Infrared Spectrograph
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IRS-TR 05002: Improving the Wavelength Calibration of Short-Low and Long-Low

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Abstract

We have measured and corrected small, but systematic offsets in the wavelength calibration of the Short-Low and Long-Low modules on the IRS. The offsets are on the order of one pixel or less in all modules, and they are generally to the blue. We have applied corrections which are a series of linear functions of wavelength.

1 Introduction

From September, 2004 to the present, evidence has been accumulating that the wavelength calibration of the low-resolution modules on the IRS could be improved. We have systematically examined the wavelengths of recombination lines in A dwarfs and molecular hydrogen and forbidden emission lines in galactic and extragalactic sources (at various redshifts) in order to map the required wavelength correction as a function of wavelength.

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2 Analysis

We begin with spectra extracted and calibrated from SL and LL images using a variety of techniques. We have tested the various techniques by applying them to the same data, and have found no measurable shift in the apparent positions of extracted spectral lines with technique. All of the techniques use the wavesamp files for SL generated on 2003 December 11 and for LL generated on 2003 December 13.

Line centers were determined using Gaussian fits, and for extragalactic sources, expected line centers corrected for measured redshift.

The wavelength calibration of the IRS is controlled by what are called "wavesamp" files, which contain, for each wavelength element, the central wavelength and its physical coordinates on the detector array, in the form of five (x,y) pairs, one for the center and one for each corner of the quadrilateral. A complete correction of the wavesamp file would require that the (x,y) coordinates of the wavelength elements be adjusted, but this process is complicated and would be best done at the Spitzer Science Center (SSC). We have opted for a simpler interim correction: changing the wavelengths of the wavelength elements while leaving their detector coordinates untouched.

The current wavesamp files are designed to be on the same wavelength grids in regions where orders of a given module overlap. We preserve this constraint in the solutions determined below.

3 Results

Figures 1 and 2 present the resulting offsets and applied corrections for SL and LL, respectively. In each plot, point sources are plotted with plus signs and extended sources with diamonds. The "x's" are point sources in the bonus order.

In SL, there is a small but systematic difference between point sources and extended sources which probably arises from systematic pointing offsets (see IRS-TR 04006). As a consequence, we relied on the extended sources because the positions of the lines in their spectra are less susceptible to pointing offsets, either random or systematic. The extended-source data are consistent with a consistent with a constant offset in SL order 1 of 0.042 μm. The bonus order is consistent with this same offset, although an offset decreasing linearly with wavelength would also fit the bonus-order data. Because we have insufficient data, we appealed to Occam's Razor and adjust the bonus order in conformity with SL1.

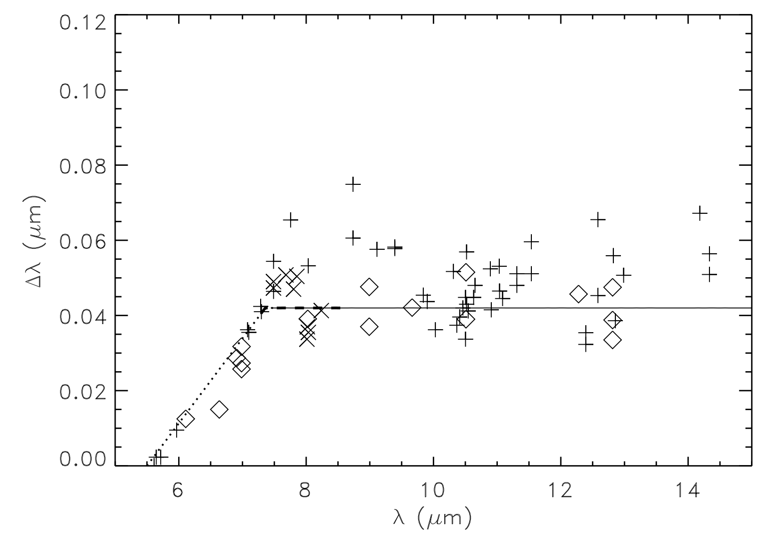

Figure 1 — The measured wavelength offset and correction for SL. Point sources are plotted with plus signs, extended sources with diamonds. Point sources measured in the bonus order are plotted with 'x's". The corrections are plotted with lines: order 2—dotted; order 1—solid; bonus order—dashed.

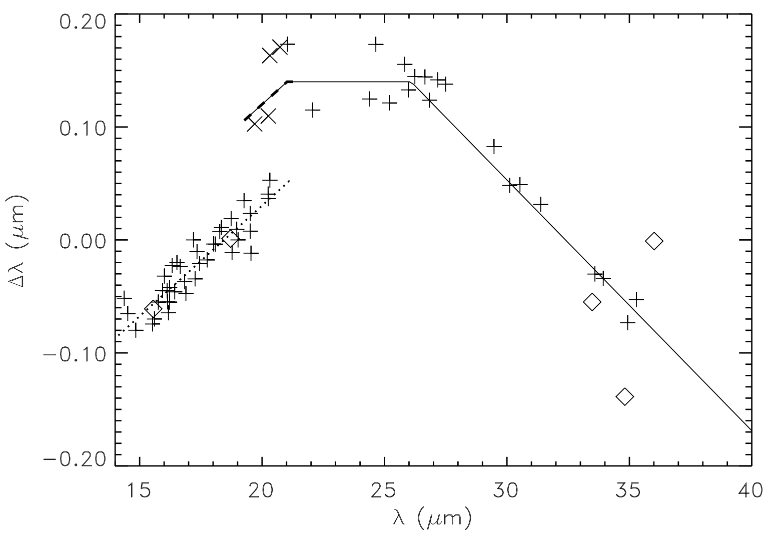

Figure 2 — The measured wavelength offset and correction for LL. Plotting symbols are as in Fig. 1.

In SL order 2, the data clearly show that the offset decreases to the blue. We fit the the data with a line running from 0.042 μm at 7.4 μm to zero at 5.5 μm. The linear correction is:

$$\Delta\lambda = 0.0221\,\lambda\, -\, 0.1216 \quad (\mu\mathrm{m}). \tag{1}$$

In LL, the larger pixels and lower resolution reduce the impact of wavelength shifts due to location of a source within the slit. Consequently, we treat point-source and extended-source data equally.

The general trend in LL is for the offset to increase with increasing wavelength in LL order 2, then to decrease again in LL order 1. The region between 20 and 26 μm is more problematic, due to a paucity of data. It is in this region where a more thorough analysis by the SSC is most likely to produce somewhat different results. We assume a constant offset of 0.140 μm in this region because that is the simplest correction consistent with the data.

To maintain the same wavelength grid in the region of overlap between the bonus order, LL1, and LL2, we shift the correction for LL2 up by exactly one pixel (0.0879 μm). This correction is consistent with the data from the bonus order, as Figure 2 shows.

For LL2, the formal wavelength corrections is:

$$\Delta\lambda = 0.0192\,\lambda\, -\, 0.3542 \quad (\mu\mathrm{m}). \tag{2}$$

For the bonus order shortward of 21.13 μm, the correction is:

$$\Delta\lambda = 0.0192\,\lambda\, -\, 0.2663 \quad (\mu\mathrm{m}). \tag{3}$$

From 21.13 to 26.26 μm, we have adopted a constant correction of 0.140 μm. This applies to both LL1 and a small piece of the LL bonus order. For LL1 beyond 26.26 μm, the correction is:

$$\Delta\lambda = -0.0227\,\lambda\, +\, 0.7353 \quad (\mu\mathrm{m}). \tag{4}$$

4 Conclusion

We have implemented these wavelength corrections as an experimental version of the wavesamp files. They are available within Smart as version “E3”. These modified files should serve as an interim improvement until the SSC issues a formal upgrade to the official wavesamp files.

References

Sloan, G. C., Keremedjiev, M. S., & Kasliwal, M. M. 2004, IRS-TR 04006: The Double-Star Experiment and Pointing to Short-Low Order 1