SPICA
Space Infrared Telescope for Cosmology and Astrophysics

JAXA
Japan Aerospace Exploration Agency

Overview of SPICA Coronagraph Instrument (SCI)

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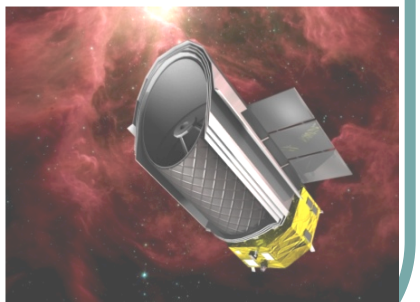


Our Science Cases with SCI: Summary

	Science case	λ (μm)	Obs. mode	Category
(1)	Planet formation process revealed by thermal history	4 – 12	Spectroscopy	Exoplanet
(2)	Atmospheric structure of Jovian exoplanets	4 – 20	Spectroscopy	Exoplanet
(3)	Constraining heavy element abundance of Jovian exoplanets	4 – 20	Spectroscopy	Exoplanet
(4)	Solid matter in planet-forming systems	6 – 28	Spectroscopy	ISM
(5)	Formation and supply of solid matter from old stars to the ISM	6 – 28	Spectroscopy, Imaging	ISM
(6)	Fueling nearby AGN through dusty torus	6 – 28	Spectroscopy	AGN
(7)	Interaction between relativistic jets and dust	6 – 28	Spectroscopy	AGN
(8)	H_2 and He in the atmosphere of Jovian exoplanets	10 – 28	Spectroscopy	Exoplanet
(9)	Direct detection and characterization of icy giant exopalnets	10 – 28	Imaging	Exoplanet
(10)	Co-evolution of AGNs and host galaxies	12 – 28	Spectroscopy	AGN

This presentation features exoplanets science cases, (1) (8) and (9).

Planet Formation History revealed by thermal history (2/2)

- Science Requirement
  - Wavelength range: 4 – 12 μm
    to cover CO (4.7 μm), CH_4 (6.5 μm, 7.7 μm), NH_3 (6.1 μm, 10.5 μm), H_2O 6.2μm
  - Spectral Resolving Power: R=200
    - to characterize the temperature of Jovian exoplanets' atmosphere
  - Sensitivity:
    - < 3×10^{-5} Jy @ λ = 4 μm, < 5×10^{-5} Jy @ λ = 12 μm to detect ~<1Gyr old 1 – 10 M_J Jovian exoplanets
  - Coronagraphic requirement:
    IWA < 3 λ/D, OWA > 20 λ/D
    * IWA: 7.5 AU @ d=10 pc, λ = 4 μm, 22.5 AU @ d=10pc, λ = 12 μm
    * OWA: 50 AU @ d=10pc, λ = 4 μm, 150 AU @ d=10pc, λ = 12 μm
    Contrast : $<10^{-5}$ @ 4um. $<10^{-4}$ @12um after PSF subtraction

H_2 and He in the atmosphere of Jovian exoplanets (2/2)

- Science Requirement
  - Wavelength range: 10 – 28 μm

    to cover broad CIA features of H_2 - H_2 and H_2 - He
  - Spectral Resolving Power: R=20 – 50

    to characterize broad CIA features of H_2 - H_2 and H_2 - He
  - Sensitivity:

    $< 5 \times 10^{-5}$ Jy @ $\lambda = 10$ μm, $< 1 \times 10^{-4}$ Jy @ $\lambda = 28$ μm
    for 1Myr – Gyr old, 1 – 10 M_J Jovian exoplanets
  - Coronagraphic requirement:

    IWA < 3 λ/D, OWA > 20 λ/D

    Contrast : $< 2\times10^{-5}$ @ 10um. $< 510^{-4}$ @12um after PSF subtraction

Direct detection and characterization of icy giant exoplanets (2/2)

- Science Requirement
  - Wavelength range: 10 – 28 μm

    to cover cover thermal IR emission from cool exoplanets
  - Spectral Resolving Power: R=2 - 5

    to detect by the imaging mode.
  - Sensitivity:

    $< 5 \times 10^{-6}$ Jy @ $\lambda = 10$ μm, $< 1 \times 10^{-5}$ Jy @ $\lambda = 28$ μm

    for 1Myr – Gyr old, 1 – 10 M_J Jovian exoplanets
  - Coronagraphic requirement:

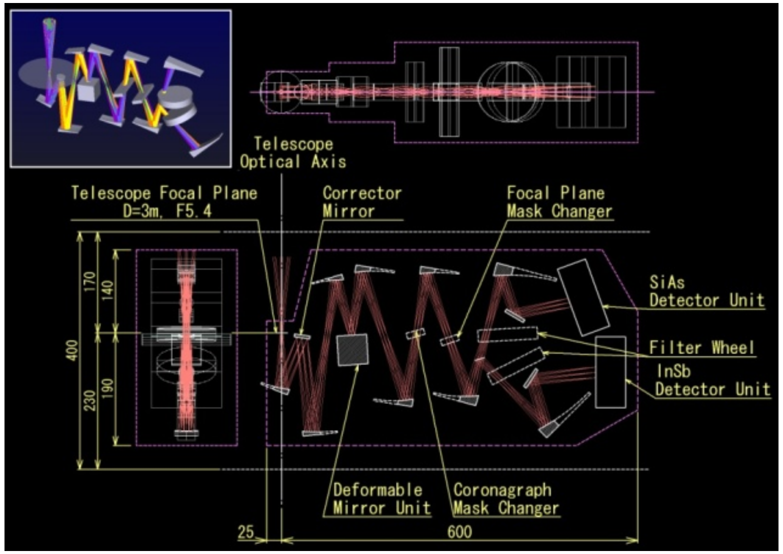
    IWA < 3 λ/D, OWA > 20 λ/D

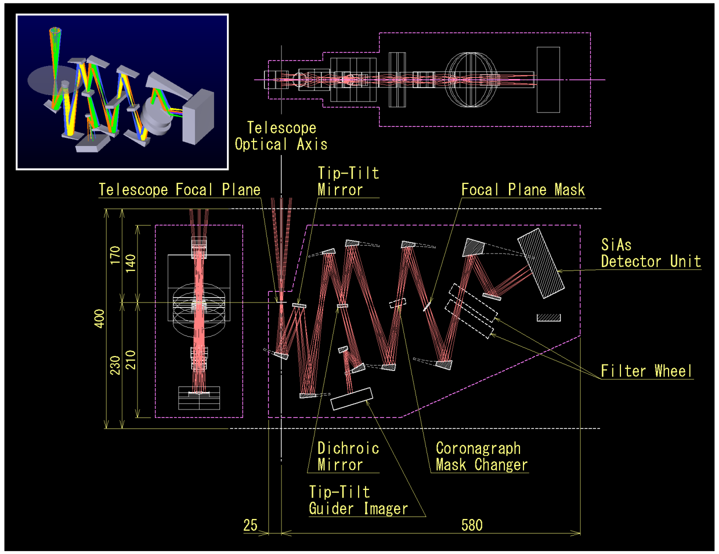
    Contrast : $<10^{-4}$ @ 10um. $<10^{-4}$ @28um after PSF subtraction

Instrument Capabilities

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 3.3 λ/D 1.7 λ/D 4.4 λ/D 12 λ/D 6.5 λ/D 32 λ/D
Spectral Resolution	200 (spectroscopy mode)
Filters and Grisms	Installed in the tandem-series wheels Wheel 1: Band-pass filters or ND or Blank Wheel 2: Grism or ND or Blank
Field of View (FoV)	1' × 1' at the center of the FoV of the telescope
Detector	1k × 1k Si:As array (Raytheon)
Sensitivity	Example: 5σ, 1h integration, w/o speckle noise, low zodi. case. 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	Example: 5σ, 1h integration, K5V primary star, 3.3 - 12 λ/D average. 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)

SCI Hardware Design





- Optical configuration optimized
- Mask design has been studied extensively
- Simplifications!
  - No short channel
  - No deformable mirror (thanks to study of wavefront error, telescope design, and scientific requirement: contrast: $10^{-6} \rightarrow 10^{-4}$)

→ Technical feasibility much improved