) are listed the main characteristics of the detector (D'Alessio et at, 2000). The major improvement with respect to NICMOS3 device is the reduced readout noise. The Quantum Efficiency(QE) for the desired wavelength range is around 0.65.

The limiting sensitivity estimates given in table 1(b) for point sources are for achieving a signal-to-ratio of 5 with a total integration time of 15 minutes. Median seeing in the V-band at the site is around 1.4" (Das et al, 1999). From (Glass, 1999)

$$seeing \propto \lambda^{-0.2} \tag{1}$$

and taking sky background into account we find that the exposure times for 80 percent utilization of the full-well ($3 \times 10^5 e^-$) capacity of the detector pixels, turn out to be 144, 35 and 12 seconds for J, H and K bands respectively.

2. Optical Design

The optics of the camera was designed using Focus Software's ZEMAX program. The main design consideration was to use as few elements as possible. This is to ensure good total transmission and also to reduce the cost of the camera.

When working in near-infrared regime the choice of materials is quite limited by the fact that normal glasses like BK7 are opaque beyond $2\mu m$ (Oliva and Gennari, 1998).

Also, since the lenses must be cooled to cryogenic temperatures their coefficients of thermal expansion and temperature dependence of refractive index must be small. The first few designs were optimised using BaF_2/BK7 with NaCl, KBr and KCl. The problem with BK7 is already pointed out and the former were found out to be highly hygroscopic and therefore best avoided. The design now uses two pairs of $CaF_2 - SiO_2$ achromatic doublets (Persson et al, 1992). BaF_2 can also be used instead of CaF_2 but the latter has better durability in the ambient environment (McCarthy et al, 2001). Some parameters regarding the two materials can be found on the website www.ispoptics.com.

The detector will work close to liquid nitrogen temperature. The optics also will sit inside the dewar to achieve good sensitivity in K-band. But there will be no cold tongue attaching the optics directly to the liquid nitrogen can and hence the optics will be at a higher temperature. The optical design is therefore optimised at −100°C. The manufacturing specification at room temperature has then been arrived at using the multi-configuration facility of ZEMAX.

Fig. 2 shows the optical layout of the camera. All the lenses are of 70mm diameter. The first pair of lenses($CaF_2 - SiO_2$) form an achromatic doublet and are placed 300 mm

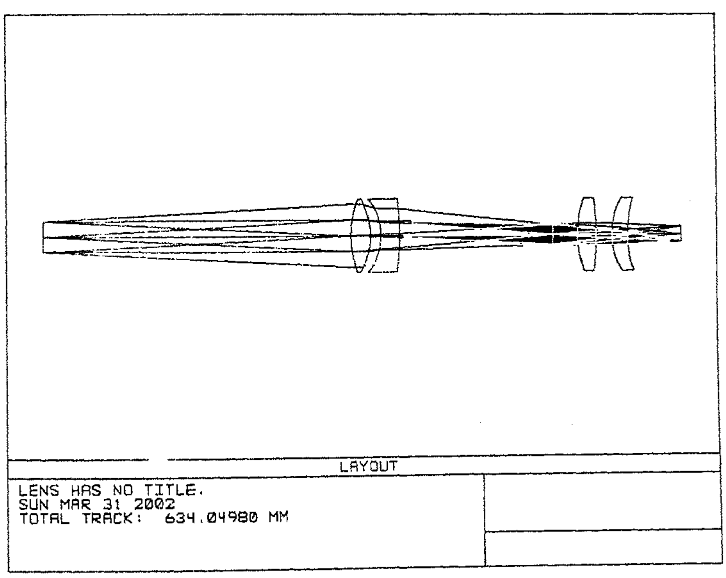
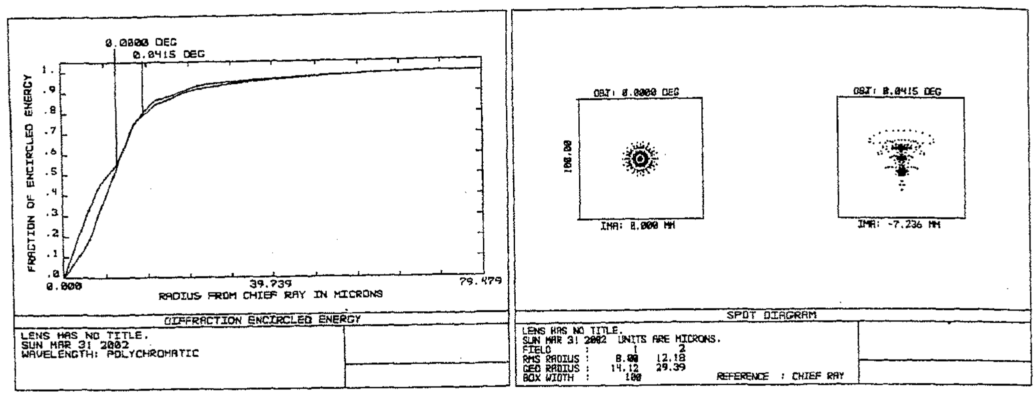


Figure 1. Optical layout of NIPI. The focal plane of the telescope is reimaged onto the PICNIC detector with a image scale reduction by a facotr of 2.

from the telescope focal plane. The telescope primary mirror which sereves as an entrance pupil is imaged onto a 19 mm pupil which is 128 mm from the image plane. The filter wheel containing four filter slots will be located at this position. The second pair images the telescope focal plane onto the detector. The design is optimised for H-band and the telescope would have to be refocused when changing filters. Fig. 2(a) shows the encircled



(a) (b)

Figure 2. (a) The encircled energy as a function of distance from chief ray. The two curves are for on-axis (0°.0) and full-field (0°.0415) point objects. (b) The polychromatic spot diagrams for on-axis (0°.0) and full-field (0°.0415) point objects. These are for the entire H-band.

energy as a function of distance from the principal ray for a point source object which (i) lies on-axis and (ii) at the edge of the field (2.5 arc minutes). If one considers the total energy in H band ($1.5\mu m - 1.8\mu m$), 90% of it is contained in a region of radius 22 μm. However, there are individual wavelengths in the band for which the radius increases to 25 μm. The rms spot size radii for on-axis and off-axis point objects (fig. 2(b) are seen to be 8 μm and 12 μm respectively. In establishing the image quality, the effects of the telescope optics also has been taken into account. Spherical aberration, coma and field curvature contribute equally in increasing the spot sizes.

3. Hardware and Software

The data-acquisition electronics hardware for NIPI will be an adaptation of the IUCAA CCD controller. This electronics system is being built and tested in the laboratory currently. The main differences from the existing CCD controller are in the clock and bias signals, the need for fast readout and looped integration cycles, the ability to do both reset-reads and non-destructive reads etc. A new version of the CCD controller software is being developed which will be capable of being configured to run any of the existing visual or near-IR detectors.

References

D'Alessio, F. , et al, 2000, In Masanori, I. and Morwood, F. M. ,editors, *Optical and IR Telescope Instrumentation and Detectors, Proc. of SPIE*, **4008**, 748.

Das, H. K. , et al, 1999, *BASI*, **27**, 609.

Glass, I. S. , 1999, *Handbbok of Infrared Astronomy*,Cambridge University Press

McCarthy, Jr. D. W. et al, 2001, *PASP* , **113**,353.

Oliva, E. and Gennari, S. ,1998, *A & AS*,**128**, 599.

Persson, S. E. , et al, 1992, *PASP*, **104**, 204.