

Software Release Note

IRC_SPECRED V2.0

The reduction toolkit for AKARI IRC04 observations

Y. Ohyama, 28 May 2008

Table of contents

0. Introduction
1. Installation notes
2. Toolkit bug fixes
3. New tips
4. Improvement of calibration/processing parameters
5. New features
6. Changes in command specifications
7. Calibration data updates

0. Introduction

This document describes the main improvements of the last version of the IRC_SPECRED software (V2.0), as compared with previous versions. The reader is directed to the updated version of the IRC Instrument Data User Manual (V1.4) for more details on all the aspects of the data reduction with this toolkit software.

1. Installation notes

The newly-released version 2.0 should NOT be used with older version of the software. Each version should be installed separately, under a separate directory. Alternatively, the existing software directory should be removed first, before installing the new one. This is because each version relies on different calibration database sets, and many toolkits were rewritten for the latest calibration data.

If you want to compare the results between versions, be sure to rename the directory name of the old version, say, 'IRC_SPEC_TOOLKIT' to 'IRC_SPEC_TOOLKIT.V1', and install the new one under new 'IRC_SPEC_TOOLKIT' directory. Then, by resetting the 'IRC_SPECRED_ROOT' environment parameter of the shell to point to the old directory, like,

```
setenv IRC_SPECRED_ROOT <your directory name>/IRC_SPEC_TOOLKIT.V1/
```

and

```
source ~/.bashrc
```

one can switch back to the older version.

2. TOOLKIT bug fixes

2.1: X-shift of the spectroscopy apertures

The 'X-shift' value of source extraction apertures, measured on NP images separately, was not taken into account properly in shifting the MIR-S/L apertures. The shift actually applied was too big, introducing over-correction of the shift. As a result, for pointings that suffered from larger telescope/satellite jitter, the correction was not accurate enough. Note that the X-shift correction could be applied manually while plotting with the `plot_spec_with_image` command (with 'space_shift' option), and the resultant spectra were actually correct even with the older toolkit.

Also, for point-source spectroscopy at 'Np' aperture, shifting the aperture box along space (X) direction failed (i.e., no correction was applied) while performing a second run of the toolkit (with '/Np_slit' option) in the old toolkit even if the shift value was measured correctly in the 1st run (without the '/Np_slit' option). This problem is solved in the latest toolkit version 2.0.

2.2: Removing some sub-frames for stacking on ds9:

The functionality for removing one or more subframes individually/interactively on the DS9 window had a malfunction, and the images chosen to be removed from the stacking list were not actually removed. This problem is solved in the latest toolkit version 2.0.

2.3: Flat change according to the observation date:

In order to cope with changes in 'flat features' seen in SG1 and SG2 around Jan. 2007, the toolkit should automatically choose an appropriate flat image based on the observation date found in the FITS header, but this did not work in the old versions. All data were treated as to be observed before Jan 2007 in the old version. This problem is solved in the latest toolkit version 2.0.

2.4: Mask shifting for sky subtraction for each sub-frames:

As the pointing attitude slightly changes while taking series of sub-frames, the mask position should be changed according to the drift pattern among sub-frames, to correctly subtract the sky from individual sub-frames before stacking. The old version software had a bug in shifting the mask, and the latest version toolkit can shift the mask appropriately.

2.5: Bitshift (wraparound) correction:

We found that the bitshift correction (or wraparound correction) was not correct for the MIR-S/L images that include sources as bright as, or close to, the saturation limit. This created strange-shaped spectra for such data. The latest toolkit can make the correction appropriately. See also section 5.3 'saturation masking'.

2.6: Short-exposure frame processing:

The processing of short-exposure frames had bugs in the old version, and the processed images were sometimes completely masked out. The problem is solved in the latest toolkit version 2.0.

2.7: Wrong flux scale of the slit spectra with /diffuse option:

The aperture correction was unexpectedly applied for the slit spectrum with any slit options (/Ns_spec, /Nh_spec, /Ls_spec) when spectra were plotted with /diffuse option in plot_spec_with_image command. The aperture correction should only be adopted for point-like sources. The bug resulted in wrong flux scaling. This malfunction is corrected in the latest toolkit version 2.0.

3. New tips:

3.1: Flat fielding for slit spectroscopy data:

It is now clear that the quality of the spectroscopy flat for NG (at Nh, Ns, and Np), or the S/N of the flat, is not good enough to perform a good flat fielding. Slit spectroscopy users are strongly recommended to use the option '/no_slit_flat' at the irc_spered command line.

We expect that no big differences are found among the two spectra, except for random pixel-to-pixel variation of the flux, or some narrow (as narrow as one-pixel size) spike features, and therefore spectra processed without the flat fielding look better in terms of S/N. It is recommended for users to compare the results processed with and without the flat fielding by themselves, and take the one with better quality.

3.2: Removing effect of column pull-down in NIR images:

The toolkit version 2.0 has a new feature (an option) to mask the columns affected by the column pull-down effect (see section 5.1 of this document). However, if one finds that there are still severe damages in the stacked images, one can remove the sub-frames interactively on ds9.

Users may want to know some ideas on the probability of the occurrence of the column-pull-down. The very first spectroscopy sub-frame image are likely to be damaged more easily, because the array could have been exposed to brighter stars during the satellite maneuvering (before actually starting the science exposures). Also, the first sub-frame after taking the reference image can be damaged more easily because the array could have been exposed to bright field stars since the image is taken through broad-band imaging mode.

4. Improvement of calibration/processing parameters

4.1: Source mask sizes:

The latest version of the toolkit can treat object masks more properly in the sky fitting, and now the mask size is just large enough to cover the spectra.

After this improvement in masking, the sky fitting accuracy has improved, and hence, the photometric accuracy of the spectra got better, by not subtracting too much sky counts beneath the objects. The improvement is more evident for MIR-S/L where the sky level is higher and more structured due to the flat pattern.

4.2: Sky fitting over stacked images:

After improving the sky fitting accuracy for individual sub-frames, we found that the lower order of the sky fitting function for stacked images is just enough for the fit. So, now the orders are set to 1 for MIR-S/L (c.f. 4 in the older version).

4.3: Dark subtraction for slit spectra at NIR:

Since the sky level is faintest at the slit (N_s , N_h) and N_p at NIR, the quality of the background images is limited by uncertainties of the super-dark image. Therefore, we simply subtract a constant

value, not the scaled super-dark image, from the observed 2D image in the latest version of the toolkit. This dark subtraction method works only for NIR spectra at Ns, Nh, and Np.

5. New features

5.1: New option for masking column-pulled-down columns for NIR spectroscopy (NP/NG):

Because of characteristic of the NIR array, strong point-like signal causes the so-called column-pull-down effect, which easily affects to the NIR data. The column-pull-down effect is often observed as severe damage in the NIR spectroscopy data, even after stacking the sub-frames. The effect is often found in the data of;

- (1) big cosmic-ray hits,
- (2) bright peak of the NP spectra at their shortest wavelength (around 2.4um), and
- (3) reference images.

You may also find weak, but notable counter-effect of the pull-down (or pull-up) in some sub-frames that are taken right after the sub-frame that actually suffered from severe column-pull-down. To prevent the damage, the latest toolkit has a new feature to detect and mask the pulled-down (and pulled-up) columns, with an option `'/nir_correct_column_pull-down_correction'`. See the IDUM for more details.

Note, however, if one finds that the effect is too severe to be removed with the option, it might be a better idea to remove the subframe interactively on the ds9. See section 'new tips' for more information.

5.2: Spectroscopy WCS in output FITS images:

The FITS output images of the extracted spectra (`*.specimage_wc_indiv.fits` and `*.specimage_fc_indiv.fits`) now have spectroscopy WCS for spectral plots (wavelength vs counts or flux). One can use, for example, the SPLOT task on the IRAF to see the spectra, after processing the data with the toolkit. See the IDUM for more details.

5.3: Saturation masking:

The saturation masking functionality has been updated significantly. Now, the spectroscopy toolkit accepts the same method adopted in the imaging toolkit in masking the saturated pixels. More specifically, the software first checks the short-exposure images, and find regions where expected counts in longer-exposure frame exceeds the saturation limit based on the exposure time ratio of short-/long-exposure frames. Then, the regions are masked in the longer-exposure frames.

6. Changes in command specifications

6.1: Changes of 'change_offset' command format:

For easier maintenance of the wavelength information both in IDL save files and FITS output images that now have wavelength information, the command format of the 'change_offset' has been expanded to include more arguments to create/save new FITS outputs with updated wavelength offset. See the IDUM for the new format.

7. Calibration data updates

7.1: NP/SG1/2 response curves:

With improved sky subtraction (and improved spectral photometric accuracy), we re-calibrated the spectral-response of NP/SG1/SG2. The procedure for measuring the wavelength zero-point was also revised, requiring an update of the spectral (wavelength dependent) responses. The new calibration data set is provided with the distribution of new toolkit.

7.2: Aperture correction tables:

For the same reason, the aperture correction table should be updated for SG1/2. Now the fraction of peak flux (counts at a very center pixel of the object) increased slightly, compared with the results of older version, thanks to better sources masking.