Poster No. 101

Development of a Multi-band Imager Part for TAO Optical Instrument

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Abstract

Optical follow-up observations for newly discovered transients are essential to understanding their nature. A typical spatial resolution of optical observations is an order of arcsecond, so it effectively identifies transient sources reported by other messengers. We are developing a new optical instrument for the TAO 6.5 m telescope in Chile and plan to construct a multi-band imager part first. Its field of view will be a circle of 4-arcminute diameter, and it can obtain 3-band images simultaneously. The detectors will be CMOS sensors, enabling us to perform high-speed observations up to 100 frames per second. We have started fabricating the imager part, and the lens system will be delivered next March. The instrument will also acquire a spectroscopy part, although its specifications are to be determined.

1. Introduction

- Follow-up observations by multi-messengers influence the understanding of newly discovered transients because each messenger reveals a different aspect.
- We will carry out follow-up observations in optical with new instrument.

IceCube (NSF)

LIGO (Caltech/MIT)

Features of optical observations

- Good spatial resolution, ordered in 1'', helps us to identify the newly discovered transient sources.
- The optical instrument is easy to produce and operate.
- Optical light is a tracer of ~10^4 K materials and ionized gas.

- The time resolution of standard CCDs, the detector used frequently, is lower than 1 frame per second.
- Too many sources, including transients and non-transients, in a field of view occasionally prevent finding the target.
- Optical light is severely affected by dust extinction.

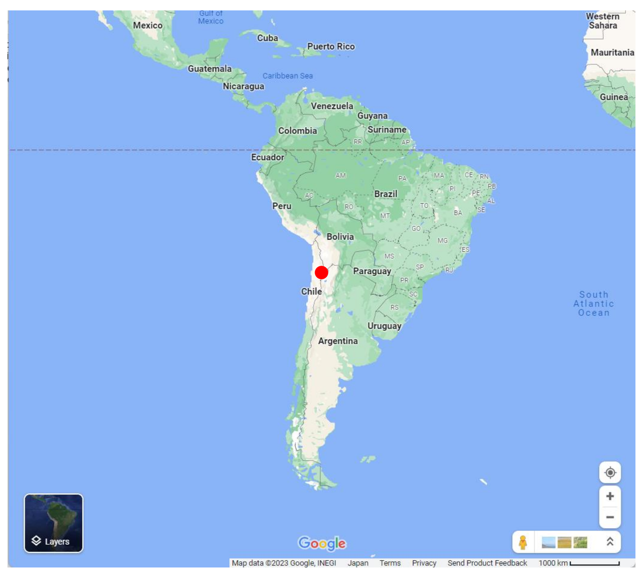
2. TAO 6.5-m Telescope

- TAO stands for the Univ. of Tokyo Atacama Observatory.

- We are constructing a 6.5-m telescope on the summit of Cerro Chajnantor at Atacama in northern Chile.
  - A large aperture provides deep images and spectra in a short time.
  - Good seeing (spatial resolution), ~0.7''.
  - At the highest altitude observatory, 5640 m, which has high transparency even in mid-infrared wavelengths.
  - TAO is in the Southern Hemisphere, 23 degrees south and can access the southern sky. We will cover all the sky with TAO, Subaru, and other Japanese telescopes.
  - TAO telescope is a university telescope, so the telescope schedule will be flexible and accept Time of Opportunity (ToO) observations.

- NIR and MIR instruments, NICE, SWIMS, and MIMIZUKU, will be connected to the telescope, but an optical instrument has yet to be constructed.

We are developing a new optical instrument for the TAO telescope.



Location of TAO site (red circle)

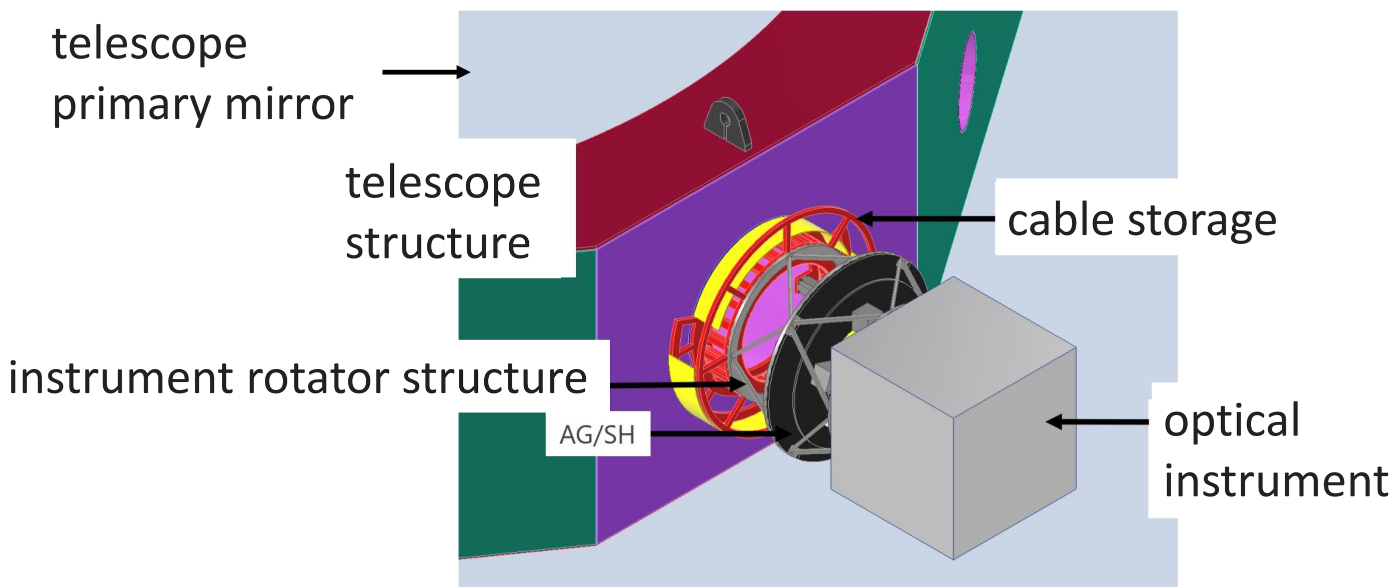
Telescope enclosure with the coating chamber install work (TAO Project, Univ. of Tokyo)

Base ring for the telescope (TAO Project, Univ. of Tokyo)

3. Instrument rotator

- The optical instrument will be mounted to a bent-Cassegrain focus of the telescope via an instrument rotator.
- The FoV for observation instruments will be ~10-arcminute diameter.
- The instrument rotator will acquire a Shack-Hartmann (SH) sensor for monitoring the telescope mirror and the auto guider (AG) system for correcting the telescope pointing error by monitoring stars. (lower figure)

Telescope assembled temporarily in Japan (TAO Project, Univ. of Tokyo)

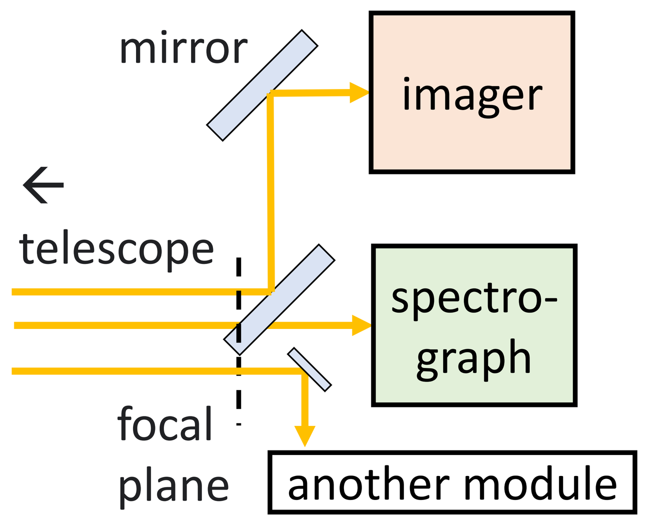


Rough design of the optical instrument and the instrument rotator mounted on the telescope.

4. Instrument

Overall

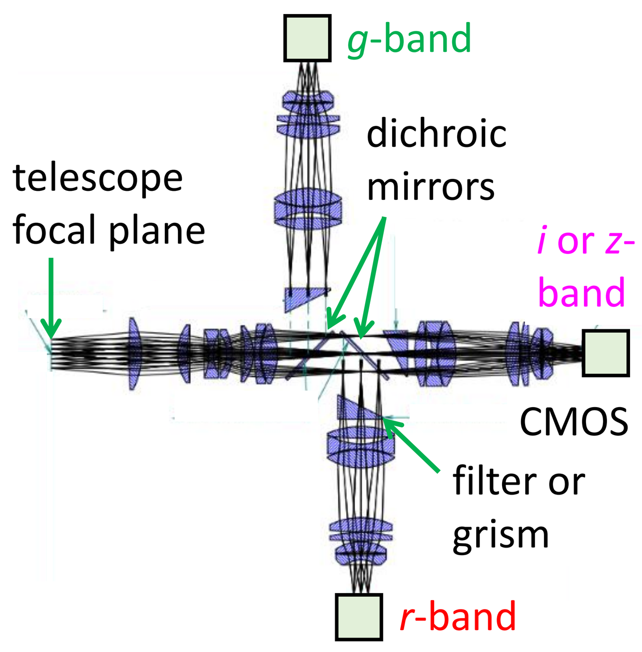
- The instrument will acquire an optical imager and spectrograph as modules.
- FoV of each module is separated as space telescopes.
- The possibility of other modules is under discussion.



Conceptual diagram of the optical instrument

Imager

- Basic design is the same as the Seimei Telescope / TriCCS.
- The imager can obtain 3 band images simultaneously with using dichroic mirrors.
- Detectors: CMOS sensors, which can obtain images in up to ~100 fps.
- FoV: ~4-arcminute diameter
- Pixel scale: ~0.15 arcsec / pixel
- Optics design will be completed soon. We will receive lenses in March 2025.

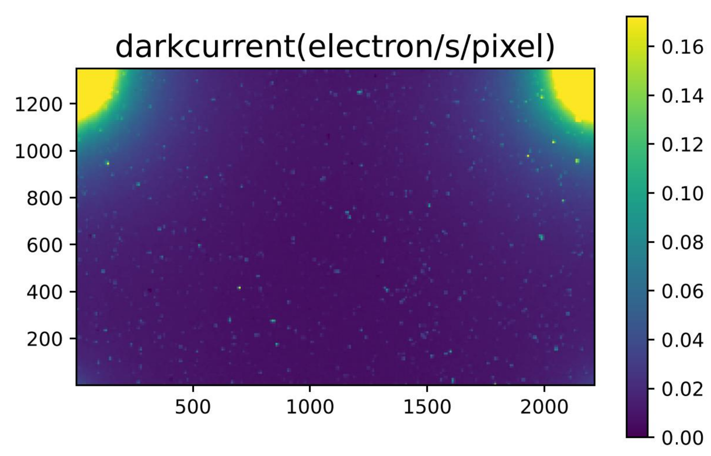


Seimei/TriCCS optics: a good reference for the imager module

Spectrograph (TBD)

- Light to the spectrograph passes through a slit on the mirror at the telescope focal plane.
- Wavelength: ~400-1000 nm
- Spectral resolution: ~700
- It may acquire an integral field unit (IFU).

CMOS sensor for the instrument



Dark current map of the CMOS sensor (preliminary)