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SPICA Mid-Infrared Instrument (SMI)

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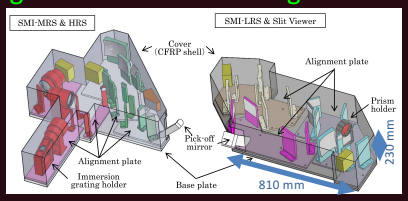
SPICA Mid-infrared Instrument (SMI) is one of the two focal-plane science instruments planned for SPICA. SMI covers a wavelength range of 12–36 μm with the four channels: low-resolution spectroscopy (LR; 17–36 μm), mid-resolution spectroscopy (MR; 18–36 μm), high-resolution spectroscopy (HR; 12–18 μm), and broad-band camera (CAM at 34 μm, slit viewer for LR).

SMI specifications

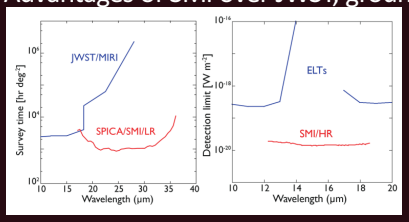
- LR-CAM: prism (4 slits, 10′ long, R~100), with a 10′x12′ slit viewer. High-speed dust-band mapping.
- MR: Echelle grating with a cross-disperser (1′ long, R~2000), combined with a beam-steering mirror. High-sensitivity multi-purpose spectral mapping.
- HR: CdZnTe immersion grating (R~30000), realizing compact optics. High-resolution molecular-gas spectroscopy.

Optical & Mechanical design



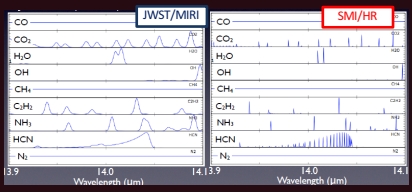
Parameter	LR	CAM (slit viewer for LR)	MR	HR
Band center - μm	27	34	27	15
Wavelength - μm	17–36	34	18–36	12–18
Spectral resolution *R*	50–120	5	1300–2300	28000
Field of view	600" x 3.7" 4 slits	600" x 720"	60" x 3.7" 1 slit	4"x1.7" 1 slit
Band centre FWHM	2.7"	3.5"	2.7"	2"
Pixel scale	0.7" x 0.7"	0.7" x 0.7"	0.7"	0.5"
Detector 1K x 1K	Si:Sb	Si:Sb	Si:Sb	Si:As
Point source sensitivity				
Continuum - Jy	50	13	400	1500
Line - 10^{-20} W/m²	8		4	1.5
Survey speed - arcmin²/hr	~16 (100 μJy @ 30 μm)	~5900 (100 μJy @ 30 μm)	~1.5 (3×10^{-19} W/m² @ 28 μm)	
Diffuse source sensitivity (5σ, 1 hr)				
Continuum - MJy/sr	0.05	0.05		
Line - 10^{-10} W/m²/sr			1	1.5
Saturation limit - Jy	~20	~1	~1000	~20000

Advantages of SMI over JWST, ground-based facilities



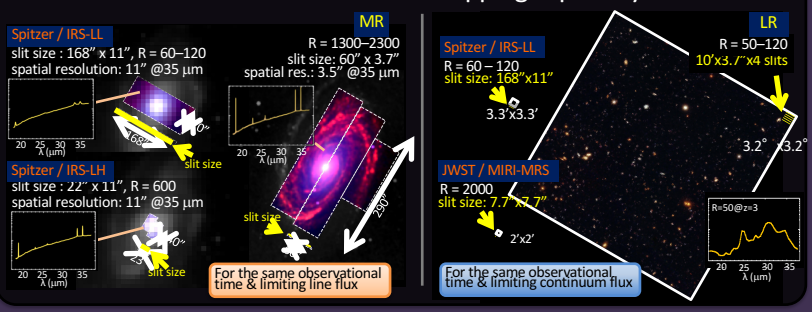
(Left) Survey speed of LR, time to reach 10^{-19} W/m² for a 10′x10′ area.

(Right) Line sensitivity of HR, compared to ground-based facilities.



The spectral resolution of HR, as compared to JWST/MIRI (R~3000), is important to mitigate the line blending.

Demonstration of SMI mapping capability

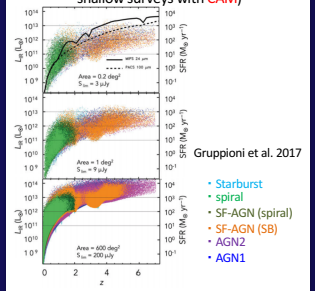


SMI key sciences

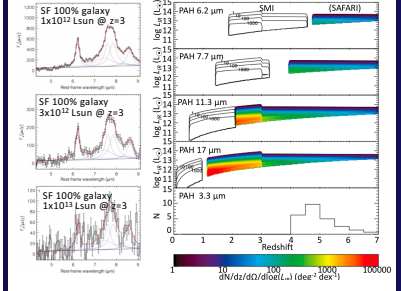
LR-CAM surveys will detect organic matters (PAH) and minerals in high-z galaxies as well as in planet-forming disks, while MR will characterize them in detail. HR will characterize molecular gases and resolve their velocities in planet-forming disks.

Evolution of galaxies

L_{IR}-*z* dist. of detectable galaxies
(0.2 deg² ultra-deep, 1 deg² deep, 600 deg² shallow surveys with CAM)



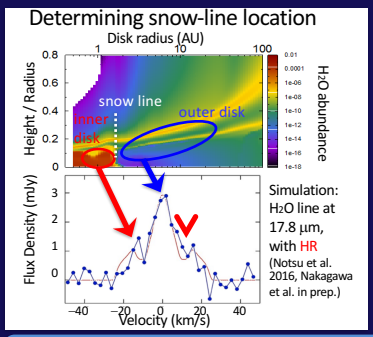
L_{IR}-*z* dist. of detectable PAH galaxies
(10 deg² with 600 hrs with LR) Kaneda et al. 2017



Wide-area spectroscopic survey with LR
⇒ Detection of ~50000 PAH galaxies at z up to 5
⇒ Diagnosis of PAH galaxies, AGNs & follow-ups for MR and SAFARI
⇒ Characterization of star-forming galaxies & AGNs in high-z Universe
Imaging survey with CAM ⇒ star-formation history up to z = 7

Protoplanetary/debris disks to our Solar system

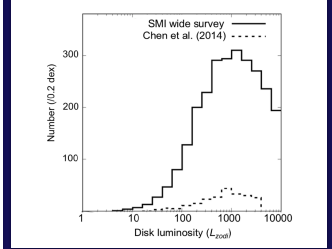
Determining snow-line location



Simulation: H_2O line at 17.8 μm, with HR (Notsu et al. 2016, Nakagawa et al. in prep.)

Detecting exo-zodiacal clouds

Expected number of disks by the SMI cosmological surveys with LR (Kaneda et al. 2017)



High-resolution spectroscopy with HR
⇒ Planet formation and evolution, tracing the gas dispersal process, and identifying the location of the snow-line.
Wide-area spectroscopic survey with LR
⇒ Detection of debris disks down to levels close to our Solar system.

Critical technologies

- Immersion Grating: machining & material selection established, reflection coating under development. Cryogenic performance will be measured.
- Detector: thermal design for annealing tested in CC-CTP. Current spec. of Si:Sb confirmed. Collaboration with Taiwan (ASIAA) is re-started.

Current status

- Review by Science Instrument Advisory Board (22 Aug., 21-22 Dec.)
- 3 SMI white papers (Gruppioni et al. 2017, Kaneda et al. 2017, Nakagawa et al. in prep.)
- Re-analysis of the SMI/LR-CAM optics to make space for SAFARI, to install a cold shutter.
- Observation and calibration strategies.
- Detector-related activity, Developing immersion grating.