Infrared Spectrograph
Technical Report Series

IRS-TR 04007: Measuring the Precision of Reconstructed Pointing

M.S. Keremedjiev & G.C. Sloan *

3 September, 2004

Abstract

Correcting for Spectral Pointing-Induced Throughput Error (SPITE) requires an accurate assessment of the location of an object within a spectroscopic slit. The simplest means would be to use the reconstructed pointing information available with each image generated by the Spitzer Science Center (SSC). Here, we show that the reconstructed pointing is not accurate enough to make SPITE corrections for the sub-arcsecond offset errors most commonly encountered.

1 Introduction

The narrow entrance apertures on the Infrared Spectrograph (IRS) onboard the Spitzer Space Telescope result in partial blockage of radiation from a point source onto the detector arrays. As described by Sloan et al. (2003; IRS-TR 03001) the throughput is a function of both wavelength and position of the source in the aperture. They refer to the resultant errors in the spectra as Spectral Pointing-Induced Throughput Error, or SPITE. They also suggested that the reconstructed pointing for each image produced by the Spitzer Science Center (SSC) might

*Infrared Spectrograph Science Center, Cornell University

provide a means of determining the location of a target within an aperture and thus correcting for SPITE. This report analyzes the effectiveness of the reconstructed pointing from the Spitzer Science Center.

2 Method

The double-star experiment, deescribed by Sloan et al. (2004; IRS-TR 04006) provides a means of accurately testing the quality of the reconstructed pointing. This experiment tracks one source across the slit of Short-Low Order 1 (SL1) while another star is simultaneously visible in the blue peak-up field, which allows the pointing to be measured to within a few hundredths of an arcsecond.

IRS-TR 04006 provides the means to determine the position of the center of the SL1 slit in the v direction (the dispersion direction) to within $\sim 0.''03$. In the w direction (cross-dispersion direction), there is no direct means of determining the absolute position, although the location of the reference star in the peak-up field still provides *relative* pointing information with a an accuracy similar to the absolute uncertainty in the v direction. To convert the relative Δw offsets to absolute measurements, we will assume that the mean of the Δw offsets is zero.

The objective here is to compare the actual v, w pointing determined using the reference star to the reconstructed pointing. We will make the comparison using the pointing errors Δv and Δw, which are the differences between the requested and measured v, w positions. We find these from the reconstructed pointing by differencing the requested and reconstructed field-of-view coordinates in the FITS header for each exposure (RA_RQST, DEC_RQST, RA_FOV, DEC_FOV) and rotating them into a reconstructed pointing error (Δv, Δw) using the position angle of the spectroscopic slit on the sky (PA_FOV).

3 Results

Figure 1 compares the reconstructed and actual Δv pointing errors as a function of exposure ID, which increases as the source is scanned across the slit. During the course of the experiment, the two measures of the Δv offset diverge. The actual pointing errors remain roughly constant, but the reconstructed pointing error drifts by $\sim +0.''8$.

Figure 2 plots the Δw pointing errors similarly to Figure 1, with similar results. While the actual Δw changes very little from the beginning of the experiment

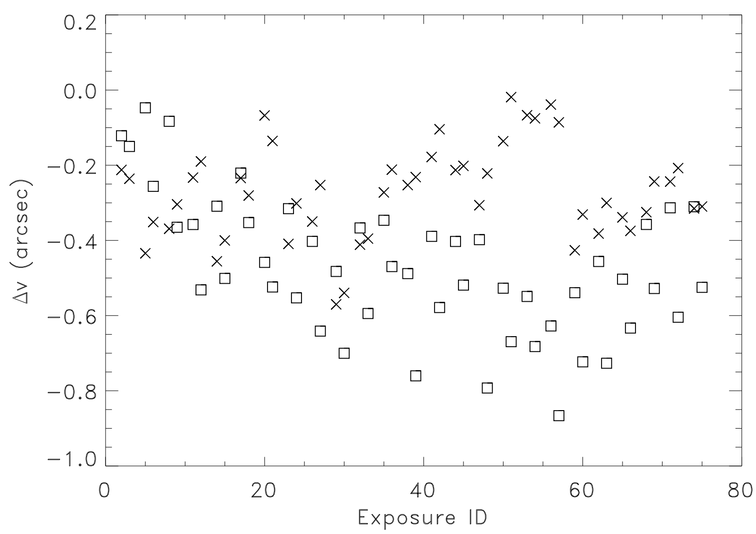

Figure 1 —Reconstructed and actual Δv pointing errors as a function of exposure ID, using rectangles for the reconstructed pointing and crosses for positions measured using the reference star in the peak-up field. The exposure ID number increases as the source is scanned across the slit. The measurements diverge; the reconstructed pointing errors move to progressively more negative values during the course of the scan, even though the actual pointing errors, as measured from the reference star in the peak-up array, remain roughly constant.

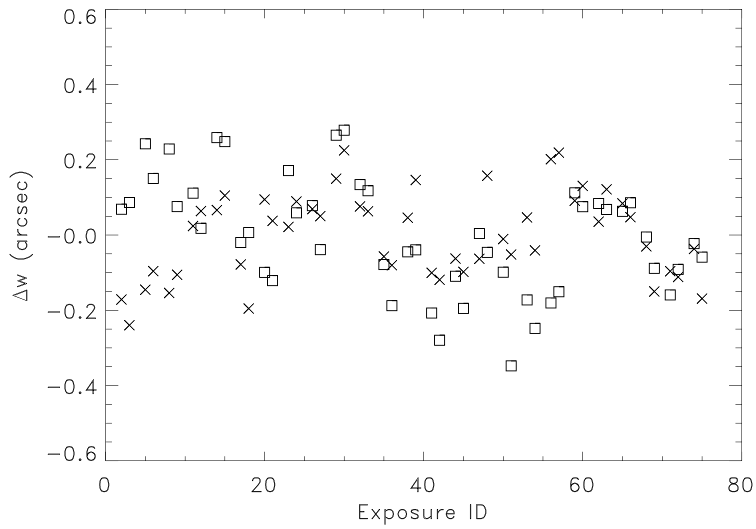

Figure 2 —As Figure 1, but for Δw. The relative zero points for the two sets of data are arbitrary; we chose the centroid of the distribution to be zero, but we could have chosen the initial positions for each data set as zero. As with the Δv direction, the reconstructed and actual pointing diverge during the scan.

to the end, the reconstructed Δw has drifted by $\sim -0.''6$. As stated earlier, the respective zero value for the two methods of measurement are arbitrary, making it more difficult to assess the absolute pointing error.

Table 1 compares the differences between the reconstructed pointing and the actual pointing, as measured with the reference star in the peak-up array for both nod positions and for the combined set of data. The standard deviations in Table 1 give a good indication of the statistical uncertainty in the reconstructed pointing, which is on the order of $0.''2$. In addition to these random errors, there is a signficant systematic difference between the reconstructed and actual pointing errors in Δv in Nod 2. This difference between nods is apparent in Figure 1, where the reconstructed pointing for adjacent exposures differs by approximately $0.''2$.

4 Conclusion

Analysis of the reconstructed and actual pointing from the double-star experiment reveals a statistical error of $\sim 0.''2$ between the two. In addition there is a systematic difference in the Δv coordinate of $\sim 0.''2$, as well as a general drift in

TABLE 1
DIFFERENCE BETWEEN RECONSTRUCTED AND ACTUAL POINTING.

	Nod 1 ($''$)	Nod 2 ($''$)	Both ($''$)
Δv	0.085 ± 0.224	0.318 ± 0.218	0.202 ± 0.248
Δw	0.025 ± 0.171	-0.025 ± 0.197	0.000 ± 0.171

the reconstructed pointing error during the course of the 1.6-hour experiment of $\sim 0.''8$ in Δv and $\sim 0.''6$ in Δw, as shown in Figures 1 and 2.

The SSC has claimed that the reconstructed pointing should be good to within approximately one arcsecond, but should not be relied on for finer positional certainty. Our results, with systematic drifts in the position smaller than, but on the order of, one arcsecond confirm this limit.

As IRS-TR 04006 describes, a typical pointing error of $0.''4$ would produce a loss in throughput of several percent in SL1. Therefore one would need positional accuracy better then $0.''4$, preferably on the order of $0.''2$, to accurately correct for SPITE. We therefore conclude that the uncertainties in the reconstructed pointing are large enough to prevent it from being useful for making SPITE corrections.

References

Sloan, G.C., Nerenberg, P.S., & Russell, M.R. 2003, IRS-TR 03001: The Effect of Spectral Pointing-Induced Throughput Error on Data from the IRS

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