The SPICA Coronagraph Instrument (SCI)

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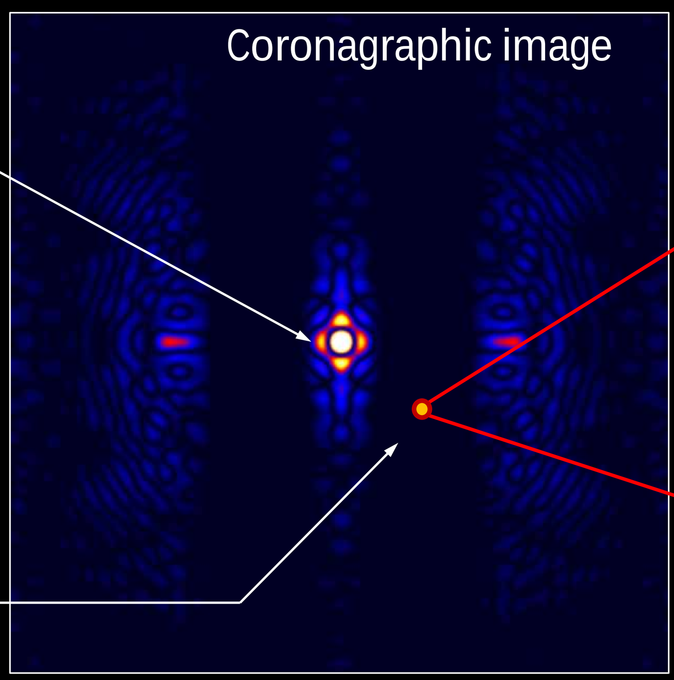
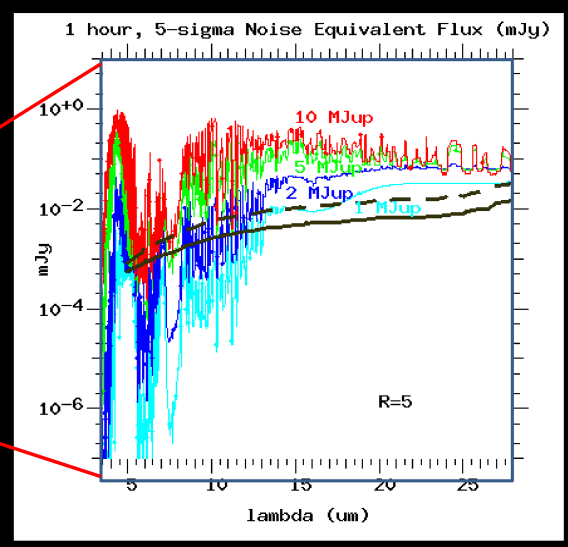
Space Infrared Telescope for Cosmology and Astrophysics (SPICA) is a next-generation infrared astronomy mission with cooled (<6K) large (3-m class) telescope. The SPICA mission provides us with a unique opportunity to make high dynamic-range observations because of its large telescope aperture, high stability, and the capability for making infrared observations from deep space. The SCI is a high dynamic-range instrument proposed for SPICA in order to pioneer small-scale structures surrounding bright stars and galactic nuclei, which specifically include important issues of space science; extra-solar planets, proto-planetary and debris disks, and dusty tori of AGN.

Science with the SCI: we can see it!



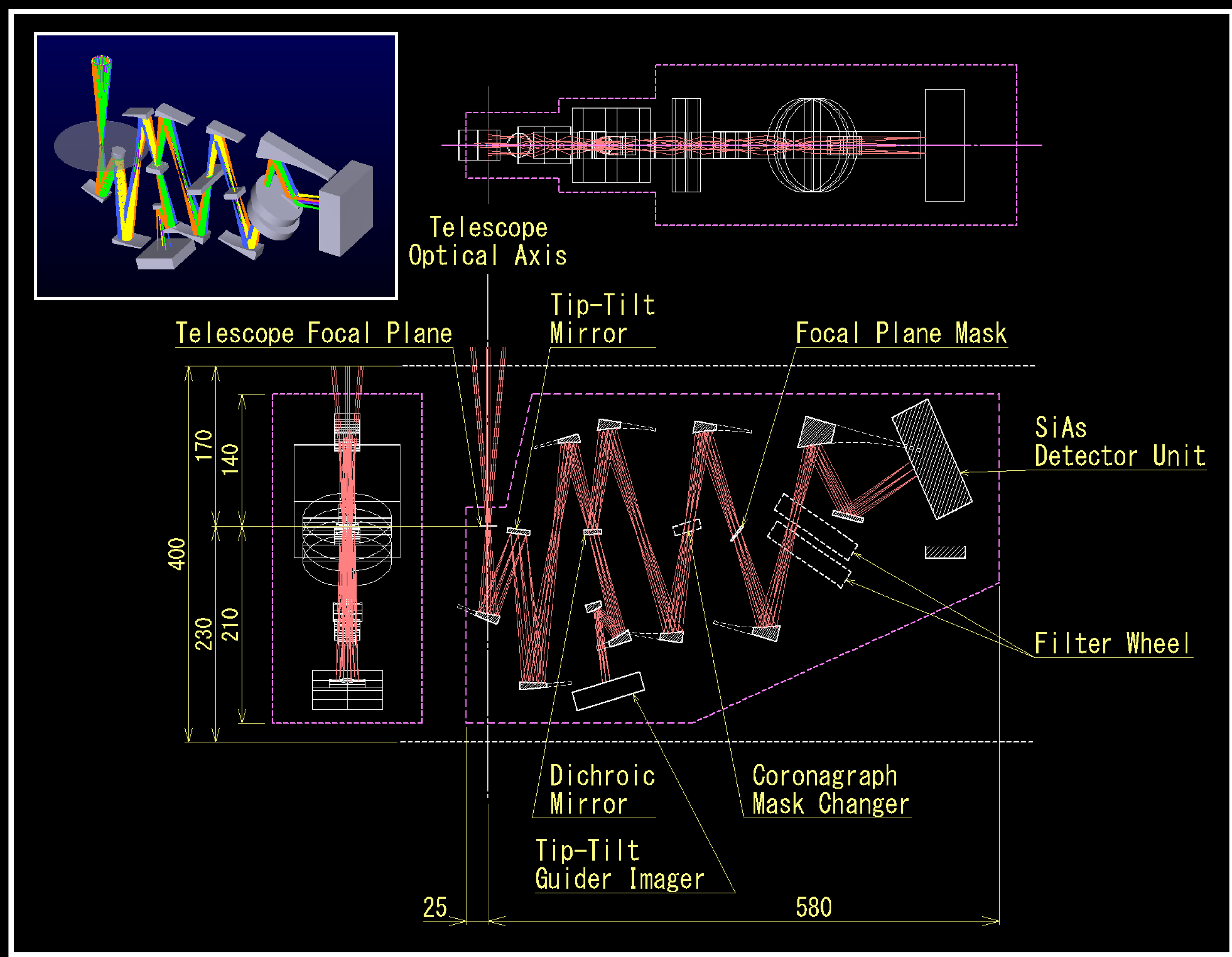
Coronagraphic spectroscopy



Simulated spectrum of Jovian exoplanets (Burrows et al. 2003) and the sensitivity of the SCI (Kotani 2012)

Major science cases	Mode*1	λ (mm)	R*2
• Planet formation process revealed by thermal history	S	4 – 12	200
• H_2 and He in the atmosphere of Jovian exoplanets	S	10 – 28	50
• Atmospheric structure of Jovian exoplanets	S	4 – 20	200
• Constraining heavy element abundance	S	4 – 20	200
• Direct detection and characterization of icy giants	I	10 – 28	2
• Solid matter in planet-forming systems	S	6 – 28	200
• Formation and supply of solid matter from old stars to the ISM	S	6 – 28	200
	I	6 – 28	2
• Galactic nuclei	S	6 – 28	200

*1: S and I mean spectroscopy and imaging, respectively.
*2: R is spectral resolving power.



SPICA Mission

SPICA is the next-generation infrared astronomy mission. With its cooled (<6K) large (3-m class) telescope, SPICA will be able to achieve superior sensitivity and high spatial resolution.

SPICA Specifications

- Mission Goals: Revealing the origins of planets and galaxies through mid-to far-infrared observations
- Telescope dia. 3-m class (3.2m in the current design)
- Telescope temp. <6K
- Core Wavelength: 5-210µm
- Total mass 3.7t
- Orbit: Halo orbit around libration point S-E L2
- Launch : FY2022

SCI Specifications

- Observation mode: Coronagraphic spectroscopy, Coronagraphic imaging
- Wavelength coverage: 4 – 28 µm
- Coronagraph method: Binary pupil mask
- Inner Working Angle / Outer Working Angle:

	Mask-A	Mask-B	Mask-C
Inner Working Angle	3.3 λ/D	1.7 λ/D	4.4 λ/D
Outer Working Angle	12 λ/D	6.5 λ/D	32 λ/D

- Spectral Resolution: 200 (spectroscopy mode)
- Filters and Grisms: Installed in the tandem -series wheels
- Field of View (FoV): 1'×1'
- Detector: 1k×1k Si:As array (Raytheon)

- Sensitivity

(5σ, 1h integration, w/o speckle noise, low zodi.)

Case of R = 5: (mJy)	Case of R = 200: (mJy)
5×10^{-4} (λ = 5 µm)	2×10^{-2} (λ = 5 µm)
2×10^{-3} (λ = 10 µm)	3×10^{-2} (λ = 10 µm)
5×10^{-3} (λ = 20 µm)	4×10^{-2} (λ = 20 µm)

- Contrast

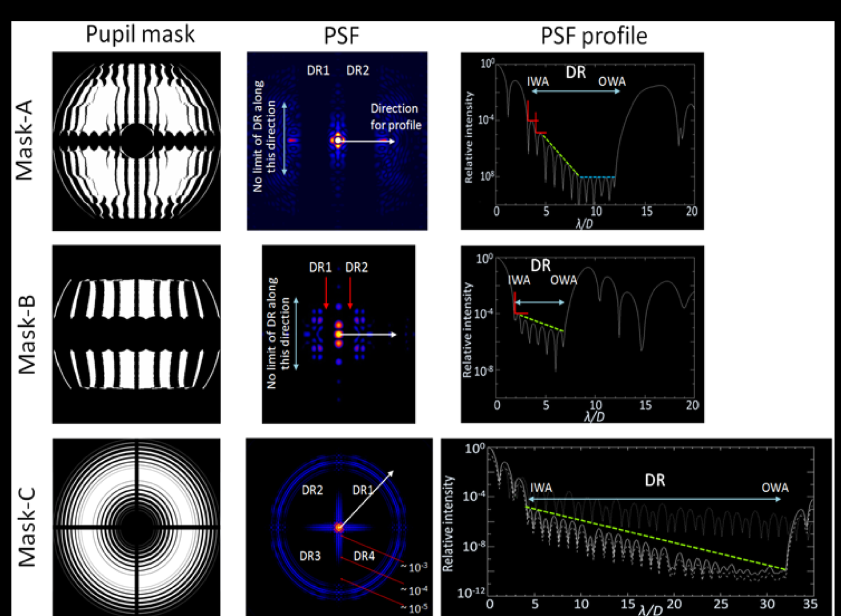
(5σ, 1h integration, K5V primary star)

Limit with PSF subtraction	Raw contrast limit
1.4×10^{-6} (λ = 5 µm)	3.6×10^{-4} (λ = 5 µm)
2.8×10^{-6} (λ = 10 µm)	1.6×10^{-4} (λ = 10 µm)
3.2×10^{-5} (λ = 20 µm)	1.6×10^{-4} (λ = 20 µm)

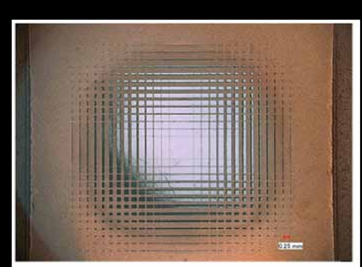
Critical technologies:

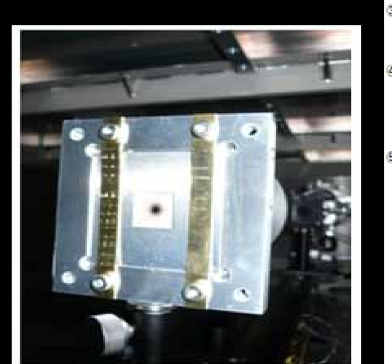
(2) fine off-axis metal-mirror structure and (3) the tip-tilt mirror system are other critical technologies. (see Oseki et al. (2013) and Mitani et al. (2013) presented in this symposium.

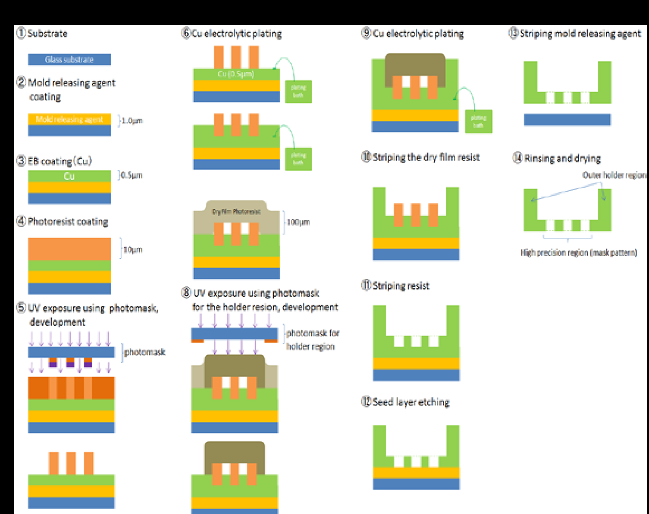
(1) binary pupil mask coronagraph



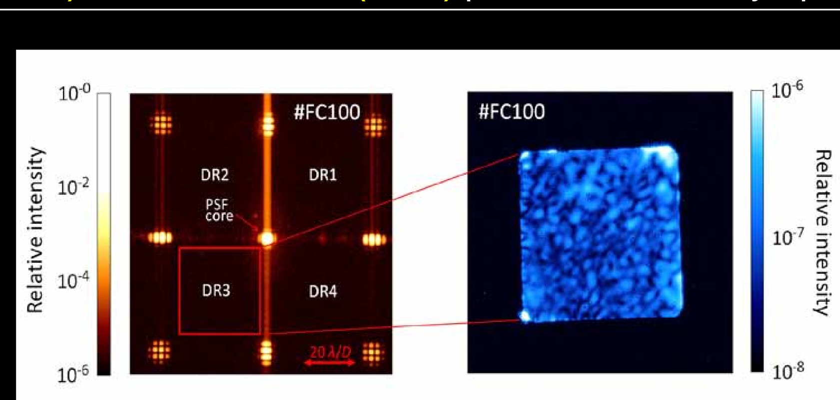
Mask design applicable for the obscured pupil.

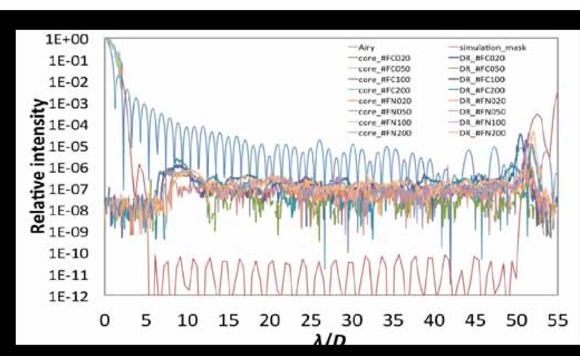






Left-top: fabricated free-standing mask (classical checkerboard design). Left-bottom: the free-standing mask installed in a testbed. Right: fabrication process of the free-standing mask (Haze 2012, Enya et al. 2012).





Top: coronagraphic images obtained by laboratory test. Bottom: profiles of the coronagraphic images. Very high contrast (~10^{-7}) was achieved.