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Spitzer IRS Pipelines for General Users

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Abstract. An effort is underway to make the Spitzer InfraRed Spectrograph (IRS) data-processing pipelines available for use by astronomers worldwide. This will allow users to reprocess raw data downloaded from the Spitzer archive with customized calibration files, updated operational parameters, and/or a modified list of processing steps. The pipelines will create all standard BCD (basic calibrated data) and post-BCD products, plus additional intermediate products. The pipelines will be made up of newly developed Perl and C-shell "executive" scripts, plus the binary-executable modules currently used in operations (the modules' source code will not be distributed, however). The scripts are being designed for ease of use and will facilitate user-customization. The operating systems targeted for support are Mac OS X, Linux, Solaris, and possibly Windows.

1. Introduction

Fang *et al.* (2003) previously described the automated data-processing done at the Spitzer Science Center (SSC) for the InfraRed Spectrograph (IRS) data acquired by the Spitzer Space Telescope, although the reader is cautioned that this document may be somewhat out of date. The present paper focuses on our latest effort to develop and package the latest IRS pipelines for distribution to general users, i.e., outside of the SSC operational environment.

The next section outlines the basic features envisaged for the six Spitzer IRS pipelines for general users, and the section following that gives a brief description of each of these pipelines. Concluding remarks are made in the final section.

2. Basic Pipeline Features

Data directories. Generally a data directory contains all the data for one Spitzer Astronomical Observing Request (AOR), for all channels (or infrared passbands). It has the same structure as that of the data retrieved from the Spitzer archive (see Table 1), and contains raw data, processed data, calibration files, and controlled-data files (CDFs). All pipeline processing is done in a data directory for a given channel.

Pipelines. There are six separate IRS pipelines (see Figure 1). Nominally all six pipelines are run for "low-res" data (channels 0 and 2), and only four of the pipelines, i.e., the BCD and Coadd pipelines, are executed for "high-res" data (channels 1 and 3).

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Table 1. Data-directory structure.

Directory	Contents
<AOR #>/<channel #>/raw	Unprocessed files.
<AOR #>/<channel #>/bcd	BCD images and spectra.
<AOR #>/<channel #>/pbcd	Coadd and bksub images and spectra.
<AOR #>/<channel #>/cal	Calibration files.
<AOR #>/<channel #>/cdf	Controlled-data files.

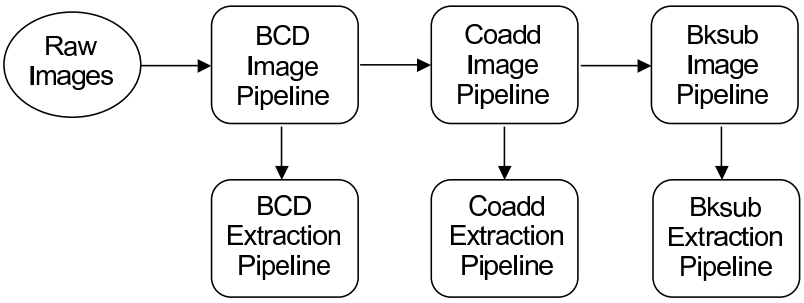

Figure 1. The six Spitzer IRS pipelines ("BCD" means basic calibrated data).

Processing and options. Once a data directory is available with raw data, the pipeline for creating the BCD images may be executed. Before running this pipeline, the user may elect to make alterations to the pipeline's inputs or the pipeline itself. Possible changes include: 1) using custom calibration files; 2) adding, deleting, and/or reordering the processing steps (requires user modification of the relevant pipeline script); 3) changing the processing parameters (via the CDFs) of one or more of the processing steps; and 4) running other software such as the SSC's IrsClean program on the data.

Calibration files. The user may place custom calibration files in the "cal" subdirectory of the data directory of interest. Alternatively calibration files may be retrieved from the Spitzer archive and used. Otherwise the pipeline will automatically select and copy the appropriate calibration files from the "base directory" (see Table 2), differentiated by channel, time of observation, and possibly exposure time.

Controlled-data files (CDFs). The user may place updated control files in the cdf subdirectory to cause non-standard parameters to be used during processing. Otherwise the pipeline will automatically copy the appropriate cdf files from the base directory (see table at bottom), based on channel.

3. The Six Pipelines

The first pipeline produces BCD (Basic Calibrated Data) images, one per raw image. Here are the basic processing steps:

1. Convert pixel data from integers to floating-point numbers [cvti2r4]
2. Estimate uncertainties [snestimator]

Table 2. File subdirectories in the base directory of the software distribution.

Directory	Definition
help/	User documentation files.
cal/	Standard calibration files. Files from this subdirectory are automatically selected from here and copied to a work area when needed.
cdf/	Standard control data files. These files specify details about how specific pipeline steps are performed. Files from this subdirectory are automatically selected and copied from here to a work area when needed.
scripts/	High level executive scripts that control the pipeline process. These scripts select files for processing and then runs the appropriate modules.
bin/	Binary executables. These are the same modules that are used in the operational pipelines.
lib/	Dynamic-link libraries (if any, or as needed).
include/	Header files, etc.

3. Convert from DN to electrons [dntoflux]
4. Perform saturation correction [satcor]
5. Remove global droop [droopop]
6. Remove per-row droop [rowdroop]
7. Remove dark-offset baseline [darkbase]
8. Subtract dark current [cubesub]
9. Correct for detector non-linearities [linearizc]
10. Detect and mask radhits [radhit]
11. Remove the "jail bars" [darkdrift]
12. Compute ramp slopes [slope_finder]
13. Remove residual droop [droopres]
14. For channel=0, remove stray light from peakups [slremov]
15. For channels 1 & 3, remove inter-order crosstalk [crosstalk]
16. Apply flatfield correction [flatap]

The "Coadd Image" and "Bksub Image" pipelines perform the same steps as above, except that there are additional processing steps. The former pipeline coadds the input BCD images of the same exposure to produce coadded images (within an AOR there can be many exposures or groups of BCDs with common instrument/telescope settings). The latter pipeline subtracts the pairs (two nods) of coadded images to generate the background-subtracted images.

All three extraction pipelines, i.e., for BCDs, coadds of BCDs, and background-subtracted coadd images, perform four basic steps:

1. Compute the flux profile across the orders
2. Locate the source position
3. Extract the spectrum (electrons/second)
4. Convert the spectral data to flux data units (Janskies)

Only standard extraction is employed; optimal extraction (Narron, Ogle, and Laher, 2007), which requires the user-tunable options that are available in the SSC's Spice[2] software, is not currently available in these pipelines.

4. Conclusion

The software described herein will give the user unprecedented insight into how IRS Spitzer data are processed at the Spitzer Science Center (SSC), as well as allow users to do customized IRS raw-data reduction using re-configurable SSC software tools. Most likely the scripts and additional software for the general-user Spitzer IRS pipelines as discussed here will be bundled with the SSC's Spice software.

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[2] `http://ssc.spitzer.caltech.edu/postbcd/spice.html`