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Resurrection of Subaru+COMICS for the study of solar system objects with ground-based mid-infrared observations

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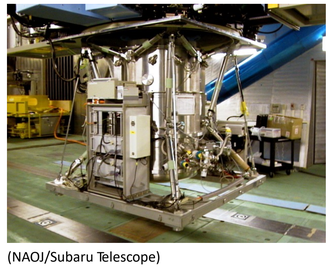
Mid-infrared observations effectively capture thermal radiation from dust in space and emission bands of organic molecules. They are an essential wavelength domain for observing solar-system objects of ~30-300K. However, mid-infrared instruments currently available on ground-based telescopes are very limited, making regular observations practically impossible. The Cooled Mid-Infrared Camera and Spectrometer (COMICS) had been installed on the Subaru Telescope for nearly 20 years and has achieved interesting and important results, but it was decommissioned in 2020. JWST has started observing in the mid-infrared with MIRI. However, the observation with JWST is highly competitive, and the visibilities of the solar system moving objects are highly constrained by their solar elongation angles. It will still take at least several years for TAO/MIMIZUKU to be fully operational. Thus, we have started a project to resurrect COMICS. It is the most reliable and efficient approach for the asteroid/comet study with mid-infrared observations. COMICS provides imaging and spectroscopic capabilities from 7.5-25 micron (N- and Q-bands). As a first step, we will restart imaging and low-resolution spectroscopy in the N-band.

Cooled Mid-Infrared Camera and Spectrometer (COMICS)



(NAOJ/Subaru Telescope)

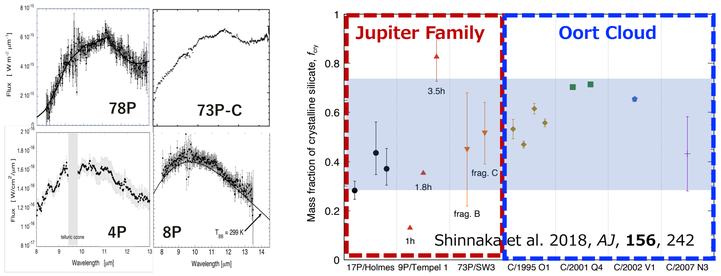
- **Subaru Telescope + COMICS**
  - **7.5 – 25 μm (N and Q-bands)**
  - 320x240 pix Si:As detecters x 6
  - Cassegrain focus
- **Imaging (42" x 32")**
  - N-band: 6 continuum + 5 narrow filters
  - Q-band: 4 filters
- **Spectroscopy (40"-length slit)**
  - N-band low resolution (R~250)
  - N- & Q-band mid resolution
  - N-band high resolution

COMICS had already been in operation for about **20 years** at Subaru telescope **until S20B**. Many scientific results for solar system objects have been acquired with COMICS, but COMICS was decommissioned.

Solar system sciences with COMICS

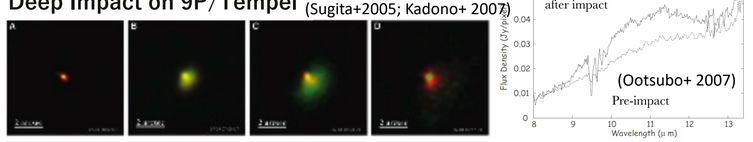
➢ **Crystalline Silicate** grains in Comets

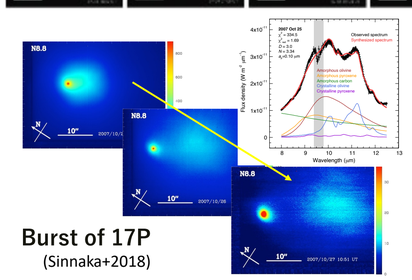
- We observed ~10 short period and ~15 long period comets in 2003—2020 and detected crystalline silicate in various comets. **Crystalline fraction** of silicate in comet (~ 30-70%) is estimated.

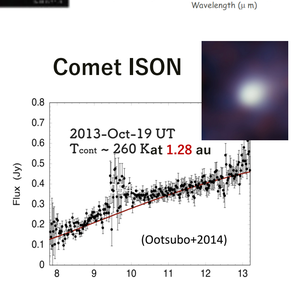


- COMICS observations captured special events (**impact, burst, vanish**, etc.) and grain properties for various comets.

Deep Impact on 9P/Tempel (Sugita+2005; Kadono+ 2007)

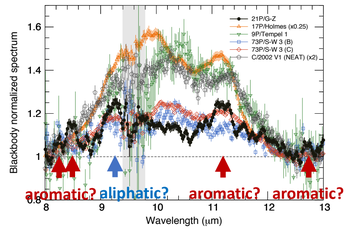






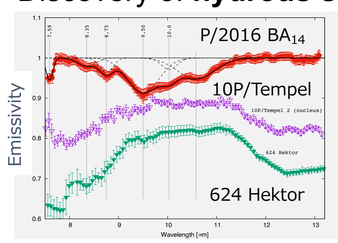
References:
[1] Sugita et al., Science 310, 274 (2005); [2] Kadono et al., ApJ 661, L89 (2007); [3] Ootsubo et al., ESA Publ SP-643, 45 (2007)); [4] Shinnaka et al., AJ 156, 242 (2018); [5] Ootsubo et al., Icarus 338, 113450 (2020); [6] Ootsubo et al., Icarus 363, 114425 (2021)

➢ Discovery of **complex organics** in comet



- COMICS detected the UIR features in the spectrum of comet 21P, which can be attributed to the complex organics like aromatic hydrocarbons. (Ootsubo+ 2020)

➢ Discovery of **hydrous silicates** on the comet nucleus



- COMICS observed the thermal emission from the comet nucleus of C/2014 BA14. There are features from the silicate that resemble large grains of phyllosilicates. (Ootsubo+ 2021)

Expected future results

COMICS is expected to unravel **the thermal and dynamical evolution of comets/asteroids**.

- Crystalline / amorphous silicate dust
- Hydration of dust in the comets/asteroids

Mid-IR observations are also essential to study and select **the target objects for future asteroid/comet exploration**.

Resurrection of COMICS and future plans

- **The reason why we want COMICS**
  - ➢ There are notable MIR spectral features for crystalline and hydrous silicate. COMICS is still a powerful tool for this study.
  - ➢ JWST has started the observations in the mid-IR. However, JWST observation is highly competitive and strict for the moving objects with the limitation of the solar elongation angle.

  To restart the COMICS is the most reliable and efficient for the asteroid/comet study in the mid-IR !!!
- **Future plan**
  - ➢ We have secured a 3-year budget (until 2026/3).
  - ➢ Since COMICS has not been in operation for three years, we need to check the status of COMICS before the observations. We want to start these works as soon as possible.

We welcome new collaborative opportunities with and/or contributions **from anyone in the wider astronomical community, not just those interested in the solar system science.**