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MID INFRARED SPECTROMETER ONBOARD SPICA

Hirokazu Kataza[1] , Itsuki Sakon[2] and SPICA pre-project team

[1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, Japan

[2]Department of Astronomy, School of Science, University of Tokyo, 7-3-1 Ho ngo, Bunkyo-ku, Tokyo 113-0033, Japan

Abstract

Mid-infrared spectroscopic capabilities, conceptual design, and estimated performances are described. We have low resolution spectroscopic capability as part of the wide field camera, medium resolution spectroscopic capability with image slicer based IFU, and high resolution spectroscopic capability based on immersion grating. Estimated noise equivalent flux for a point source with medium resolution is 150 μ Jy / 700 μ Jy for 10 to 19 μm / 19 to 35 μm respectively.

Key words: Missions: SPICA mid-infrared spectroscopy

1. Introduction

Key science objectives for spectroscopic capabilities in the mid-infrared wavelength region in the SPICA mission consist of three major issues. i) Formation and evolution of planetary systems: Detect gas contents of protoplanetary disks, resolve their line profiles according to the orbital motion and reveal the structure of the disks. From the dust features, reveal mineralogy of protoplanetary and debris disks. ii) Life cycle of material in the Galaxy: Detect molecular absorption lines of interstellar medium and reveal chemical evolution of gas and dust in the Galaxy. iii)Formation and evolution of galaxies: Give a diagnosis energy source of ULIRGs and reveal star-formation history of galaxies.

These science objectives require spectroscopic capabilities in the mid-infrared wavelength region. Here we present the current list of the specifications, the conceptual design of the high and medium resolution spectrometers, and an estimate of their performance.

2. Mid-infrared spectroscopic capabilities

Table 1 lists the spectroscopic capabilities in the mid-infrared wavelength region. Wide field camera, named MIRACLE, has a low resolution spectroscopic mode with long slit, multiple slits, and slitless way. MIRMES (Mid-Infrared Medium-Resolution Echelle Spectrometer) has wavelength resolving power around a thousand and has IFU (integral filed unit) by image slicer. MIRHES (Mid-Infrared High-Resolution Echelle Spectrometer) (Kobahashi et al., 2008) has wavelength resolving power around thirty thousand using immersion grating.

Table 1. Mid-infrared spectroscopic capabilities.

		Wavelength coverage [μm]	$\Delta R/R$	FOV [arcsec]
MIRACLE	Short	5 ∼ 27	∼60 – 200	360×360
	Long	20 ∼ 38	∼60 – 200	360×360
MIRMES	Short	10.28∼19.28	∼1500	3.7×5.55
	Long	19.22∼36.04	∼900	7,2×10.8
MIRHES	Short	4 ∼ 8	∼30000	3.5×0.72
	Long	12∼18	∼30000	6.0×1.2

3. MIRMES

Figure 1 shows the concept of MIRMES. It consists of two arms that cover the short wavelength region and the long wavelength region. Both arms share the same field of view (more precisely, the fov of the short arm is part of that of the long arm) and we can observe the same region on the sky with both channels at the same time.

Arm S/L has resolving power around 1500/900 respectively. Image slicer for arm S has 5 rows of 3.7 arcsec length and 1.11 arcsec width. Total field of view for arm S is 3.7 × 5.55 arcsec. We are developing a prototype spectrometer (Okamoto et al., 2008) with IFU (Mitsui et al., 2008). For arm L, slicer has 3 rows of 7.6 arcsec length and 3.6 arcsec width and total field of view is 7.7 × 10.8 arcsec. For arm S/L, Si:As 1024 × 1024 detector / Si:Sb 1024 × 1024 detector is employed respectively.

Estimated performances of MIRMES are as follows. Figure 2 and 3 show the noise equivalent flux for a diffuse source and for a point source. In both cases the noise sources are detector dark current, background zodiacal light, and read out noise of the detector in Figure 4.

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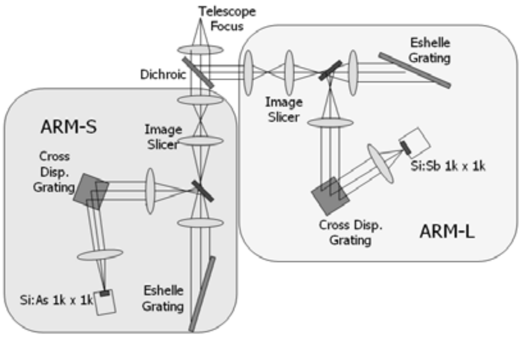

Figure 1. Concept of MIRMES.

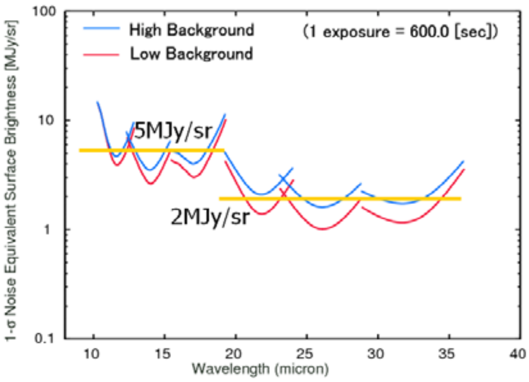

Figure 2. Noise equivalent flux for a diffuse source. Exposure time is normalized by 274.3 sec. Frame integration time is assumed 600 sec.

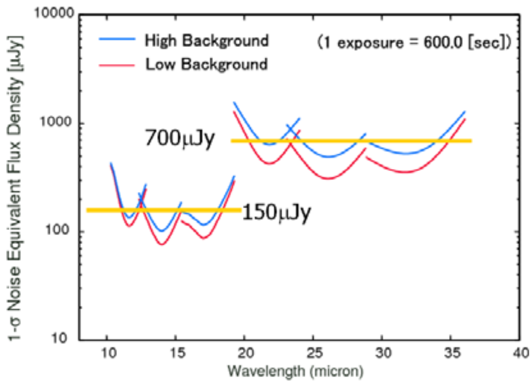

Figure 3. Noise equivalent flux for a point source. Exposure time is normalized by 274.3 sec. Frame integration time is assumed 600 sec.

3.1. MIRHES

MIRHES is a high dispersion spectrometer base on immersion grating. It has two channels for short wavelength region and long wavelength region. These two channels are completely independent from each other. Figure 5 shows the schematic optical layout of channel S. Layout of channel L is almost the same as this.

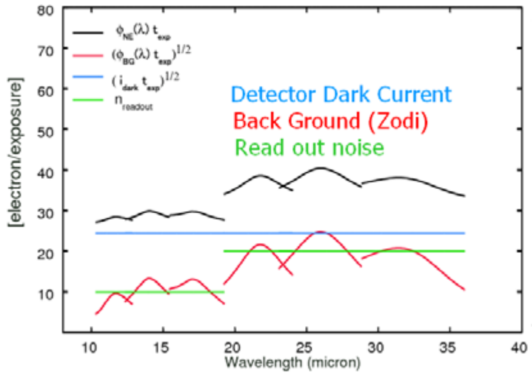

Figure 4. Assumed noise sources for MIRMES.

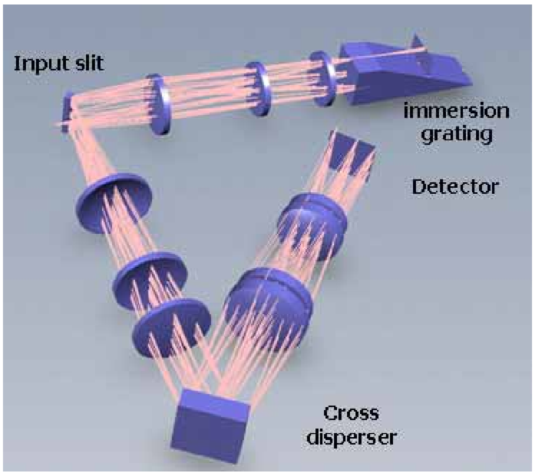

Figure 5. Optical layout of MIRHES short channel.

Channels S/L use ZeSe / KRS5 immersion grating respectively. Polycrystalline ZnSe with refractive index 1.5 is our first choice for the S channel because it is known to have good optical homogeneity. Fly-cutting technique is established to fabricate a large pitch immersion grating (Ikeda et al., 2008). Surface roughness of 5 nm (rms) is achieved while required value is 15 nm. Achieved grating efficiency is larger than 70–80%. We are temporarily considering KRS-5 as a candidate material for the immersion grating for the L channel. Fabrication technique is not established for this material with required size. And KRS-5 is to some extent, unstable material against thermal shock. We may have to consider another material for the immersion grating in L channel.

References

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