The Cornell Atlas of Spitzer Infrared Spectrograph Sources
CASSIS updates LR5, LR6, LR7

V. Lebouteiller, D.J. Barry, H.W.W. Spoon, J. Bernard-Salas, G.C. Sloan, J.R. Houck, D.W. Weedman

February 13, 2015

Contents

This document presents updates to the Cornell Atlas of Infrared Spectrograph Sources (CASSIS: http://cassis.sirtf.com) and supplements the seminal paper by (Lebouteiller et al., 2011), hereafter L11).

CASSIS is a spectral atlas for low-resolution ($R \sim 60-127$) mid-infrared ($5-38\,\mu$m) spectra from the Infrared Spectrograph (IRS; Houck et al. 2004) on board the *Spitzer* Space Telescope (Werner et al., 2004). The spectra provided by CASSIS are meant for direct publication. Two versions are provided, the optimal extraction that is adapted for point-like sources (see Lebouteiller et al. 2010), and the tapered column extraction (aka "regular") better suited for partially-extended sources. CASSIS provides a quantitative measurement of the source spatial extent to guide the user to the best product. We refer

to L11 for the full description of CASSIS. We list in the following the main changes and improvements for the new releases of CASSIS.

1 Summary of releases

- LR4, released August 5, 2011. This was the first public version that is described in L11.
- LR5, released March 26, 2013
- LR6, released February 26, 2014
- LR7, to be released

2 CASSIS low-resolution pipeline update LR5

BCD pipeline version CASSIS is a post-Basic Calibrated Data (BCD) pipeline. BCD products are calibrated detector images with most instrumental artifacts already corrected by the Spitzer Science Center (SSC) BCD pipeline. CASSIS automatically performs the steps separating BCD images from spectra: bad pixel cleaning, exposure combination, background subtraction, spectral extraction, nod spectra combination, defringing, and flux calibration. While version S18.7.0 of the BCD pipeline was used for LR4, the latest and final version S18.18.0[1] is used as of LR5.

Contaminating sources The presence of a contaminating source in the nominal image and in the background image(s) is critical to constrain what background subtraction method is eventually used (between *by-order*, *by-nod*, or no subtraction at all). The algorithm in versions as of LR5 is less conservative as compared to LR4. The parameters were adjusted so that a contamination is identified as such only when it affects significantly the source spectrum.

Tapered column extraction While the optimal extraction is adapted for point-sources, CASSIS also provides a tapered column extraction that can be used both for point-sources and partially-extended sources. Tapered column extractions in LR4 were presented with the best background subtraction based on diagnostics drawn from the optimal extraction algorithm (including in particular the presence of contaminating sources). This could cause a problem for tapered column extraction of extended sources, for which require a background subtraction *by-nod* cannot be used. The background subtraction *by-nod* might remove part of the source itself, and, since the tapered column extraction width scales with the source extent, the extraction aperture will include part of the "negative" profile. As of LR5, CASSIS assumes instead a subtraction *by-order* by default for tapered column extraction of partially-extended sources. In the presence of a contaminating source in the *by-order* background, no subtraction is performed.

Defringing In CASSIS, defringing in the LL1 module is applied only when the signal-to-noise (S/N) is larger than a given ratio (currently S/N>5). We have improved the S/N determination in LR5 so that all the spectra with sufficient S/N are now defringed.

Image and spectra combination For the combination of exposure images, a combination of the median and error-weighted average was used in LR4. As of LR5, CASSIS uses a resistant mean with outlier rejection. As far as spectra are concerned, for a given module and order, the combination of the two nod spectra includes a new and more robust outlier detection algorithm.

Ignoring nod spectrum with a low detection level For each possible background subtraction method (*by-order*, *by-nod*, no subtraction), the CASSIS algorithm compares the detection level of each nod. If one nod is significantly worse than the other it is ignored for the nod combination. While the same detection level was used for all background methods in LR4, versions LR5 and up use the actual detection level for the corresponding method.

[1]The changes between S18.7.0 and S18.18.0 are documented in
http://ssc.spitzer.caltech.edu/warmmission/sus/mlist/archive/2011/msg001.txt

Shift between order spectra When a serendipitous (contaminating) source is found in the slit, the local background (modeled by a 0-order polynomial) subtraction is skipped because it might introduce systematic errors. In some cases, only one nod can be affected by this problem, but a local background subtraction may be performed for the other one. This could result in a shift between the two nod spectra. This problem is solved in version LR5.

Uncertainties CASSIS LR5 used an updated version of the SMART/AdOpt package (Lebouteiller et al., 2010). The update changes the flux uncertainty determination. The latter were somewhat underestimated in LR4.

Extraction method As of LR5, CASSIS chooses the best extraction method between optimal extraction and tapered column extraction, based on the source spatial extent. The default spectrum shown and the default products reflect this choice. The alternative method can still be accessed through the product menu.

Errors Versions LR5 and up provide the total error by default, which adds the statistical rms error to the systematic error (mostly due to the observed differences between nod spectra). Individual errors (statistical, systematic, and calibration) are provided as well.

3 CASSIS low-resolution pipeline update LR6

Background emission The other order images are subtracted to remove rogue pixel as well as very extended emission such as the zodiacal dust emission. Since the other order images correspond to a spatial position significantly far from the source position (i.e., on the order of a full slit length), this can result in a local residual background emission in order-subtracted images. This sometimes led to some contamination in LR5 (and LR4) spectra, especially for faint sources. The local background is now removed as of LR6 for order-subtracted images, by modeling a flat large-scale emission across the slit. The same local background is subtracted for the tapered column extraction and optimal extraction. In the case of tapered column extraction though, the local background is not removed if the source is very extended (since in this case the "local background" is likely originating from the source itself).

Default extraction method When the detection level is too low and no accurate spatial extent can be determined, optimal extraction is now chosen as the default spectrum as it is the method that results in the best signal-to-noise ratio.

Image and spectra combination When the dispersion of coordinates over the exposures is large, individual exposure images cannot be combined anymore and have to be extracted separately instead. The dispersion threshold has been increased in LR6. A bug was fixed when multiple spectra for a given module/order/nod have to be combined (which happens only when the images could not be combined because of a significant dispersion of the pointing over the exposures).

Spatial extent Better determination of the spatial extent, a parameter used to decide the best extraction method between optimal for point sources and tapered column for partially-extended sources. The new spatial extent determination method is more robust and provides more accurate values when a significant background emission is present in the spatial profile.

Products The default spectrum is now trimmed (overlaps between spectral orders are removed).

4 CASSIS low-resolution pipeline update LR7

Background emission A local background subtraction is performed for the nod-subtracted images as of LR7, similarly to what was done for the order-subtracted images in LR6. This improves significantly the agreement between the two individual nod spectra for very faint sources and as a result, provides a much better determination of the source's flux level.

Tapered column extraction For the tapered column extraction of nod-subtracted images, the spectrum can be uncertain is the source is extended since the window in which the flux is integrated could include part of the "negative" spatial peak (due to the nod image difference). In LR7, the spatial extent threshold – above which the use of tapered column extraction for nod-sutracted images is not reliable anymore – has been fine tuned from 1.75 times the PSF width to 1.5 times the PSF FWHM.

5 Caveats

SL/LL jump It is common to observe a jump between the SL spectrum and the LL spectrum. This is observed in partially extended sources and is a result of the different entrance slit dimensions across the spectrometer apertures. The CASSIS spectra are unstitched. CASSIS provides by default the best extraction method between optimal (for point sources) and tapered (for partially-extended sources). Jumps between SL/LL will mostly be seen in the optimal extraction of partially-extended sources, which is not a default product. The user may adjust the spectral segments to compensate for continuum misalignments.

Residual fringes The LL1 defringing is a complex process that might require different fitting parameters in some cases. A set of parameters was chosen for CASSIS to accomodate most of the fringing patterns. Some residuals can remain. CASSIS provides the fringed spectra as optional products if the users desire to defringe the spectra themselves.

Spikes Although a particular attention is given by CASSIS to the removal of bad pixels and spikes in the spectra, it is possible that some spectra show spikes. For this reason, it is advised to check the various versions of the spectra (individual nod spectra, different background subtraction method, tapered column extraction vs. optimal extraction).

SL2 wiggles In some cases, point-like source may show some wiggles at short wavelengths, especially in the SL2 module. This is due to the undersampling of the data, as explained in (Lebouteiller et al., 2010). The flux calibration in the optimal extraction accounts for this effect, but if for some reason the source position is not *extremely* accurate (e.g., complex profile deviating from a pure point source), the wiggles might appear.

References

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