Near-infrared Imager, Spectrometer, and Polarimeter (NISP)

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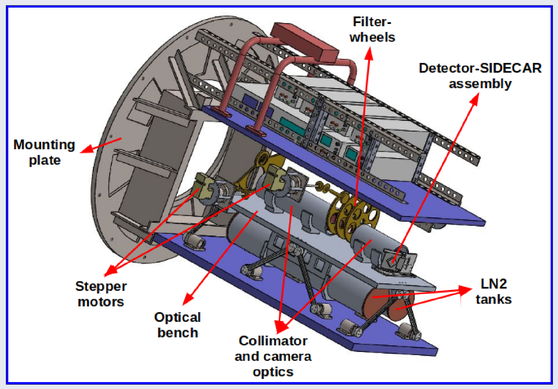
Abstract

Near-Infrared Imager, Spectrometer, and Polarimeter (NISP) is an upcoming multifaceted back-end instrument to be used at the main port of 2.5 m telescope of Mount Abu Observatory, operated by Physical Research Laboratory (PRL). NISP will have the ability to function in imaging, spectroscopic and polarimetric modes in a selectable manner. Near-infrared broadband filters (Y, J, H, $\mathrm{K_s}$, and K) used in the instrument will cover the wavelength of about 0.8 to 2.5 microns. The optics has been designed in-house to provide an FOV of $10' \times 10'$ in the imaging mode using an H2RG detector from Teledyne. The spectroscopic design with R 2000 has been achieved using grisms. Further, NISP will also facilitate imaging-polarimetry in two shots (0° and 90°, 45° and 135°) with the help of two wollastons used in its optical design. NISP electronics has also been designed and developed indigenously at PRL. This poster provides an overview of diverse scientific goals of NISP and its sub-systems, with glimpses of their development.

Mount Abu Observatory, PRL

- **Location at Gurushikhar, Rajasthan:**
  $24^\circ 39' 17.34''$ N, $72^\circ 46' 45.18''$ E, 1680 m

Near-infrared Imager, Spectrometer, and Polarimeter (NISP)



- **Array configuration:** 2048 × 2048 pixels (H2RG detector from Teledyne, USA)
- **Field of view:** 10 × 10 $\mathrm{arcmin^2}$
- **Pixel Scale:** 0.29 arcsec/pixel
- **Filters:** Y ($0.90 - 1.15$ μm), J ($1.17 - 1.33$ μm), H ($1.49 - 1.78$ μm), $\mathrm{K_s}$ ($1.99 - 2.31$ μm), and K ($2.03 - 2.37$ μm)

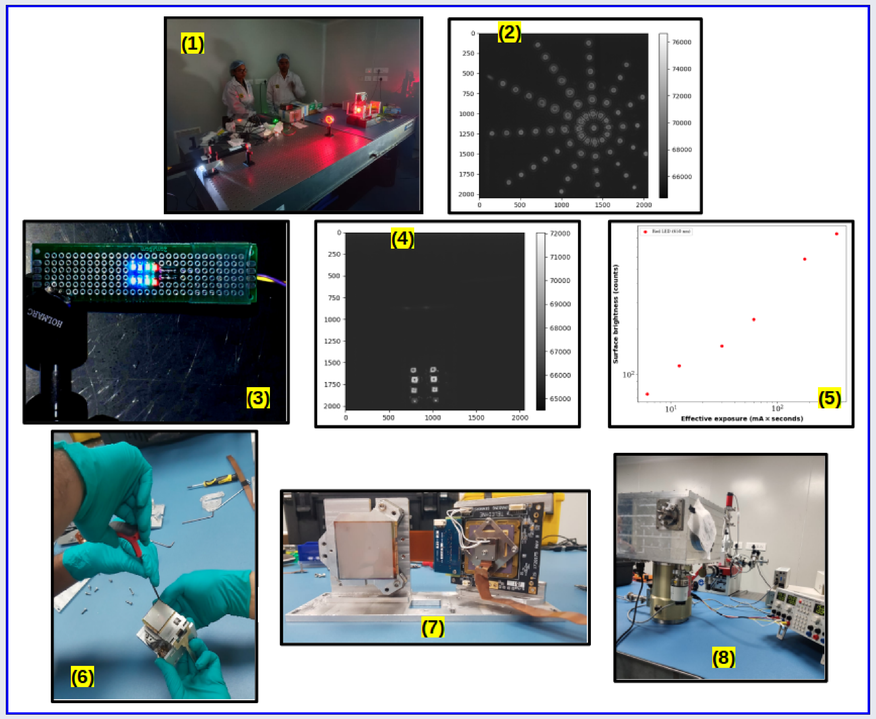
Diverse Science Objectives

- Studies of solar system objects (from minor bodies to planets)
- Studies of extra-solar planetary systems, M-dwarfs
- Research on transient sources (novae, supernovae, and related eruptive variables)
- Studies of star forming regions and clusters
- Using P Cygni profiles to probe the white dwarfâs properties in Cataclysmic Variables
- Providing simultaneous near infrared (NIR) observations for multiwavelength studies of AGNs
- NIR observations of Be/X-ray binaries
- Deep Infrared Imaging of Northern Spiral arms of the Milky Way
- NIR study of Proto-Planetary Nebulae

Design Parameters

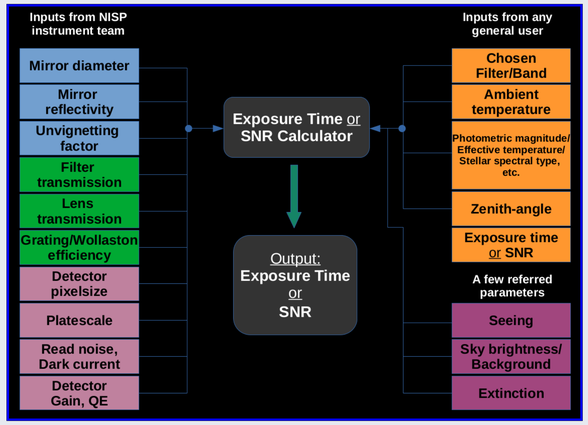
- Teledyne H2RG detector with 2K × 2K active pixels
- Optimum functionality for all three modes of operations
- Y, J, H, $\mathrm{K_s}$ broad band filters
- Two slots for the selected narrow band filters
- 10 × 10 $\mathrm{arcmin^2}$ FoV in imaging mode
- Spatial resolution of around 0.3 arcsec/pixel
- Spectroscopic resolving power of R∼2000
- Multiple long slits of varying widths
- Double-shot imaging polarimetry using two wollastons
- Cryogenic (77 K; LN2) operating temperature
- Maximum weight of ∼400 kg
- Maximum height within 1.0 m

In-house development of test set-ups for various sub-systems of NISP



(1,2) Beam collimation set-up at room temperature for imaging a patterned mask on to Read-out Integrated Circuit (ROIC) and its output image, (3,4,5) Optical/NIR LED set-up and electronics to check their response on to ROIC in cryogenic condition and the results, (6) ROIC being installed with the help of handling tool on detector mounting plate, (7) ROIC mounted alongside cryogenic SIDECAR ASIC, (8) Cryogenic set-up for ROIC and cryogenic SIDECAR

Sensitivity Calculation



- We have developed a python-based user-friendly GUI for performing sensitivity calculations for NISP.
- Seeing value has been extrapolated to NIR based on the optical measurements.
- Sky brightness values for Mt Abu have been used from Prajapati et al. (2023).
- Extinction values for Mount Abu has been referred from Gupta et al. (2004) .
- The resulted sensitivities are shown in the table here:

Band	Central Wavelength (in μm)	Sensitivity in magnitudes [a] (S/N = 10, Exposure = 60 sec) Photometry	Spectroscopy	Polarimetry
Y	1.02	18.5	14.6	17.6
J	1.25	17.7	14.1	16.9
H	1.64	17.0	13.1	16.1
$\mathrm{K_s}$	2.15	14.7	-	13.8
K	2.2	-	10.4	-

[a]Values given here are for the assumed efficiencies of lenses, grism, and wollastons. Exact efficiencies of which are yet to be incorporated after the discussion with manufacturers.

Summary

- NISP is an upcoming multifaceted near-infrared back-end instrument for the 2.5 m telescope of Mount Abu Observatory.
- Its in-house development at Physical Research Laboratory includes:
  (1) designing of optics, mechanics and opto-mechanics
  (2) set-up and testing of optics, electronics and opto-electronics
  (3) fabrication and assembly.
- It will boost the ongoing science coming out using state-of-the-art 2.5 m telescope in diverse astronomical research areas.

References

- Gupta A. C., Banerjee D. P. K., Ashok N. M., Joshi U. C., A&A (2004)
- Prajapati P., Mishra A., Rawat A., Ganesh S., JoAA (2023, Accepted)

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