

**SAGE-Spectroscopy:**  
The life-cycle of dust and gas in the  
Large Magellanic Cloud  
(PI: F. Kemper, PID: 40159)

Data delivery document v2.0

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# Chapter 1

## SAGE-Spec overview

### 1.1 Introduction to the goals of the SAGE-Spec program

The SAGE-Spectroscopy legacy proposal (SAGE-Spec; PI: F. Kemper, PID: 40159; Kemper et al. 2010) is the spectroscopic follow-up to the successful SAGE-LMC legacy program (Meixner et al. 2006; PI: M. Meixner, PID: 20203) that mapped the Large Magellanic Cloud (LMC) with all bands of the IRAC and MIPS instruments on board the Spitzer Space Telescope. The acronym SAGE stands for Surveying the Agents of Galaxy Evolution, and thus the project aims to make an inventory of the budget of gas and dust involved in the life-cycle of matter in the Magellanic Clouds.

The SAGE-Spec legacy program has used IRS and the SED mode on the MIPS instrument to obtain spectroscopic information of a representative sample of point sources and extended regions in the LMC, with two goals in mind:

The first goal is to study the composition and properties of gas and dust in environments relevant to the life-cycle of matter, from evolved stars to the interstellar medium and ultimately to star-forming regions. Combining this information with statistics obtained from the SAGE-LMC project will allow us to get a complete picture of the cycle of gas and dust in terms of mass *and* in terms of composition and physical properties.

Secondly, sources in the SAGE-LMC point source catalogue will be classified using a classification scheme tested against the SAGE-Spec sample. In addition to the observations made within the context of the SAGE-Spec proposal, we have extended the sample to contain *all* IRS and MIPS-SED observations within the original SAGE-LMC footprint (“the archival sample”).

In total, 224.6 hours of observations were made and 196 positions were targeted with the IRS instrument, resulting in 197 point sources being observed; 48 point sources were observed with MIPS in SED mode and 20 extended regions were also targeted with MIPS: 10 HII regions and 10 diffuse regions. In addition, the reduction and delivery of all the IRS and MIPS-SED spectroscopic data within the SAGE-LMC footprint adds a further  $\sim 800$  IRS (mostly point-source) targets and several other extended regions. A paper giving an overview of the project has recently been submitted (F. Kemper et al. 2010, submitted)

Of the 196 point sources observed with IRS, all were observed using the SL module ( $\lambda \approx 5\text{--}14\ \mu\text{m}$ ), and 128 were also observed using LL ( $\lambda \approx 14\text{--}37\ \mu\text{m}$ ). Upon examination, the LL

observation of one source, SSID16 (GV 60), picked up another target rather than the intended target. Thus there are 197 distinct point sources in the proposal sample at this point. Spectra of a number of serendipitous objects were obtained, and these will be delivered in a future data release. 48 of the brightest points sources were also targeted with MIPS in SED mode and a number of serendipitous sources were also found, bringing the total of MIPS-SED point sources up to 63. For our source selection strategy, please see the overview publication for the project, Kemper et al. (2010).

## 1.2 Description of the observations in the current data release

This second delivery of data from the SAGE-Spec Spitzer Legacy Program improves upon the data delivered in delivery #1 and adds both IRS and MIPS-SED data on point sources and extended regions observed in the LMC with Spitzer. We deliver reduced data from the Spitzer archive which falls within the SAGE footprint on the LMC. This delivery includes IRS staring mode data from Spitzer cycles 1–3 and the Guaranteed Time Observations (GTOs). This comprises 403 spectra of 352 objects or lines-of-sight. Details of program data included can be found in Table 1.1. We match this spectral data with near- and mid-IR photometry (see next section). In addition, we update some of the matching broadband photometry previously delivered with the 197 SAGE-Spec proposal point sources.

For the first time we release IRS mapping data of 23 diffuse and HII regions in the form of order cubes, 3 of which were taken from the Spitzer archive. All but one (SSDR12) of these regions are also covered by MIPS-SED observations, for which we also deliver reduced data. Our previous reductions of MIPS-SED data of 48 point sources have been revised, and several serendipitous sources have been added to the sample so that the total number is now 61 (with 63 spectra; Table 1.2).

## 1.3 Description of the observations in previous data releases

In the first delivery of SAGE-Spec data in August 2009 we delivered IRS staring mode spectra of 197 point sources and MIPS-SED spectra of 48 point sources selected from the SAGE catalogue. The IRS staring mode spectra are complemented by matching photometry from SAGE (IRAC and MIPS; Meixner et al. 2006), MCPS (Zaritsky et al. 2004), 2MASS (Skrutskie et al. 2006) and IRSF (Kato et al. 2007). We also delivered Postscript plots of the 197 the IRS spectra with associated photometry.

## 1.4 Description of the observations in future data releases and delivery timeline

Further data deliveries will be made to the Spitzer Science Center (SSC) on a six-monthly basis, as follows:

**Autumn 2010:** A re-reduction of IRS staring data for the 197 SAGE-Spec proposal sources.

Object classifications for these sources. Reductions of the calibration data from the Spitzer IRS archive. Revised order cubes for IRS and MIPS-SED extended regions. Integrated spectra for these extended regions.

**Spring 2011:** Reductions of the remaining IRS staring data from the Spitzer archive (cycles 4 & 5). Object classifications for the entire Spitzer IRS archive (GTO, cycles 1–5, calibration data). Spectral classifications for the entire Spitzer IRS archive (GTO, cycles 1–5, calibration data). Statistical object classification of the SAGE point source catalogue. Feature maps of extended regions covered by IRS and MIPS-SED observations.

Table 1.1: Archival IRS staring data in the present delivery

| Cycle   | Program ID | Program PI    | notes                            |
|---------|------------|---------------|----------------------------------|
| 1 (GTO) | 18         | Uchida        | 10 hires spectra                 |
| 1 (GTO) | 63         | Brandl        | 19 hires, 17 lores spectra       |
| 1 (GTO) | 103        | Bernard-Salas | 18 hires, 18 lores spectra       |
| 1 (GTO) | 124, 129   | Gehrz         | 6 slhi, 2 lores spectra          |
| 1 (GTO) | 200        | Sloan         | 29 lores spectra                 |
| 1 (GTO) | 249        | Indebetouw    | 6 lores spectra                  |
| 1 (GTO) | 263        | Woodward      | 1 lores spectrum                 |
| 1 (GTO) | 464        | Cohen         | 7 lores spectra                  |
| 1       | 1094       | Kemper        | 9 hires, 2 slhi, 9 lores spectra |
| 1       | 2333       | Woodward      | 4 slhi spectra                   |
| 1       | 3426       | Kastner       | 60 lores spectra                 |
| 1       | 3470       | Bouwman       | 1 hires spectrum                 |
| 1       | 3483       | Rho           | 1 lores spectrum                 |
| 1       | 3505       | Wood          | 31 lores spectra                 |
| 1       | 3578       | Misselt       | 13 lores spectra                 |
| 1       | 3583       | Onaka         | 12 lores spectra                 |
| 1       | 3591       | Kemper        | 53 lores spectra                 |
| 2       | 20080      | Polomski      | 1 lores spectrum                 |
| 2       | 20443      | Stanghellini  | 20 lores spectra                 |
| 2       | 20752      | Reynolds      | 1 hires spectrum                 |
| 3       | 30067      | Dwek          | 4 lores spectra                  |
| 3       | 30077      | Evans         | 1 lores spectrum                 |
| 3       | 30180      | IRAC          | 1 lores spectrum                 |
| 3       | 30332      | Sloan         | 1 lores spectrum                 |
| 3       | 30345      | Sloan         | 4 hires spectra                  |
| 3       | 30372      | Tappe         | 7 lores spectra                  |
| 3       | 30380      | Clayton       | 1 lores spectrum                 |
| 3       | 30544      | Morris        | 1 lores spectrum                 |
| 3       | 30788      | Sahai         | 24 lores spectra                 |
| 3       | 30869      | Kastner       | 1 slhi, 8 lores spectra          |

Table 1.2: Point sources observed in MIPS-SED mode

| SSID | Source name                | Co-ordinates (J2000)      | AOR key  | Former SSID |
|------|----------------------------|---------------------------|----------|-------------|
| 600  | SAGE1C J043727.60-675435.0 | 4h37m27.61s, -67d54m35.0s | 22459648 | 500         |
| 601  | SMP-LMC-11                 | 4h51m37.82s, -67d05m17.0s | 22450432 | 501         |
| 602  | IRAS04530-6916             | 4h52m45.70s, -69d11m49.4s | 22453504 | 502         |
| 603  | IRAS04537-6922             | 4h53m30.11s, -69d17m49.3s | 22457088 | 503         |
| 604  | LH $\alpha$ 120-N89        | 4h55m06.53s, -69d17m08.5s | 22460416 | 504         |
| 605  | WOH 6064                   | 4h55m10.48s, -68d20m29.9s | 22448640 | 505         |
| 606  | IRAS04557-6639             | 4h55m50.59s, -66d34m34.7s | 22457344 | 506         |
| 607  | IRAS04562-6641             | 4h56m22.59s, -66d36m56.8s | 22457600 | 507         |
| 608  | R66                        | 4h56m47.08s, -69d50m24.8s | 22453760 | 508         |
| 609  | R71                        | 5h02m07.40s, -71d20m13.0s | 22454016 | 509         |
| 610  | IRAS05047-6644             | 5h04m47.00s, -66d40m30.3s | 22451456 | 510         |
| 611  | SMP-LMC-21                 | 5h04m51.97s, -68d39m09.5s | 22450688 | 511         |
| 612  | SMP-LMC-28                 | 5h07m57.62s, -68d51m47.3s | 22450944 | 512         |
| 613  | SMP-LMC-36                 | 5h10m39.60s, -68d36m04.9s | 22459664 | 513         |
| 614  | IRAS05137-6914             | 5h13m24.66s, -69d10m48.1s | 22452992 | 514         |
| 615  | MSX-LMC222                 | 5h13m41.99s, -69d35m26.7s | 22451712 | 515         |
| 616  | SAGE1C J051347.73-693505.3 | 5h13m46.5s, -69d35m10s    | 22451712 | —           |
| 617  | MSX-LMC349                 | 5h17m26.93s, -68d54m58.7s | 22449920 | 516         |
| 618  | IRAS05216-6753             | 5h21m29.68s, -67d51m06.6s | 22451968 | 517         |
| 619  | SAGE1C J052222.95-684101.0 | 5h22m22.96s, -68d41m01.1s | 22457856 | 518         |
| 620  | HS270-IR1                  | 5h23m53.93s, -71d34m43.8s | 22458112 | 519         |
| 621  | SMP-LMC-62                 | 5h24m55.08s, -71d32m56.1s | 22451200 | 520         |
| 622  | LH $\alpha$ 120-N51-YSO1   | 5h26m01.22s, -67d30m11.9s | 22458368 | 521         |
| 623  | LH $\alpha$ 120-N49        | 5h26m03.10s, -66d05m17.2s | 22454272 | 522         |
| 624  | LH $\alpha$ 120-N49        | 5h26m07s, -66d05m00s      | 22454272 | —           |
| 625  | MSX-LMC577                 | 5h26m30.60s, -67d40m36.7s | 22455296 | 523         |
| 626  | LH55                       | 5h26m38.6s, -67d39m23s    | 22455296 | —           |
| 627  | IRAS05281-7126             | 5h27m23.14s, -71d24m26.3s | 22458624 | 524         |
| 628  | IRAS05280-6910             | 5h27m40.06s, -69d08m04.6s | 22454528 | 525         |
| 629  | IRAS05291-6700             | 5h29m07.59s, -66d58m15.1s | 22450176 | 526         |
| 630  | IRAS05298-6957             | 5h29m24.53s, -69d55m15.9s | 22448896 | 527         |
| 631  | IRAS05325-6629             | 5h32m31.95s, -66d27m15.2s | 22452224 | 528         |
| 632  | IRAS05328-6827             | 5h32m38.59s, -68d25m22.4s | 22452480 | 529         |
| 633  | RP775                      | 5h32m44.40s, -69d30m05.5s | 22459904 | 530         |
| 634  | IRAS05330-6826             | 5h32m48.3s, -68d23m59s    | 22452480 | —           |
| 635  | SAGE1C J053249.35-693036.8 | 5h32m49.4s, -69d30m37s    | 22459904 | —           |
| 636  | IRAS05329-6708             | 5h32m51.36s, -67d06m51.8s | 22449152 | 531         |
| 637  | MSX-LMC783                 | 5h32m55.44s, -69d20m26.6s | 22455552 | 532         |
| 638  | HV2671                     | 5h33m48.92s, -70d13m23.6s | 22454784 | 533         |

continued on next page...

Table 1.2 – continued from previous page

| SSID | Source name                | Co-ordinates (J2000)      | AOR key  | Former SSID |
|------|----------------------------|---------------------------|----------|-------------|
| 639  | SN 1987A                   | 5h35m23.8s, -69d17m07s    | 17720320 | —           |
| 640  | MSX-LMC741                 | 5h35m25.83s, -71d19m56.6s | 22455808 | 534         |
| 641  | SN 1987A                   | 5h35m31.5s, -69d17m09s    | 22393344 | —           |
| 642  | SN 1987A                   | 5h35m38.1s, -69d16m43s    | 17721600 | —           |
| 643  | SN 1987A                   | 5h35m38.2s, -69d16m43s    | 22394624 | —           |
| 644  | R126                       | 5h36m25.85s, -69d22m55.7s | 22455040 | 535         |
| 645  | 30Dor-17                   | 5h37m28.09s, -69d08m47.8s | 22452736 | 536         |
| 646  | H88b 86?                   | 5h38m40.9s, -69d25m14s    | 22460672 | —           |
| 647  | LH $\alpha$ 120-N158B      | 5h38m44.53s, -69d24m38.3s | 22460672 | 537         |
| 648  | LH $\alpha$ 120-N159-P2    | 5h39m41.86s, -69d46m11.9s | 22453248 | 538         |
| 649  | LH $\alpha$ 120-N159-K4?   | 5h39m55.0s, -69d46m16s    | 22459136 | —           |
| 650  | LH $\alpha$ 120-N160-1     | 5h39m59.49s, -69d37m30.3s | 22458880 | 539         |
| 651  | LH $\alpha$ 120-N159S      | 5h40m00.67s, -69d47m13.4s | 22459136 | 540         |
| 652  | LH $\alpha$ 120-N160-3     | 5h40m04.4s, -69d38m21s    | 22458880 | —           |
| 653  | UFO1                       | 5h40m11.83s, -70d10m04.2s | 22456064 | 541         |
| 654  | WOH-G457?                  | 5h40m11.95s, -70d09m15.7s | 22449408 | 542         |
| 655  | RP85                       | 5h40m33.57s, -70d32m40.3s | 22460160 | 543         |
| 656  | SAGE1C J054043.15-701110.3 | 5h40m43.18s, -70d11m10.3s | 22456320 | 544         |
| 656  | SAGE1C J054043.15-701110.3 | 5h40m43.18s, -70d11m10.3s | 22456832 | —           |
| 657  | MSX-LMC1794                | 5h40m44.00s, -69d25m54.5s | 22456576 | 545         |
| 658  | MSX-LMC956                 | 5h40m49.27s, -70d10m13.6s | 22456832 | 546         |
| 658  | MSX-LMC956                 | 5h40m49.27s, -70d10m13.6s | 22456320 | —           |
| 659  | BSDL2955                   | 5h45m43.9s, -67d09m55s    | 22459392 | —           |
| 660  | BSDL2959                   | 5h45m44.80s, -67d09m28.2s | 22459392 | 547         |

Table 1.2: The reader is also referred to van Loon et al. (2010) for integration times, quality control and other information.

## 1.5 Format of the database at the Spitzer Science Center

The SAGE-Spec database can be reached via the Legacy page on the Spitzer Science Center website, or via direct link:

<http://ssc.spitzer.caltech.edu/legacy/sagespechistory.html>

The database is made up of a tables of metadata and associated data products (FITS files, FITS data cubes, plots of spectra and associated photometry). The format of these tables is slightly different for the IRS staring data and the MIPS-SED data.

### 1.5.1 IRS staring point source data

The IRS staring spectra have an associated metadata file, which is in IPAC tbl format. This table has slightly different formats for the SAGE-Spec proposal targets (delivered to the SSC



in August 2009) and the Spitzer archival targets (first delivered to the SSC in February 2010).

**SAGESpecID:** This is a unique identifier for each target. SAGE-Spec point sources are labelled with numbers 1–197, which are obtained by ordering the sources sequentially according to Right Ascension (R.A.). Archival sources in this delivery are labelled 1000–1351.

**label:** This is a unique identifier for each spectrum. It is constructed by concatenating R.A. (to 4 decimal places) and declination (dec; to 4 decimal places), instrument name (i.e., IRSX or MIPS) and module name with nod or processing information, for example:  
79.7943-69.5629\_IRSX\_SL\_(scaled).

For the archival targets, this label also includes the SAGE-Spec ID and an integer which increments with every associated spectrum, for example:

70.1187-69.9202\_IRSX\_1006\_1\_SL\_LL\_(scaled)

70.1190-69.9203\_IRSX\_1006\_2\_SH\_LH\_(scaled)

70.1192-69.9206\_IRSX\_1006\_3\_LL\_(scaled)

For further details, see **modules**, below).

**ra:** Right ascension Field-Of-View (FOV) co-ordinates (J2000)<sup>1</sup>.

**dec:** Declination FOV co-ordinates (J2000)<sup>1</sup>.

**SAGEIRACID:** Associated SAGE-LMC IRAC source designation.

**SAGEMIPSID:** Associated SAGE-LMC MIPS 24  $\mu$ m source designation.

**AORkey:** Astronomical Observation Request (AOR) number of the Spitzer observation.

**progid:** Program ID in which data were obtained (for SAGE-Spec this is 40159).

**instrument:** IRSX for Infrared Spectrograph, MIPS for Multiband Imaging Photometer for Spitzer.

**modules:** One of:

SL, LL (scaled)

SL, LL (unscaled)

SL (scaled)

SL (unscaled)

LL (scaled)

LL (unscaled)

SL Order 1 Nod 1

SL Order 1 Nod 2

SL Order 2 Nod 1 plus bonus order

SL Order 2 Nod 2 plus bonus order

---

<sup>1</sup>We purposefully choose to use FOV co-ordinates (i.e., ra\_fov and dec\_fov in the FITS headers) over requested co-ordinates (ra\_rqst and dec\_rqst, also found in FITS headers, and which are those obtained when one queries via Leopard, for example) since the FOV co-ordinates most accurately determine the region of space the telescope is pointing at. In general, FOV co-ordinates differ from requested co-ordinates by  $\approx 0''.75$ . However, in extreme cases, there can be a difference of up to  $\approx 5''.7$  between the two co-ordinate systems in the SAGE-Spec IRS sample.

LL Order 1 Nod 1

LL Order 1 Nod 2

LL Order 2 Nod 2 plus bonus order

LL Order 2 Nod 1 plus bonus order

SH, LH (scaled) [archival data only]

SH, LH (unscaled) [archival data only]

SL, SH (scaled) [archival data only]

SL, SH (unscaled) [archival data only]

In most cases, the end user will require just the SL, LL (scaled) version of the spectrum or equivalent high-resolution spectrum. For the SAGE-Spec proposal sources (SSID1–197) we have delivered spectra for each individual nod; for the SAGE-Spec archival sources (SSID1000–1351) we only deliver scaled and unscaled stitched spectra.

**pipelineVersion:** Spitzer data reduction pipeline version.

**objectName:** Chosen name for object, usually the oldest historically.

**alternateName:** Other useful identifiers.

**quality:** Data quality notes are: 'OK'; 'Wa' (warning, use spectrum with caution); 'Fa' (fatal, spectrum is bad) – see the notes field for an explanation [archival data only]

**notes:** quality control comments detailing any data complexities [archival data only]

Spectra are then available separately as single files or a large archive, with or without additional photometry points. Please see the README file for further information.

## 1.5.2 MIPS-SED point source data

The MIPS-SED data are available as separate files with incorporated metadata. Column headings are:

**SAGESpecID:** This is a unique identifier for each point source. MIPS-SED sources are labelled with numbers 500–562, which are obtained by ordering the sources sequentially according to Right Ascension (R.A.).

**label:** This is a unique identifier for each spectrum. It is constructed by concatenating R.A. (to 4 decimal places) and declination (dec; to 4 decimal places), instrument name (MIPSSSED) and an optional integer increment for sources with more than one spectrum, for example: 85.1799-70.1862\_MIPSSSED\_2.

**ra:** Right ascension co-ordinates (J2000)

**dec:** Declination co-ordinates (J2000)

**objectName:** Chosen name for object.

**quality:** This can be one of “good”, “ok”, “poor” and “bad”. These terms are explained in Section 3.1.3.

**waveLength:** wavelength in microns.

**flux:** flux in Jansky units.

**fluxUnc:** flux uncertainty in Jansky units.

**SN:** signal-to-noise ratio.

**sky:** sky noise.

### 1.5.3 IRS & MIPS-SED extended region data

Metadata for extended region data comprises of:

**Name:** Chosen name for object; SDR represents SAGE-Spec Diffuse Region, DEM numbers are taken from the catalogue of Davies et al. (1976).

**ra:** Right ascension co-ordinates (J2000)

**dec:** Declination co-ordinates (J2000)

**IRS SL AORID:** AOR number for IRS SL observation.

**IRS LL AORID:** AOR number for IRS LL observation.

**MIPS-SED AORID:** AOR number for MIPS-SED observation.

This data is also presented in Table 2.1.

## 1.6 Format of the plots which accompany the data delivery

Each plot, which has a filename of `<label>.ps` (e.g., `76.2155-66.6354_IRSX_SL_LL_scaled.ps`), is composed of four panels (see Fig. 1.1). Clockwise from the top-left these panels represent:

Full IRS spectrum plotted with error bars.

Full IRS spectrum plotted with modules in different colours to show where the joins lie.

Spectral energy distribution with photometric points and IRS spectrum, shown in log scale.

Spectral energy distribution with photometric points and IRS spectrum, shown in linear scale.

Each plot also includes the SAGE-Spec ID and the chosen point source name.

## 1.7 Photometric matching of point source data

For each SAGE-Spec source a cone search using a radius of  $20''$  is performed against the SAGE-LMC photometric database. The possible matches are retained in the following manner:

1. Only the closest match in each of the categories below are chosen.
2. Each of these closest matches is further restricted:
  - (a) IRAC (3.6, 4.5, 5.8, 8.0  $\mu\text{m}$ ) matches must be within  $3''$ .
  - (b) MIPS 24 $\mu\text{m}$  matches must be within  $3''$ .
  - (c) MIPS 70 $\mu\text{m}$  matches must be within  $10''$ .

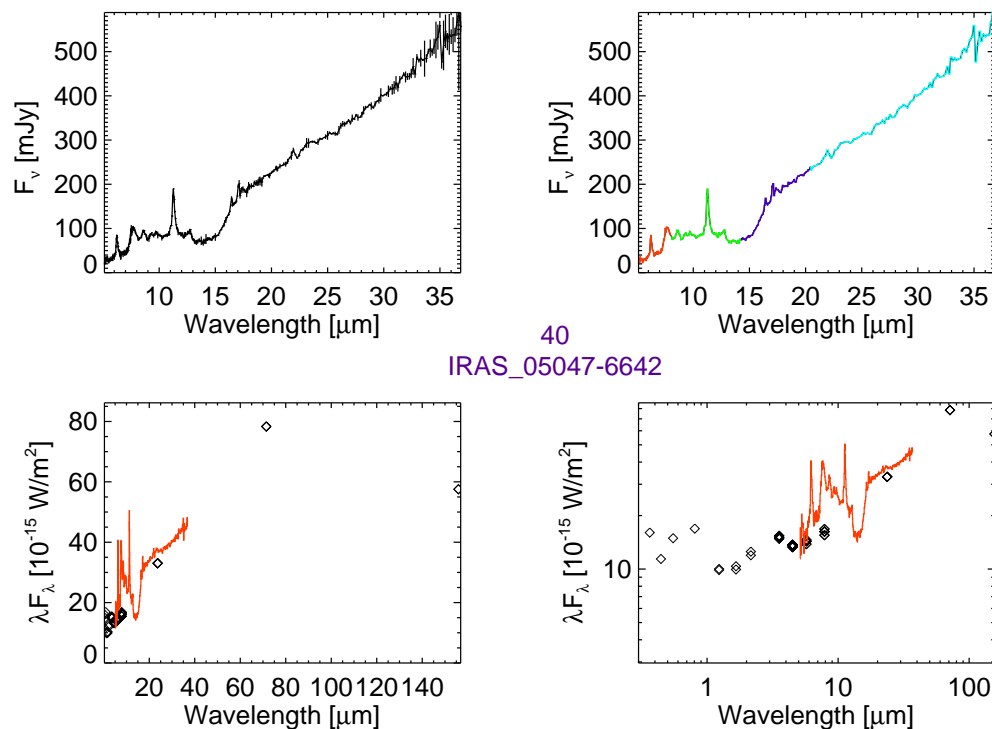


Figure 1.1: An example plot of the IRS staring data for SAGE-Spec source 40 (see text).

- (d) MIPS  $160\mu\text{m}$  matches must be within  $20''$ .
- (e) Two Micron All Sky Survey (2MASS) JHK matches must be within  $3''$ .
- (f) Infrared Survey Facility (IRSF) JHK matches must be within  $3''$ .
- (g) Magellanic Clouds Photometric Survey (MCPS) UVBI matches must be within  $3''$ .

## 1.8 Core team members

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**Karl Gordon (Space Telescope Science Institute):** IRS extended region and MIPS-SED data reduction.

**Margaret Meixner (Space Telescope Science Institute):** science overview, observing strategy, database, SAGE-LMC photometry liaison.

**Remy Indebetouw (University of Virginia/NRAO):** quality control, IRS extended region data reduction.

**Massimo Marengo (Harvard CfA/Iowa State University):** source classification.

**Greg Sloan (Cornell University):** IRS staring data reduction, observing strategy.

**Xander Tielens (Leiden Observatory):** science overview.

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MCPS data are publicly available from

<http://ngala.as.arizona.edu/dennis/mcsurvey.html>

The IRSF website is at: [http://www.z.phys.nagoya-u.ac.jp/~irsf/index\\_e.html](http://www.z.phys.nagoya-u.ac.jp/~irsf/index_e.html)

## Chapter 2

# IRS spectroscopy

### 2.1 Point sources

#### 2.1.1 Observation settings

All IRS observations in this data delivery were obtained in staring mode, using the SL and LL modules. Each target was observed after a high-accuracy peak-up, usually on the target itself. In cases where the target was too bright or faint or in a crowded region, the telescope peaked up on a nearby 2MASS source. Within each module, the number and length of integration cycles for the two apertures matched, in order to maximize the options for background subtraction.

All SAGE-Spec IRS staring data were obtained by the Spitzer Space Telescope from IRS Campaigns 47 to 53. These covered the period from January 9 to August 16 2008.

#### 2.1.2 Data processing

The IRS data in this delivery were processed using the SSC pipeline S17.2. Before spectra were extracted, the background was subtracted from each image, and the resulting difference image was cleaned to replace pixels flagged as bad with data from neighbouring pixels. Spectra were extracted from individual images, then calibrated and co-added.

For SL, the default background subtraction was an aperture difference, where an image with the source in one aperture served as the background for the image with the source in the other aperture, but the same nod position. For example, for SL1 nod 1, the background image was SL2 nod 1. For LL, the default was a nod difference, where the image with the source in one nod position served as the background for the image with the source in the other nod position in same aperture. Thus LL1 nods 1 and 2 served as backgrounds for each other, and likewise for LL2 nods 1 and 2.

In many cases, complex backgrounds or additional sources in the on-target aperture or off-target aperture forced us to modify the background subtraction. In addition to aperture or nod differences, we occasionally resorted to cross differences (other aperture, other nod). In some cases, no suitable background subtraction was possible, which could result in compromised or useless spectroscopy. See Section 2.1.3 for more detailed information.

We relied on the `bmask` images supplied with each data image by the SSC and the campaign rogue masked produced by the SSC to identify bad pixels. Any pixel with a `bmask` value of 4096 or higher was replaced. Any pixel which was identified as a rogue in any two campaigns from the start of the mission through Camp. 54 was also replaced. Additionally, all NaNs in the data were replaced.

To replace bad pixels, we applied the `imclean.pro` IDL procedure written at Cornell University. This algorithm now serves as the core of the pixel-replacement within `irsclean.pro`, which is provided by the SSC. To replace a bad pixel, the spatial profile of neighbouring rows are scaled to the row with the bad pixel. A replacement value is constructed from good data in the same column. This algorithm assumes that spatial structure of the source is unchanged over the rows in question and thus it could break down in the vicinity of spectral changes in spatial structure, such as spatially extended emission from a forbidden line near an unresolved continuum source.

To extract spectra from the spectral images, we used the `profile`, `ridge`, and `extract` modules of the SSC pipeline. These are available within SPICE. The resulting extraction is equivalent to a tapered-column extraction within SMART, with the extraction aperture two pixels wide in the dispersion direction and increasing in width in the cross-dispersion (spatial) direction linearly with wavelength. The S17.2 data are actually a mixture of pipeline versions, with SL calibrated to S15.3 and LL effectively unchanged since S15.3. Thus we used the S15.3 `wavesamp` and `psf_fov` (Point-spread function field of view) files when extracting. These set the extraction apertures as follows:

| order    | width (pix) | wavelength ( $\mu\text{m}$ ) |
|----------|-------------|------------------------------|
| SL2      | 4.000       | 6.0                          |
| SL-bonus | 5.333       | 8.0                          |
| SL1      | 8.000       | 12.0                         |
| LL2      | 4.250       | 16.0                         |
| LL-bonus | 5.445       | 20.5                         |
| LL1      | 7.172       | 27.0                         |

Spectra are extracted from each spectral image in a given nod position, then calibrated from digital units to flux density units (Janskys). The spectral correction is based on comparison of similarly processed spectra of calibration stars to spectral templates for those stars produced at Cornell. (A paper describing this process is in preparation.) HR 6348 (K0 III) served as the calibrator for all SL data. It and two later K giants, HD 166780 (K4 III) and HD 173511 (K5 III) served as the calibrators for all LL data.

The spectrum reported for each nod position includes the mean of the individually extracted spectra in that position, and the formal uncertainty in the mean (standard deviation / square root of the number of images). The individual nod spectra are included in this data delivery.

To produce a complete spectrum for SL and LL, which are also included in this delivery, we average the spectra from the two nods, and we append the data from the three orders to each other. When combining the nods, spikes and divots which appear in only one nod but not the other are rejected. In these cases, only the data from the better-behaved nod are used. New uncertainties in the mean are calculated (before spike rejection, not after), and if they

are larger than the propagated error from the two nods, are used in their place. Note that the formal uncertainty in the mean of two data is just half the difference in the data.

Thus this data delivery includes five spectra from SL and five from LL (the combined spectrum from the module and the four components from both nods in both apertures). In addition, we also provide a combined low-resolution spectrum, produced by appending the LL data to the SL, and a final low-resolution spectrum, corrected for discontinuities between segments (stitched), and with extraneous data removed (trimmed).

To produce this final spectrum, we assume that the discontinuities between spectral segments arise from pointing errors, which lead to partial truncation of mispointed sources by the slit edges. Thus, segments are calibrated upwards to the presumably best-centered segment. This usually means that SL is scaled upward to LL, since pointing errors have more impact in the smaller SL slit. The corrections are multiplicative scalar corrections and have no dependence on wavelength. This assumption is reasonable for corrections of roughly 10% or less. For larger corrections, the general shape of the continuum can no longer be relied upon as accurate. The bonus-order data have been combined with overlapping first- and second-order data before spectra are corrected for discontinuities. The corrections are calculated using the wavelengths of overlap between adjacent spectral segments. In the case of SL2 and LL2, the bonus order which were taken at the same time, and with the target at the same place in the aperture, provide the overlap needed between first- and second-order data.

Two more modifications have been made to spectra in the final delivered product. Any uncertainty which suggests a signal/noise ratio greater than 500 is reset so that the S/N equals 500. Finally, spectra are truncated to delete data which cannot be calibrated, using the wavelength ranges in the table below:

| order    | wavelength range<br>( $\mu\text{m}$ ) |
|----------|---------------------------------------|
| SL2      | 5.10 – 7.59                           |
| SL-bonus | 7.73 – 8.39                           |
| SL1      | 7.59 – 14.33                          |
| LL2      | 14.20 – 20.54                         |
| LL-bonus | 19.28 – 21.23                         |
| LL1      | 20.46 – 37.00                         |

Note that from 20.46 to 20.54  $\mu\text{m}$ , all three LL segments are valid. The regions of overlap between segments are the regions used to determine corrections for discontinuity.

### 2.1.3 Quality control of the data

The Basic Calibrated Data (BCD) generated by the Spitzer pipeline was checked visually by members of the SAGE-Spec team. Various data errors were flagged, and BCDs which would require deviation from the standard processing (Sect. 2.1.2) were noted. Errors found included FUDL (Fast Uplink Downlink) errors, caused by improper data transmission from the spacecraft, cosmic ray hits on the CCD, spectral images which contained more than one spectral trace (i.e., detection of a nearby source in addition to the targeted source) and “jailbarring”,



where repeating vertical patterns (residuals) every four columns are left by Spitzer's A/D converters in cases of a high background on the peak-up arrays (e.g., if the emission from a bright source happens to fall on a peak-up array). In addition, background emission or gradients may have required a change in the standard subtraction algorithm, as detailed above (Sect. 2.1.2). One DCE (Data Collection Event) was visually examined per EXPID (exposure ID), of which there were usually several per module in each BCD. In general, these errors were corrected by: **FUDL errors:** The spectra from the affected images were dropped from further consideration. In addition, images with FUDL errors were not used for background subtraction.

**cosmic rays:** Most cosmic ray hits were flagged as such and replaced by our `imclean.pro` procedure. Images with unflagged cosmic ray hits were treated in the same way as images with FUDL errors if the affected pixels were in the vicinity of the source (or the source in another image if the affected image was used as a background).

**multiple sources and background issues:** These generally required that we modify the background subtraction scheme. In some cases, we were forced to drop one of the nod spectra from consideration because there was no way to avoid problems caused by other sources or background gradients (either in the target image or in a background image). In a few cases, we were unable to mitigate for the problems, and these are noted in Table B.1.

#### 2.1.4 Caveats

Users of the staring-mode IRS spectra should be sure to examine the error bars to the spectra because these they indicate confidence limits and potential problems with the data. In particular, large error bars throughout a spectral segment indicate that the two spectra from the individual nod positions do not agree, probably due to additional sources or background gradients in the slit which we were unable to correct. Also, a large error bar for a single pixel when surrounded by much smaller error bars indicates that at that wavelength, one of the two nod spectra contained a large spike or divot that was rejected when the nods were combined into a single spectrum. The error bar was calculated based on the rejected datum and retained.

Users should also be aware that the LL slit is significantly larger than the SL slit (10'' across compared to 3.6''), and that many of the SAGE-Spec sources show some spatial structure. Often, the SL segments were normalized up to the LL segments more than the ~10–15% expected for random pointing errors for unresolved sources. The `CORRSL2`, `CORRSL1`, `CORRLL2`, and `CORRLL1` keywords in the spectral file headers contain the factors by which each segment was divided to align the spectra; anything smaller than 0.85 indicates a spatially extended source.

The large LL slit often contains excess background emission, which will result in the spectrum beginning to rise in the LL1 spectral segment. This rise to the red is often, but not always, accompanied by larger error bars, since the spectra from the sky subtraction will have differing degrees of success in the two nods in these cases.

## 2.2 Extended sources

Table 2.1: SAGE-Spec Extended Regions

| Name      | RA(2000)  | Dec(2000)  | IRS SL AORID | IRS LL AORID | MIPS-SED AORID |
|-----------|-----------|------------|--------------|--------------|----------------|
| SSDR 1    | 83.009083 | -68.470444 | 22460928     | 22460928     | 22465024       |
| SSDR 2    | 85.925042 | -68.252056 | 22461184     | 22461184     | 22465280       |
| SSDR 3    | 78.931834 | -68.055639 | 22461440     | 22461440     | 22465536       |
| SSDR 4    | 71.920208 | -67.208611 | 22461696     | 22461696     | 22465792       |
| SSDR 5    | 88.975792 | -68.199194 | 22461952     | 22461952     | 22466048       |
| SSDR 6    | 86.817875 | -70.715417 | 22462208     | 22462208     | 22466304       |
| SSDR 7    | 83.789000 | -70.056722 | 22462464     | 22462464     | 22466560       |
| SSDR 8    | 81.604875 | -67.485583 | 22462720     | 22462720     | 22466816       |
| SSDR 9    | 83.044708 | -68.353000 | 22479360     | 22479360     | 22480384       |
| SSDR 10   | 83.095625 | -66.478194 | 22479872     | 22479872     | 22480896       |
| SSDR 11   | 85.915208 | -68.771833 | 24241664     | 24241664     | 24242432       |
| SSDR 12   | 82.779583 | -68.320000 | 24242176     | 24242176     | —              |
| DEM L 8   | 73.026292 | -66.924194 | 22469120     | 22469120     | 22474240       |
| DEM L 10  | 73.049584 | -69.345306 | 22469376     | 22469376     | 22474496       |
| DEM L 34  | 74.208709 | -66.413889 | 22469632     | 22469632     | 22474752       |
| DEM L 40  | 74.421709 | -67.648306 | 22469888     | 22469888     | 22475008       |
| DEM L 55  | 75.421708 | -70.646889 | 22470144     | 22470144     | 22475264       |
| DEM L 86  | 77.483292 | -68.900889 | 22470400     | 22470400     | 22475520       |
| DEM L 188 | 81.267917 | -71.463111 | 22470656     | 22470656     | 22475776       |
| DEM L 243 | 83.879583 | -66.044111 | 22470912     | 22470912     | 22476032       |
| DEM L 308 | 86.224583 | -67.348389 | 22471168     | 22471168     | 22476288       |
| DEM L 323 | 87.218292 | -70.064305 | 22471424     | 22471424     | 22476544       |
| 30 Dor    | 84.7063   | -69.0993   | 18630144     | 18635008     | 18633728       |

### 2.2.1 Observation settings

All the IRS extended source observations in this data delivery were obtained using the standard IRS spectral mapping template. The names, central coordinates, and AOR numbers for the IRS observations are given in Table 2.1. The regions mapped were chosen to be large enough to sample the entire region or a representative region (usually a radial strip). All the observations were paired with dedicated background observations taken in a low surface brightness region located outside of the LMC.

### 2.2.2 Data processing

The pipeline reduced IRS spectral mapping data were retrieved from the Spitzer archive (versions S17.0.4 to S18.7.0). These individual observations were combined into spectral cubes using the CUBISM software (Smith et al. 2007). The dedicated off-LMC background observations were subtracted from the on- and off-source mosaics prior to combining using CUBISM.

Each extended source spectral mapping observation results in six different order cubes (except for 30 Dor that only has four order cubes). These six different order cubes per object are the deliverables for this release. Later releases will include a single merged spectral cube covering the entire IRS spectral range. Full astrometry for each cube (both spatial and spectral) is captured as part of the FITS header of the spectral cube.

### **2.2.3 Quality control of the data**

The quality control on the IRS spectral mapping observations was focused on examining the mosaics. Some of the faint sources exhibit issues with varying instrumental darks during the exposure and mismatches between spectral orders. Fixes for these issues are being investigated and provided in future releases.

## Chapter 3

# MIPS-SED spectroscopy

### 3.1 Point sources

#### 3.1.1 Observation settings

All the MIPS-SED point source observations in this data delivery were obtained using the standard MIPS-SED point source template. The chop distance and total exposure time was adjusted based on the nearby sources seen in the MIPS 70  $\mu\text{m}$  image and the measured MIPS 70  $\mu\text{m}$  photometry, respectively.

#### 3.1.2 Data processing

The MIPS-SED data were processed through the MIPS Data Analysis Tool (DAT, v3.10, 3 Jul 2007). The details of the MIPS DAT are given by Gordon et al. (2005). The product of the MIPS DAT is both on-source background subtracted (on-off), on-source only, and off-source only rectified mosaics combining all the appropriate observations in an AOR. For the majority of the sources, the on-source background subtracted mosaics (on-off) was used as this removes the majority of the background emission and residual instrumental signatures.

The spectra were extracted from the 2D rectified mosaics. First, a spatial profile was created by collapsing the 2D mosaic along the wavelength axis. In most cases, the maximum in the spatial profile identified the source position along the slit. The extraction was done using the standard width of 5 pixels with residual background subtraction done using two regions 3 pixels wide located on either side of the source. In the few cases where the off-source chop position was contaminated by another source, the on-source data was used and the background subtraction using the two background regions on either side of the source. For a few, faint sources, the source position was fixed to the default location.

The extracted spectra were trimmed to reject all data beyond 95 microns as these wavelengths are contaminated by 2nd order flux. The spectra were corrected to infinite aperture and calibrated using the results given by Lu et al. (2008).

### 3.1.3 Quality control of the data

The quality control on the MIPS-SED observations was focused on examining the mosaics and spatial profile of the source. The quality of a spectrum was deemed as “good” if there was no source in the off-source position and the spatial profile was distinctly a point source. A source was “ok” if there was a faint source in the off-source position or if its spatial profile was not as simple as a single point source, but still enough like a point source to get a decent extraction. A source was “poor” if there was a bright source in the off-source mosaic or it was very extended. A source was “bad” if there was no reasonable source to be extracted.

## 3.2 Extended sources

### 3.2.1 Observation settings

All the MIPS-SED extended source observations in this data delivery were obtained using the standard MIPS-SED mapping template. The names, central coordinates, and AOR numbers for the MIPS-SED observations are given in Table 2.1. The regions mapped were chosen to be large enough to sample the entire region or a representative region (usually a radial strip). All the observations were paired with dedicated background observations taken in a low surface brightness region located outside of the LMC.

### 3.2.2 Data processing

The MIPS-SED data were processed through the MIPS Data Analysis Tool (DAT, v3.10, 3 Jul 2007). The details of the MIPS DAT are given by Gordon et al. (2005). The product of the MIPS DAT is both on-source background subtracted (on-off), on-source only, and off-source only rectified mosaics combining all the appropriate observations in an AOR.

For each spectral map, spectral cubes were created using custom IDL code (C. Engelbracht et al., in prep.) that uses the on-source and off-source MIPS DAT products to create a 3D spectral cube (which is basically an image at each wavelength). The dedicated off-LMC background observations were subtracted from the on- and off-source mosaics prior to combining using the custom IDL software. Full astrometry for the cube (both spatial and spectral) is captured as part of the FITS header of the spectral cube. The extended source calibration of this code has been checked between similar MIPS SED mapping and  $70\ \mu\text{m}$  imaging observations in the SINGS Legacy sample (C. Engelbracht et al., in prep.).

The spectral cubes include data beyond 95 microns, but this data should be used with extreme caution as these wavelengths are contaminated by 2nd order flux.

### 3.2.3 Quality control of the data

The quality control on the MIPS-SED spectral mapping observations was focused on examining the mosaics and fitted continuum/line strengths. Reasonable results were obtained. An additional check was made between extracted spectra of the entire regions and the equivalent

70  $\mu\text{m}$  photometry of the same regions. The results of this additional check indicates that the flux calibration of the the MIPS-SED spectral mapping is as expected.

# Appendix

## Appendix A

# Availability of spectra and photometry

Table A.1: Photometry and spectroscopy for SAGE-Spec sources observed in IRS staring mode.<sup>1</sup>

| SAGE-Spec source ID | UBVI | JHK | IRAC | MIPS    | SL | LL | MIPS-SED |
|---------------------|------|-----|------|---------|----|----|----------|
| 1                   | BVI  | ✓   | ✓    | 24      | ✓  | —  | —        |
| 2                   | —    | ✓   | ✓    | 24, 70  | ✓  | ✓  | ✓        |
| 3                   | ✓    | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 4                   | ✓    | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 5                   | BVI  | ✓   | ✓    | 24, 70  | ✓  | ✓  | —        |
| 6                   | ✓    | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 7                   | BVI  | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 8                   | BVI  | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 9                   | —    | —   | ✓    | 24      | ✓  | ✓  | —        |
| 10                  | BVI  | ✓   | ✓    | 24, 70  | ✓  | ✓  | —        |
| 11                  | ✓    | ✓   | ✓    | ✓       | ✓  | ✓  | —        |
| 12                  | BVI  | ✓   | ✓    | 24      | ✓  | —  | —        |
| 13                  | ✓    | ✓   | ✓    | 24      | ✓  | —  | —        |
| 14                  | UBV  | ✓   | ✓    | ✓       | ✓  | ✓  | —        |
| 15                  | —    | ✓   | ✓    | 24      | ✓  | —  | —        |
| 16                  | UBV  | ✓   | ✓    | 70      | ✓  | —  | —        |
| 17                  | —    | —   | —    | 24      | —  | ✓  | ✓        |
| 18                  | —    | —   | ✓    | 24      | ✓  | ✓  | —        |
| 19                  | —    | ✓   | ✓    | 24      | ✓  | —  | —        |
| 20                  | ✓    | ✓   | ✓    | 24, 160 | ✓  | ✓  | —        |
| 21                  | ✓    | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 22                  | ✓    | ✓   | ✓    | 24      | ✓  | ✓  | —        |
| 23                  | ✓    | ✓   | ✓    | 24      | ✓  | —  | —        |
| 24                  | —    | —   | —    | —       | ✓  | —  | —        |

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Table A.1 – continued from previous page

| SAGE-Spec source ID | UBVI | JHK | IRAC          | MIPS   | SL | LL | MIPS-SED |
|---------------------|------|-----|---------------|--------|----|----|----------|
| 25                  | ✓    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 26                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 27                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 28                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 29                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 30                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 31                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 32                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 33                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 34                  | ✓    | ✓   | ✓             | ✓      | ✓  | ✓  | —        |
| 35                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 36                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 37                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 38                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 39                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 40                  | ✓    | ✓   | ✓             | ✓      | ✓  | ✓  | —        |
| 41                  | UBV  | ✓   | ✓             | 24     | ✓  | —  | —        |
| 42                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 43                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 44                  | BVI  | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 45                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 46                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 47                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 48                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 49                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 50                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 51                  | —    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 52                  | —    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 53                  | BV   | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 54                  | BVI  | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 55                  | BVI  | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 56                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 57                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 58                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 59                  | BV   | ✓   | 4.5, 5.8, 8.0 | 24     | ✓  | —  | —        |
| 60                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 61                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 62                  | ✓    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 63                  | BVI  | ✓   | ✓             | 24     | ✓  | —  | —        |

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Table A.1 – continued from previous page

| SAGE-Spec source ID | UBVI | JHK | IRAC          | MIPS   | SL | LL | MIPS-SED |
|---------------------|------|-----|---------------|--------|----|----|----------|
| 64                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 65                  | —    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 66                  | BVI  | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 67                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 68                  | UBV  | ✓   | ✓             | 24     | ✓  | —  | —        |
| 69                  | ✓    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 70                  | —    | K   | 4.5, 5.8, 8.0 | 24     | ✓  | ✓  | —        |
| 71                  | —    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 72                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 73                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 74                  | ✓    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 75                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 76                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 77                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 78                  | BVI  | ✓   | ✓             | ✓      | ✓  | ✓  | —        |
| 79                  | BVI  | ✓   | ✓             | 24     | ✓  | —  | —        |
| 80                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 81                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 82                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 83                  | BVI  | ✓   | ✓             | 24     | ✓  | —  | —        |
| 84                  | ✓    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 85                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 86                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 87                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 88                  | ✓    | ✓   | ✓             | —      | ✓  | —  | —        |
| 89                  | ✓    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 90                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 91                  | —    | ✓   | ✓             | 24     | ✓  | —  | —        |
| 92                  | ✓    | ✓   | ✓             | 24, 70 | ✓  | ✓  | —        |
| 93                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 94                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 95                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 96                  | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 97                  | ✓    | ✓   | ✓             | ✓      | ✓  | ✓  | ✓        |
| 98                  | BVI  | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 99                  | BVI  | ✓   | ✓             | 24     | ✓  | —  | —        |
| 100                 | ✓    | ✓   | ✓             | 24     | ✓  | ✓  | —        |
| 101                 | BV   | ✓   | ✓             | ✓      | ✓  | ✓  | —        |
| 102                 | —    | ✓   | ✓             | 24, 70 | ✓  | ✓  | ✓        |

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Table A.1 – continued from previous page

| SAGE-Spec source ID | UBVI | JHK | IRAC | MIPS   | SL | LL | MIPS-SED |
|---------------------|------|-----|------|--------|----|----|----------|
| 103                 | —    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 104                 | UBV  | ✓   | ✓    | ✓      | ✓  | ✓  | —        |
| 105                 | BVI  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 106                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 107                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 108                 | ✓    | ✓   | ✓    | ✓      | ✓  | ✓  | —        |
| 109                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 110                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 111                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 112                 | UBV  | —   | ✓    | 24     | ✓  | —  | —        |
| 113                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 114                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | ✓        |
| 115                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 116                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 117                 | UBI  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 118                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 119                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 120                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 121                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 122                 | UB   | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 123                 | UB   | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 124                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 125                 | —    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 126                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 127                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 128                 | UBV  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 129                 | UBV  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 130                 | BVI  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 131                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 132                 | —    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 133                 | BVI  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 134                 | UBV  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 135                 | BV   | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 136                 | —    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 137                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 138                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 139                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 140                 | BV   | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 141                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |

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Table A.1 – continued from previous page

| SAGE-Spec source ID | UBVI | JHK | IRAC | MIPS   | SL | LL | MIPS-SED |
|---------------------|------|-----|------|--------|----|----|----------|
| 142                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 143                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 144                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 145                 | BVI  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 146                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 147                 | UBV  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 148                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 149                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 150                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 151                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 152                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 153                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 154                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 155                 | BVI  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 156                 | BVI  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 157                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 158                 | BV   | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 159                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 160                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 161                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 162                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 163                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | ✓        |
| 164                 | BVI  | HK  | ✓    | 24, 70 | ✓  | ✓  | —        |
| 165                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 166                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 167                 | —    | —   | ✓    | 24     | ✓  | ✓  | —        |
| 168                 | UBV  | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 169                 | UBV  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 170                 | UBV  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 171                 | UBV  | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 172                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 173                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 174                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 175                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 176                 | BVI  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 177                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 178                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 179                 | BVI  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 180                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |

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Table A.1 – continued from previous page

| SAGE-Spec source ID | UBVI | JHK | IRAC | MIPS   | SL | LL | MIPS-SED |
|---------------------|------|-----|------|--------|----|----|----------|
| 181                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 182                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 183                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 184                 | BVI  | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 185                 | —    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 186                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 187                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 188                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 189                 | BVI  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 190                 | BVI  | —   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 191                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 192                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 193                 | ✓    | ✓   | ✓    | 24     | ✓  | ✓  | —        |
| 194                 | BVI  | ✓   | ✓    | 24     | ✓  | —  | —        |
| 195                 | —    | ✓   | ✓    | 24     | ✓  | —  | —        |
| 196                 | ✓    | ✓   | ✓    | 24, 70 | ✓  | ✓  | —        |
| 197                 | ✓    | ✓   | ✓    | 24     | ✓  | —  | —        |

Table A.1: <sup>1</sup>Photometry for SSID17, 24, 125 and 133 has been altered since delivery #1. The present table represents the best available photometry.

## Appendix B

# Quality control results for SAGE-Spec IRS spectra

Table B.1: Data processing summary (see key below table).

| ID | Reduction method | SL           | LL           | Notes                     |
|----|------------------|--------------|--------------|---------------------------|
| 1  | default          | —            | —            |                           |
| 2  | default          | —            | —            |                           |
| 3  | default          | —            | —            |                           |
| 4  | default          | J-Wa         | —            |                           |
| 5  | default          | —            | —            |                           |
| 6  | modified         | Ray-Mc-Notes | B-Wa         | SL – 0300: Ray            |
| 7  | default          | —            | N-Wa         |                           |
| 8  | default          | —            | —            |                           |
| 9  | default          | —            | —            |                           |
| 10 | modified         | —            | S-Mc-1Dx,2Da |                           |
| 11 | default          | —            | —            |                           |
| 12 | default          | J-Wa         | —            |                           |
| 13 | modified         | B-Mc-Dn      | —            |                           |
| 14 | default          | —            | —            |                           |
| 15 | default          | J-Wa         | —            |                           |
| 16 | default          | —            | —            |                           |
| 17 | modified         | —            | —            |                           |
| 18 | default          | —            | —            |                           |
| 19 | default          | J-Wa         | —            |                           |
| 20 | modified         | X-Mc-Notes   | —            | SL – 0200: FUDL, 0400: Dx |
| 21 | default          | —            | —            |                           |
| 22 | modified         | P-Mc-2Dn     | S-Wa         |                           |
| 23 | default          | —            | —            |                           |
| 24 | modified         | F-Mi-Dn      | —            |                           |
| 25 | modified         | B-Mc-Dn      | B-Mc-C2      |                           |
| 26 | default          | J-Wa         | —            |                           |
| 27 | default          | S-Wa         | —            |                           |

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Table B.1 – continued from previous page

| ID | Reduction method | SL             | LL             | Notes                      |
|----|------------------|----------------|----------------|----------------------------|
| 28 | default          | S-Wa           | S-Wa           |                            |
| 29 | default          | J-Wa           | —              |                            |
| 30 | default          | J-Wa           |                |                            |
| 31 | default          | J-Wa           |                |                            |
| 32 | default          | —              |                |                            |
| 33 | default          | J-Wa           |                |                            |
| 34 | modified         | B,X-Mc-Notes   | —              | SL – 0400: bad pixel block |
| 35 | default          | —              |                |                            |
| 36 | default          | —              |                |                            |
| 37 | default          | —              |                |                            |
| 38 | modified         | J,Ray-Wa-Notes | —              | SL – 0502: Ray             |
| 39 | modified         | —              | S-Mc-Da        |                            |
| 40 | default          | —              | —              |                            |
| 41 | default          | —              |                |                            |
| 42 | default          | —              | —              |                            |
| 43 | default          | —              |                |                            |
| 44 | modified         | B-Wa           | S-Mc-1Da       |                            |
| 45 | default          | J-Wa           |                |                            |
| 46 | default          | —              |                |                            |
| 47 | default          | —              |                |                            |
| 48 | default          | J-Wa           |                |                            |
| 49 | modified         | B-Mc-Dn        |                |                            |
| 50 | modified         | B-Mc-Dn,Notes  | B-Mc-Da        | SL – 14.2 $\mu$ m spike    |
| 51 | modified         | —              | S-Mc-1C1       |                            |
| 52 | default          | —              | —              |                            |
| 53 | default          | —              | —              |                            |
| 54 | default          | J-Wa           | —              |                            |
| 55 | modified         | —              | N-Mc-1Da       |                            |
| 56 | modified         | B-Mc-1Dn       | S-Wa           |                            |
| 57 | default          | —              |                |                            |
| 58 | modified         | X-Mc-Notes     |                | SL – 0404: bad pixel block |
| 59 | default          | S-Wa           |                |                            |
| 60 | modified         | —              | N-Mc-1Da       |                            |
| 61 | default          | —              | S-Wa           |                            |
| 62 | default          | —              | —              |                            |
| 63 | default          | —              |                |                            |
| 64 | default          | —              | —              |                            |
| 65 | modified         | —              | S-Mc-1C1       |                            |
| 66 | default          | —              | B-Mc-1Da1,1Dx2 |                            |
| 67 | default          | —              |                |                            |
| 68 | default          | —              |                |                            |
| 69 | modified         | B-Mi-Dn        | B-Mi-1Da       |                            |
| 70 | default          | E-Wa           | —              |                            |
| 71 | modified         | —              | N-Mi-Da        |                            |
| 72 | modified         | S-Mc-Dn        |                |                            |
| 73 | default          | —              | B-Wa           |                            |

continued on next page. . .

APPENDIX B. QUALITY CONTROL RESULTS FOR IRS SPECTRA

Table B.1 – continued from previous page

| ID  | Reduction method | SL             | LL           | Notes                                |
|-----|------------------|----------------|--------------|--------------------------------------|
| 74  | default          | —              | —            |                                      |
| 75  | default          | —              | S-Wa         |                                      |
| 76  | default          | —              |              |                                      |
| 77  | default          | —              |              |                                      |
| 78  | default          | J-Wa           | —            |                                      |
| 79  | default          | —              |              |                                      |
| 80  | modified         | —              | S-Mc-C1      |                                      |
| 81  | default          | —              |              |                                      |
| 82  | default          | —              | —            |                                      |
| 83  | default          | N-Wa           |              |                                      |
| 84  | default          | —              | —            |                                      |
| 85  | modified         | J-Wa           | S-Mc-1Cn1    |                                      |
| 86  | default          | —              |              |                                      |
| 87  | modified         | B,J-Mi-1Dn     |              |                                      |
| 88  | modified         | B,S-Mi-Dn      |              |                                      |
| 89  | default          | S-Wa           |              |                                      |
| 90  | default          | —              | —            |                                      |
| 91  | modified         | B-Mc-2Dn       |              |                                      |
| 92  | modified         | X-Mc-Notes     | —            | SL – 0402: FUDL, 0202: Dx, 0302: Ray |
| 93  | modified         | —              | B,S-Mc-Da    |                                      |
| 94  | default          | —              | —            |                                      |
| 95  | modified         | B-Mc-1Dn       | B-Mc-1Da     |                                      |
| 96  | default          | —              | —            |                                      |
| 97  | default          | —              | —            |                                      |
| 98  | modified         | —              | S-Mc-Notes   | LL – 0802: FUDL, 0902: Da            |
| 99  | default          | —              |              |                                      |
| 100 | default          | —              | N-Wa         |                                      |
| 101 | default          | —              | —            |                                      |
| 102 | default          | —              | —            |                                      |
| 103 | modified         | —              | S-Mc-1Da     |                                      |
| 104 | modified         | J,Ray-Mc-Notes | —            | SL – 0502: Ray                       |
| 105 | modified         | J-Wa           | B-Mi-1Dx,2Da |                                      |
| 106 | modified         | —              | B-Mc-1C1     |                                      |
| 107 | default          | —              | —            |                                      |
| 108 | modified         | B-Mi-Dn        | S-Mc-Da      |                                      |
| 109 | modified         | —              | S-Mc-1Cn2    |                                      |
| 110 | default          | —              |              |                                      |
| 111 | default          | —              | —            |                                      |
| 112 | default          | —              |              |                                      |
| 113 | modified         | —              | S-Mc-1Da     |                                      |
| 114 | default          | J-Wa           | N-Wa         |                                      |
| 115 | default          | —              |              |                                      |
| 116 | modified         | J,S-Mc-Notes   | S-Mc-2Da     | SL – 0401: Ray, 0202: FUDL, 0402: Dx |
| 117 | modified         | S-Mc-Notes     | N,S-Fa       | SL – Ridge constrained               |
| 118 | default          | —              | —            |                                      |
| 119 | modified         | —              | S-Mi-Da      |                                      |

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Table B.1 – continued from previous page

| ID  | Reduction method | SL         | LL       | Notes |
|-----|------------------|------------|----------|-------|
| 120 | default          | —          |          |       |
| 121 | default          | —          |          |       |
| 122 | default          | —          | S-Wa     |       |
| 123 | modified         | —          | B-Mc-1Da |       |
| 124 | default          | —          |          |       |
| 125 | default          | —          | —        |       |
| 126 | default          | —          | —        |       |
| 127 | default          | S-Wa       |          |       |
| 128 | modified         | —          | S-Mc-Da  |       |
| 129 | default          | —          | —        |       |
| 130 | default          | —          | —        |       |
| 131 | modified         | J-Wa       | B-Mc-Da  |       |
| 132 | default          | —          |          |       |
| 133 | default          | —          |          |       |
| 134 | default          | —          |          |       |
| 135 | default          | —          | —        |       |
| 136 | default          | —          |          |       |
| 137 | default          | —          | B-Wa     |       |
| 138 | default          | —          | —        |       |
| 139 | default          | B-Wa       |          |       |
| 140 | default          | —          | —        |       |
| 141 | default          | J-Wa       | B,S-Wa   |       |
| 142 | default          | —          |          |       |
| 143 | default          | —          |          |       |
| 144 | default          | —          | —        |       |
| 145 | default          | —          | B,S-Wa   |       |
| 146 | default          | —          | N-Wa     |       |
| 147 | default          | —          | —        |       |
| 148 | modified         | B-Mc-1Dn   |          |       |
| 149 | default          | —          | N-Wa     |       |
| 150 | default          | —          | —        |       |
| 151 | default          | —          | —        |       |
| 152 | default          | B-Wa       |          |       |
| 153 | default          | —          |          |       |
| 154 | default          | —          | —        |       |
| 155 | default          | —          |          |       |
| 156 | modified         | B,S-Mc-Dn  | B,S,N-Wa |       |
| 157 | default          | —          | —        |       |
| 158 | modified         | S-Mc-2Dn   | S-Wa     |       |
| 159 | default          | —          |          |       |
| 160 | modified         | B,J-Mc-Dn  | N-Fa     |       |
| 161 | modified         | J,P-Mi-Dn  |          |       |
| 162 | modified         | N-Wa       | S-Mc-1Da |       |
| 163 | default          | —          | S-Wa     |       |
| 164 | modified         | B,J-Mi-1Dn | —        |       |
| 165 | modified         | Ray-Wa     | S-Mi-Da  |       |

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APPENDIX B. QUALITY CONTROL RESULTS FOR IRS SPECTRA

Table B.1 – continued from previous page

| ID  | Reduction method | SL         | LL         | Notes   |
|-----|------------------|------------|------------|---|
| 166 | default          | —          | —          |   |
| 167 | modified         | —          | B-Mc-1Cn1  |   |
| 168 | default          | —          | —          |   |
| 169 | modified         | B-Mc-1Dn   | B-Mi-Cn2   |   |
| 170 | modified         | —          | S-Mi-1Da   |   |
| 171 | modified         | S-Mc-Notes | S-Mi-Notes | SL – 0401: FUDL, 0201: Dx<br>LL – 1Da, 2Dn1, 2Dx2 |
| 172 | modified         | —          | S-Mc-Da    |   |
| 173 | modified         | B-Mc-1Dn   |            |   |
| 174 | modified         | F-Mi-Dn    | F-Wa       |   |
| 175 | modified         | X-Mc-Notes | —          | SL – 0301: Ray, not dropped, 0501: Dx             |
| 176 | default          | —          |            |   |
| 177 | default          | —          | —          |   |
| 178 | default          | —          |            |   |
| 179 | modified         | B-Mc-1Dn   |            |   |
| 180 | default          | —          | N-Wa       |   |
| 181 | default          | —          | —          |   |
| 182 | default          | —          | B,N-Wa     |   |
| 183 | default          | —          | —          |   |
| 184 | modified         | —          | N-Mc-1Da   |   |
| 185 | default          | —          | —          |   |
| 186 | default          | J-Wa       | —          |   |
| 187 | default          | —          | —          |   |
| 188 | default          | —          |            |   |
| 189 | default          | —          |            |   |
| 190 | default          | —          | —          |   |
| 191 | modified         | B-Mi-Dn    |            |   |
| 192 | default          | —          | —          |   |
| 193 | default          | —          | —          |   |
| 194 | default          | —          |            |   |
| 195 | default          | —          |            |   |
| 196 | default          | —          | —          |   |
| 197 | default          | —          |            |   |

|                         |   |
|-------------------------|---|
|                         | KEY: –  |
| <b>Reduction method</b> | <i>default</i> – as described in Sect. 2.1.2; <i>modified</i> – the default method of background subtraction, extraction and coadding of spectra was changed in some way, as detailed in a three-part code, constructed as: <problem>-<severity>-<solution>   |
| <b>Problem</b>          | <p><i>J</i> – jailbars in the data.<br/> <i>N</i> – significant difference in appearance between two nods.<br/> <i>FUDL</i> – FUDL (data download) error.<br/> <i>Ray</i> – cosmic ray strike.<br/> <i>P</i> – peak-up related problem.<br/> <i>B</i> – background issue.<br/> <i>S</i> – additional source.<br/> <i>E</i> – excess emission.<br/> <i>F</i> – very faint source.<br/> <i>M</i> – no source.<br/> <i>X</i> – other issue.</p>                              |
| <b>Severity</b>         | <p><i>Wa</i> – defective data, however no repair was attempted because defect was deemed minor, i.e., did not affect the extraction.<br/> <i>Mc</i> – reduction procedure was modified and successfully corrected issue.<br/> <i>Mi</i> – reduction procedure was modified and improved the issue but could not fully correct it.</p>   |
| <b>Solution</b>         | <p><i>Fa</i> – there was an issue with the data which could not be improved upon.<br/> <i>#Da#</i> – aperture difference (rather than nod difference). Where numbers are included in the code, the first number is the order number, and the second the nod, e.g., 1Da2 is LL1, nod 2<br/> <i>#Dn#</i> – nod difference (rather than aperture difference).<br/> <i>#Dx#</i> – cross difference.<br/> <i>#C#</i> – co-add was changed (usually by using only one nod).</p> |

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