IRS Data Reduction Outline

Basic information, Cal stars, Rogue pixels

1. Identify the date/time and campaign in which your IRS data were taken.
2. Download the campaign dependent rogue pixel masks for your data from http://ssc.spitzer.caltech.edu/irs/roguepixels/
3. Download and install IRSCLEAN_MASK – an IDL based package to detect and clean hot pixels. Also download and install SPICE, the tool to extract IRS spectra from the data files.
4. If you have extended sources or low S/N point sources, download the calibration star data taken in that campaign using Leopard – this will be useful to apply flux calibration corrections for different extraction aperture widths. Calibration data are typically taken as Program ID 14xy where xy is the Campaign number. So, for example, cal data taken in Campaign 19 will be in PID 1419. Also, cal stars typically have sky observations with them – download these as well.

Sky estimates

High Res Data: Point or Extended Source

5. If you have SH/LH data (or have extended sources which fill your slit in LL/SL) it is strongly recommended that you take close in time sky observations. The sky observations help significantly alleviate the effects of rogue pixels which are numerous in LH.
6. If for some reason, you have not taken dedicated sky observations, search the archive for blank sky observations taken within 24 hours of your target data. If these sky observations are not at similar ecliptic latitudes as your targets, you will have to apply a background scaling factor to be able to use these as a sky for your data. Also, be careful that you don't add noise to your data in the sky subtraction phase by choosing archival data which have comparable/longer integration times than your data frames. There is no guarantee that such sky observations exist in the archive so if you haven't considered step 5 when designing your AORs, you are risking significant flux calibration uncertainties.
7. If you have low res observations taken close in time, you can interpolate the sky values extracted from those data to derive the background at high res wavelengths.
8. You can obtain approximate background values for the date of your observations for a range of wavelengths using SPOT. These are in MJy/sr and you will have to multiply these by the solid angle of the slit width * extraction width and convert to Jy before subtracting them from your data. This is the least accurate technique.

Low res Data: Point Source

9. If you have SL/LL staring mode data, since a point source does not fill the slit, you can do a sky subtraction by subtracting the BCDs between the two nod positions. This is the preferred option if the slit does not have other sources in it and your target is faint.

10. Alternately, you can extract a sky in the off source subslit. So for example, if you are observing a source with both SL1 and SL2 in your AOR, when the source is in SL2, you can extract a sky from SL1 and vice-versa. Be sure to check that the off source subslit does not have serendipitous sources before extracting a sky.

Low res Data: Extended Source

11. If you have extended sources which fill most of your slit in LL/SL, it is strongly recommended that you have close in time sky observations built into your AORs.
12. You can obtain approximate background values for the date of your observations for a range of wavelengths using SPOT. These are in MJy/sr and you will have to multiply these by the solid angle of the slit width * extraction width and convert to Jy before subtracting them from your data in Step 10. This is the least accurate technique.

Data reduction steps

1. Be sure to have at least 2 cycles for staring mode observations – this will yield at least 4 sets of spectra and enable outlier rejection.
2. *For long duration (>1 hour) integrations on very faint (<<1-3 mJy) sources*, search for any charge accumulation (especially for high background and long integrations) by fitting ramps to the signal as a function of time. That is, take the median of each row (or 2-3 rows) within an order, in each BCD and see if the median of the same group of pixels increases with time. If so, fit a 1D polynomial to these median values and subtract the slope off. In LL, we have found that 1-2% of the charge persists on the detector between frames despite the resetting of the detector prior to each integration. This latent charge decays very slowly and is completely removed only by the anneals of the detector.
3. Subtract the 2D sky that you get either from your sky observations or calibration data from your 2D BCDs. If you have not found appropriate sky observations and are relying on the SPOT background values to do background subtraction, you will do the sky subtraction in step 10.
4. Use IRSCLEAN_MASK to mask known rogue pixels and flag any other pixels which look bad in your bcd.fits files. Rename the cleaned files as clean_bcd.fits
5. Create 2D sigma-clipped averages or medians of your 2D clean_bcd.fits files using IDL/IRAF for each nod position. You now have outlier cleaned, rogue pixel masked, background subtracted BCDs (super_bcd.fits). If you have only 2-3 cycles of staring mode data, you can skip this step and instead jump to step 8 using the clean_bcd.fits files as the super_bcd.fits files.
6. For SL and LL, subtract the average files from step 5 for each nod position from each other. This is the accepted procedure for sky subtraction if you observe point sources with low res. However, if you have an extended source which fills a significant fraction of the slit, skip this step and go to step 7.
7. For SH/LH, execute steps 2,3,4,5 on your sky observations. For extended sources observed with SL/LL, you will have to do steps 2,3,4,5 on your sky observations.
8. Run SPICE on your super_bcd.fits files, doing the basic steps of Profile, Ridge, Extract and Tune. Feel free to play around with extraction apertures to maximize signal to noise in your spectrum. But pay careful attention to the fact that if you

change the extraction apertures from the default, your flux calibration will need to be redone as outlined in step 11. In general, the default extraction apertures work well for point sources. For extended sources, you will probably have to do a full slit extraction. The S13 SPICE extended source calibration assumes that the source has a uniform surface brightness within the slit and has a flat spectrum with wavelength. It calculates the slit loss correction factor based on that assumption. NOTE: the IRS obviously does not know what the spatial profile of your extended source is and cannot correct for unknown flux losses outside the slit for your particular source.

9. You now have 2 spect.tbl files (the output of Tune), one for each nod position which you can average together. If you ran step 8 directly after step 4, then you have spect.tbl files for each cycle. Average together all these spect.tbl files using some sigma clipping criterion to reject outliers.
10. If you haven't yet done sky subtraction, subtract the sky background that you get from SPOT, from your spectrum.
11. If you have changed the extraction width from the default, you will have to apply a flux calibration correction. For a point source, this is essentially a ratio of the flux from a calibration star using the default extraction width to the flux from the same star using your extraction width. Multiply this ratio (which is wavelength dependent) to the spectrum from steps 9 or 10. Be sure that you have done exactly the same steps of rogue pixel masking, background subtraction and SPICE extraction on the calibration star as you have done for your target, before you estimate the flux calibration correction.
12. Finally, trim the edges of the orders – the edges of each orders are noisy and you need to reject the first few and last few pixels. You should have a nicely matched spectrum with orders matched and properly flux calibrated (this is less certain if you obtained the sky background from SPOT rather than from real observations).
13. Check flux calibration by comparing the flux in the spectrum with broadband imaging observations. It is also useful to extract a spectrum from a blank part of the slit in your reduced 2D spectrum (super_bcd.fits) from step 8 to check if there is any residual sky or latent charge remaining.

Line fits

1. Use IDEA, the line fitting tool which is a part of SMART to fit lines, obtain equivalent widths etc. Or use your favorite IRAF or IDL package.
2. Be sure that lines are present in both nod positions (or multiple bcd files) for reliability.
3. Be sure that the "line" is not the 13 micron teardrop known to exist in the data.
4. Be sure that the FWHM of the lines are reasonable i.e at least the spectral resolution of the instrument.
5. Do not mistake rogue pixels/cosmic rays for lines by carefully inspecting the time history of pixels. When doing full slit extraction for SH/LH, the rogue pixels (since they only decay slowly with time) can appear in both nod positions in the spectrum while cosmic rays will appear only in one nod.
6. If you have undertaken all these steps, you can write your paper !