Large Area Imaging Survey of Near–Infrared Sky with Korean Compact Space Telescopes

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with
MIRIS Team
KASI, SNU, AISAA, ISAS/JAXA
Space Observation Program in Korea

  - 2nd Satellite: Observation of Space environment by Korean Launcher
  - 3rd Satellite: MIRIS (Multipurpose Infrared Imaging System)
- Next Generation of small Satellite Series (SaTReC) (2012 ~)
  - 1st Satellite: NISS (Near-infrared Imaging Spectrometer)

(Seon et al. 2011)
MIRIS (Multipurpose InfraRed Imaging System)
- Main payload of STSAT-3, launched on Nov. 20, 2013.
- First Korean infrared camera in space

Orbit
- Altitude ~ 620km
- Eccentricity 0.002
- Inclination 97.8 deg.
- LTAN 22.4 o’clock
MIRIS

Space Observation Camera

- Wavelength: 0.9 ~ 2μm
- Aperture: 80 mm
- Detector FOV: 3.67° x 3.67° (Pixel: 51.6 arcsec)
  (c.f. Nyq. sampling @ 1.6μm = 4.1 arcsec)
- Telescope & Sensor Temp.: 180K (Passive Cooling), 90K
- Filters (5 filters)
  - I (1.05μm), H (1.6μm) – R~5, blank
  - Pa α (1.876μm), Pa α Cont (R ~ 50)
- Large area imaging survey of NIR sky
Scientific Objectives (1/3)

- **Paα Emission Line Survey**: Galactic plane (360 deg. x 6 deg.)
- **Origin of Warm Ionized Medium**
  - Previous study of WIM: Photoionization model
  - Recent study of WIM from FIMS: dust scattering
  - Verification of the dust scattering theory
- **Physical properties of interstellar turbulence**
  - Structure of WIM: Comparison between Paα (MIRIS) vs. Hα

Monte-Carlo simulation
- Uniform dust distribution; E(B-V) = 0.1
- Point source or Spherical H II region
Scientific Objectives (2/3)

- Observation of Cosmic Infrared Background (CIB)
  - Spectral peak of CIB
  - Large scale (degree-scale) fluctuation of CIB
    → connection between AKARI (Spitzer) and IRTS results
  - Observation of NEP field: 10 deg. x 10 deg.

- CIB fluctuation @ ~2μm
- IRTS
  Matsumoto et al. 2005, 2015
- AKARI
  Matsumoto et al. 2012
  Seo et al. 2015
- Spitzer
  Kashilinsky et al. 2012
Strong foreground emission: zodiacal light
- Calibration purpose: 2 orbits /day
- Continuous observation of NEP
- Monitoring of background in NEP: I & H bands
  → Revision of ZL Model & Removal of ZL component
- Observation only during eclipse: CIB & Paα survey
- 1 Pointing / 1 orbit (~10min. → effective exposure ~6.5min.)
- Avoidances
  - Sun avoidance 90 deg., Moon avoidance 35 deg.
  - Earth limb avoidance 35 deg.
DR: Main Processing (1/2)

- **Mask bad pixels**
  - Use pre-defined positions of bad pixels
  - Set them NaNs

- **Correct non-linearity**
  - Mask saturated (> 41,000 ADU) pixels (set them NaNs)
  - Divide each pixel value with pre-defined correction polynomial

- **Differentiate frames**
  - Take difference between two subsequent frames
  - Ignore frames which cannot be differentiated (e.g., frames just after reset)

- **Flat-field correction**
  - Flat templates

- **Correct distortion**
  - Use SIP (Simple Imaging Polynomial) convention to define distortion
  - Follow the algorithm of IRAF geotran task
Mask bad pixels: 17 pixels
- Found in checking the linearity for each pixel

Correct non-linearity
- Correction by dividing measured pixel values with 4\textsuperscript{th} order polynomial

![Bad pixels](image.png)

![Graph](image.png)
Measurement in space: same as that in Lab.

\[ f(x) = a \times x + b \]

with

\[ a = (0.645 \pm 0.087) \text{ ADU s}^{-1} \]

\[ b = (-0.31 \pm 0.22) \text{ ADU} \]

Consistent with ground measurements
Observation of CIB

- Targets: NEP, NGP, SGP
- 7x7 pointed observations with 50% overlaps → 4 times observations of ~10 x 10 deg.
- Wavelengths: 1.1μm (I) & 1.6μm (H) bands
- Instrument Calibration: NEP Monitoring field
CIB: NEP Wide Field

I band  2014.09  H band
CIB: NEP Monitoring Field

- Observation of NEP every another day (14%)
- Variation of background brightness due to ZL
  → Useful for ZL study, but no good data in NIR range

@ 9 μm (Pyo et al. 2010)

@ 3.6 μm (Krick et al. 2010)

Time in years starting from Dec. 1 2013
Clear variation of background brightness

I band

H band
Total observation time: > 10 hrs exposure
Noise affected by stripe pattern: ~3 times noise↑

Destriping module
→ reduction of noise↓
Effect of Destriping (Long exposure observations)

I band  

H band  

After destriping  

After destriping
H band

Significant fluctuation
  - Under the investigation
  - Non-linear features in faint signal?

Please wait for final results!
Pa-α Survey of GP

- Paα emission: less dust extinction than Hα
  → Better probe of the warm ionized medium (WIM)
- Good complement data for the estimation of star forming ratio in the Galaxy

Pa-α (Finkbeiner et al. 2003)
- Technical heritage from MIRIS
- Wavelength range: 0.9 ~ 3.8μm (continuous)
- Array format: 1024 x 1024, FoV: ~2 deg. X 2 deg. (15” resol.)
- 15cm aperture, Imaging & Low-Resolution Spectroscopy (R~20), Sensitivity ~17 AB mag. – survey area > 100 sq. deg.
NISS Science Mission

- Near-IR Imaging Spectroscopy
  - Large Nearby galaxies / Clusters of galaxies
  - Star-forming regions
  - Cosmic Near-Infrared Background

<table>
<thead>
<tr>
<th>$\lambda$ (µm)</th>
<th>line</th>
<th>Type</th>
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<tbody>
<tr>
<td>1.26, 1.64</td>
<td>[Fe II]</td>
<td>Emission</td>
</tr>
<tr>
<td>1.875</td>
<td>Pa$\alpha$</td>
<td>Emission</td>
</tr>
<tr>
<td>1.96</td>
<td>[Si IV]</td>
<td>Emission</td>
</tr>
<tr>
<td>2.212</td>
<td>H$_2$ 1-0 S(1)</td>
<td>Emission</td>
</tr>
<tr>
<td>3.05</td>
<td>H$_2$O Ice</td>
<td>Absorption</td>
</tr>
<tr>
<td>3.3</td>
<td>PAH</td>
<td>Emission</td>
</tr>
</tbody>
</table>

Near-Infrared Emission Lines

Multiwavelength observation for M55

Detection of Cosmic Near-Infrared Background (2~4 µm)
Summary

- MIRIS (in operation)
  - CIB observations: various fields
  - Large-scale fluctuation of CIB
  - Under the data reduction

- NISS (under the development phase)
  - Next NIR mission
  - NIR imaging spectroscopic capability
  - Launch: ~2017