The University of Tokyo Atacama Observatory (TAO) project

Mamoru Doi, University of Tokyo, On behalf of TAO project

Chajnantor Working Group, May. 15-16, 2015 @OSF-ALMA, San Pedro de Atacama
Goal: a 6.5-m Infrared-optical telescope at Chajnantor Summit (5640m)
High Atmospheric Transmission

The image shows a graph with three curves representing different observations at TAO (5600 m), Subaru (4200 m), and VLT (2600 m). The x-axis represents wavelength (λ in μm) ranging from 0.8 to 40, while the y-axis represents transmittance ranging from 0 to 1.
TAO team

Institute of Astronomy, Graduate School of Science, University of Tokyo

Prof. Yuzuru Yoshii   Director & Project Leader

TAO members at IoA
3 Professors,   4 Associate Professors,
5 Assistant Professors, 4 Engineers, 3 postdocs

Dept of Astronomy UT, NOAJ, JAXA, other Japanese universities
Univ. of Chile: Profs. Bronfman, Hamuy, Maza, Ruiz, Mendez, ...
Univ. of Catolica: Profs. Infante, Vanzi,
Univ. of Concepción, Univ. of Catolica de Norte, Univ. of Antofagasta,..

Chilean Government: Ministry of Foreign Affairs, CONICYT,..

CCAT project

Headquarters at Mitaka, Tokyo

Kiso Observatory at Nagano
1m- Schmidt Telescope
Site Studies (since ~1999)

Clear fraction : ~ 80%
Perceptible water vapor : < 0.38mm @ best 10%
Seeing condition : 0.69 arcsec @ V, median

Weather station
MIR whole Sky camera
DIMM (seeing monitor)

2006-
Access road by UT 2006
To be improved soon

One of the best sites for the IR astronomy
The miniTAO 1-m telescope
a pathfinder telescope of the TAO project

Completed in March 2009    Two instruments (NIR, MIR)
Operation ~2months x 1-2 / year; 10% for Chile community
Remote operation from SPdA
ANIR – an near-IR (& optical) imager

✓ Pa$\alpha$ (1.875\,\mu m) imaging from the ground

- Galactic HII Region Survey in Pa$\alpha$
- Nearby LIRG and merging galaxies survey
MAX38 – a mid-IR imager & spectrometer

✓ explores 30 micron astronomical windows

- 30 micron imaging from the ground
- Decommissioned in 11/2013

25.0 um  31.7 um

Radiance of IO at 8.9um

Longitude
The 6.5-m TAO telescope

• Best Infrared Telescope on the earth
  – Frontiers in astronomy through the new atmospheric windows
    cosmology; galaxy evolution; exo-planets; .......
  – Telescope under construction (funded in January 2013)
  – First Light 2018(?)

• 1st generation instruments
  – SWIMS (NIR), MIMIZUKU (MIR)
  – Funded by Japanese government in 2009
  – Almost completed
  – Will be attached on the Subaru telescope for test observations (2016?)
Telescope Mount

Nasmyth 2  BentCas 2

Mount: by Nishimura Co Ltd.
AG/SH: by Kyoto Nijikoubou
Mirrors

6.5-m Primary
Secondary/Tertiary
mirror mount system to be completed in two years
Enclosure and Summit Facility

Enclosure and Summit operation building by Kokusai Land Development and Nishimura Co. Ltd.

Mirror Coating Plant
Some components being made by Sanko-seikojyo
**SWIMS (for NIR)**

- **Simultaneous-band Wide field Infrared MOS Spectrograph**
  - Simultaneous imaging/spectroscopy in 2 bands (0.9-1.4 um & 1.4-2.5 um)
  - Wide field of view with good pixel resolution 9.6’ Φ, 0.126 arcsec/pix, with 2 x 4k x 4k pixels
  - Multi-object spectroscopy with cooled multi-slit masks
    - 0.9-2.5μm simultaneous spectroscopy for ~30 objects (R~1000)
  - IFU module also under development
Science drivers for SWIMS

- **Features of TAO/SWIMS**
  - almost continuous coverage in 0.9 – 2.5 µm
  - Wide field imaging and multi-object spectroscopy

- **TAO-NIR deep & wide survey**
  - Deeper with better image quality than VISTA
  - high-z galaxies, distant clusters, QSOs, SNe, minor planets, ..

![Graph showing wavelength vs. flux density with TAO and VLT data points and FoV comparison between TAO and VISTA.](image)
MIMIZUKU (for MIR)

- **Mid-Infrared Multi-field Imager for gazing at the Unknown Universe**
  - Wide wavelength coverage
    - InSb channel: 2-5.6um
    - Si:As channel: 6-26um
    - Si:Sb channel: 25-38um
  - Diffraction limited spatial resolution
    - 0.4 arcsec @ 10 micron
    - 0.8 arcsec @ 20 micron
    - 1.2 arcsec @ 30 micron
  - For accurate monitoring observations
    - Simultaneous observations of two discrete fields by the field stacker
  - New technology
    - Internal chopping
    - Mesh filter
    - Moth-eye lens coating

Field stacker unit

Optical layout for 3 channels

NIR

MIR-L

MIR-S
Science drivers for MIMIZUKU

• Features of TAO/MIMIZUKU
  – High sensitivity, high angular-resolution at 30 um bands
  – Accurate monitoring capability using the field stacker

• Targets
  – Proto-planetary disk and planet formation
  – Dust formation around stars and planetary nebulae

EX Lupi (FU Ori type, T Tauri star)
amorphous silicate

Abraham+ 2009

Amorphous + crystallized silicate
base facility at San Pedro de Atacama

Inauguration Nov. 21, 2014

- Land owned by UTokyo ~14000m^2 inside SPdA town
- Laboratory, bedrooms (5), kitchen,..
with Chile

The first light ceremony of the miniTAO on July 7, 2010 with MoF and CONICYT

Former President Piñera gave a talk At the Univ. of Tokyo on March 28, 2012

Mayor Berna visited Japan In August 2012

UTokyo forum in Chile with PUC and UCh In Nov. 2013 ~14 workshops

Chile-Japan Academic Forum at Utoke Oct. 8, 9 2014

Inauguration Ceremony of Base facility Nov. 21, 2014
Infrastructure

Power for the 6.5-m telescope
~100kVA normal ~500kVA max
cable from 5000m plane : shared with CCAT
generator or purchase from ALMA?

Network (optical fiber)
Chajnantor summit to ALMA terminal : shared with CCAT
terminal to OSF : through ALMA optical fiber
OSF to SPdA : commercial

Road access
normal access: ALMA road -> Chajnantor summit road with CCAT
installing large components: Paso de Jama -> Chajnantor summit road

Safety
keep ALMA safety regulation
own regulation mostly more strict than ALMA
everybody to go up to Chajnantor : names are informed to ALMA safety
Summary

Chajnantor summit:
High transmittance in IR and good seeing
miniTAO 1-m telescope being operated

• Base Facility at SPdA to inaugurated in Nov. 2014

• TAO telescope (6.5m) in construction
  Most of large components built
  Two instruments to be commissioned at Subaru
  TAO first Light 2018?