Spectrometer Point Source AOT and Data Products

Prepared by the SPIRE ICC

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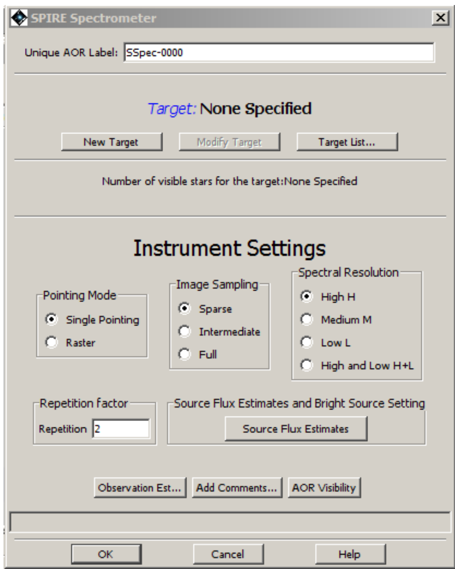
Introduction

The SPIRE spectrometer point source/sparse map AOT has been released for scheduling for observations of point sources. In HSpot, the following options are included in the release:



Pointing Mode:	"Single Pointing"
Image Sampling:	"Sparse"
Spectral Resolution:	"High H"
	"Low L"
	"High and Low H+L"

The release does not include raster or jiggle observations. Only the central detector pair (SSWD4/SLWC3) is currently correctly calibrated. The AOT is released for nominal detector bias settings (optimised for faint to moderately bright astronomical sources).

Some notes and advice on the applicability of the release:

- The calibrations of the wavelength and flux density scales are currently valid for point sources only.
- The instrument is currently operated in a way to optimize the dynamic range for the central detectors only and off-centre detectors may suffer from clipping, leading to reduced accuracy and lower signal-to-noise ratio in the continuum. Therefore, if an observation is designed to detect emission in other detectors across the array, it is better to wait before scheduling it. (Optimization of the operating parameters of the SPIRE spectrometer for mapping, including sparse mapping, is still to be completed.)
- The current settings have been shown to work well when observing Neptune. Sources brighter than this cannot be guaranteed to remain within the dynamic range of the central detectors which could lead to reduced flux accuracy and sub-optimal signal-to-noise. Our best estimate of what constitutes a source that is too bright to schedule at the present time is based on the brightness of Neptune on OD189: SLW: 50 Jy at 24 cm^{-1} (417 µm) and SSW: 150 Jy at 42 cm^{-1} (238 µm).
- Medium spectral resolution is not yet included, but will follow shortly once a reference calibration observation has been made.

This note provides a brief summary of some relevant calibration information, and outlines some relevant aspects of the data-processing pipeline.

Spectral range, line shape and resolution

The spectral ranges over which the present data can be calibrated are as follows:

Band	Spectral Range
SSW	194 – 313 µm
SLW	303 – 671 µm

At the present time, an instrumental line shape equal to the theoretical Sinc function should be assumed for the unapodised spectra. The spectral resolution element for a Fourier transform spectrometer is given by $\Delta\sigma = 1/(2 \times \text{OPD\_max})$, where OPD_max is the maximum optical path difference achieved by the mirror mechanism. The line FWHM of the Sinc function is given by $1.207 \times \Delta\sigma$. The spectral resolution achieved in the data for the released modes are:

Mode	Spectral resolution element	Line FWHM
High	0.0398 ± 0.0002 cm^{-1}	0.0480 ± 0.0002 cm^{-1}
Low	0.83 ± 0.04 cm^{-1}	1.00 ± 0.05 cm^{-1}

This corresponds to the following velocity resolution in high resolution mode across the band:

Band/Mode	Spectral Range	Line FWHM
SSW High	194 – 313 µm	280 – 450 km s^{-1}
SLW High	303 – 671 µm	440 – 970 km s^{-1}

Beam profiles

Pre-flight modelling and measurements show that the beam profiles will exhibit some variation as a function of wavelength. Preliminary measurements of the broad band beam profiles in flight indicate that ellipticity is low, and that a Gaussian profile with the following FWHM can be assumed. These values should be taken as constant over each band at the present time; the exact wavelength dependence of the beams will be determined later.

Band(µm)	FWHM and uncertainty (arcsec)
SSW 194 – 313 µm	19 ± 1.0
SLW 303 – 671 µm	35 ± 1.5

Wavelength scale accuracy

The wavelength scale accuracy has been verified using line fits to the ^{12}CO lines in five Galactic sources with the theoretical instrumental line shape (Sinc profile). This shows that the centre of the line can be determined to within a fraction of the spectral resolution element (at least 1/10) if the signal-to-noise is high. There is very good agreement between the different sources and across both bands. A systematic offset in line position of approximately +30 km s^{-1} (roughly 1/10th of a resolution element at the shortest wavelength and 1/30th at the longest wavelength) is observed: measured wavelengths will be systematically over-estimated by this amount. This may be indicative of a slightly modified instrument line shape function; this will be taken into account in future versions of the FTS pipeline.

Noise and sensitivity

The noise has been shown to reduce with increasing number of repetitions as expected in the interferograms, and out of band in the spectrum. This shows that the detectors are working as expected and there are no fundamental systematic effects that limit deep observations. However, at the present time, inside the optical band, we have some effects for the central detector pair that are related to channel fringes in the spectrum and as-yet imperfect characterisation of the releative spectral response function (RSRF). We have already made significant advances in removing these effects with the current calibration files, and work is continuing to complete this. Spectra will currently still contain some fixed pattern noise associated with these effects (particularly in the *apodised* spectrum product).

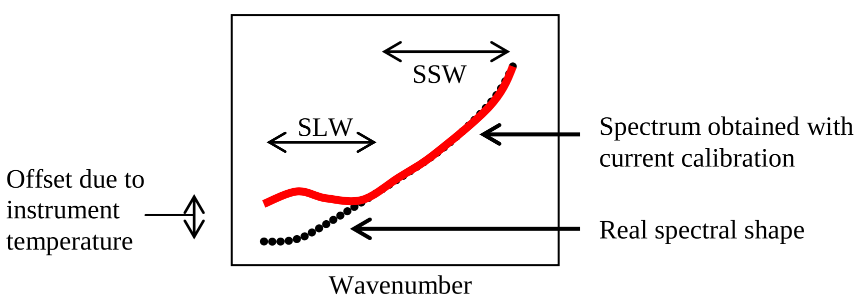
The absolute sensitivity of the FTS is very good, and the results show that we are achieving at least a factor of two better sensitivity than reported in HSpot. For deep observations, the final sensitivity depends on precise background subtraction, and the removal of the RSRF, and we expect that the sensitivity will increase further as we build up integration time in these calibration files. At present, this fixed-pattern noise starts to limit the noise after about typically 10-20 repetitions, but we expect that with further improvements in the data reduction software and calibration the fixed-pattern noise will be eliminated and will not limit deep observations. Programmes involving deep observations should still be able to achieve the desired sensitivities.

Flux calibration accuracy

The current flux calibration is based on the asteroid Vesta. Comparison with observations of Neptune and the Neptune model suggest that the absolute accuracy of the current calibration (which will be improved) is as follows:

Band	Flux density accuracy
SSW 194 – 313 µm	10 – 20 %
SLW 303 – 671 µm	~30 %

There is an additional systematic effect in the SLW band due to changes of the instrument temperature between the reference observation and the source observation. This causes an additive term in the spectrum which can be 20 Jy at worst. In the future, this additive term will be removed using knowledge of the instrument temperatures. A similar, but much smaller, effect occurs in the SSW band due to changes in the telescope temperature. These thermal variations will affect weaker sources more than strong sources. The following figure indicates the effect on the spectrum. Spectral line fluxes are unaffected by this term which is purely in the continuum.



Pointing

The pointing for the central detector pair (which are well co-aligned) has been shown to be accurate to within the spacecraft absolute pointing error of approx. 2".

Pipeline status

The current FTS pipeline released by SPIRE (HCSS v2.0) provides usable Level-1 products, but has not yet been fully optimised for removal of all instrument and observatory systematic. There are no Level-2 products because, for SPIRE’s imaging spectrometer, these are re-sampled spectral cubes which are not produced for the sparse AOT. Pipeline development is continuing to improve data quality, in particular related to the effects described above: standing waves, flux calibration, and thermal variations of the instrument and telescope. New calibration files which could improve data quality running the pipeline from Level 0.5 to Level 1 may become available in the coming weeks.

Raw SPIRE data are affected by glitches due to ionising radiation. These are currently detected in the pipeline and the affected data samples are replaced. This is particularly important for the FTS because a single glitch in the interferogram will cause a sine wave throughout the spectrum. We are currently optimizing the deglitching steps in the pipeline. At present, the data are replaced in a second-level deglitching step using a reconstruction based on samples from unglitched scans.