**Infrared Spectrograph**
**Technical Report Series**

# IRS-TR 04003: Artifacts in the Spectra of Bright Sources

G.C. Sloan*

12 June, 2004

**Abstract**

The spectra of some bright sources contain artifacts which resemble divots. An examination of spectra of ξ Dra from Campaign P shows that these artifacts are not present in any data cubes in the SSC pipeline, but they appear as soon as the data cubes are reduced to two-dimensional images. These divots then propagate through subsequent steps in the pipeline and appear in final extracted and calibrated spectra.

## 1 Introduction

Over the course of the science verification phase and early science campaigns of the IRS, several sources have been observed to have divots in their spectra. These divots typically appear as drops in flux covering either a small or large range of wavelengths. The drops can be on the order of 25% or greater.

Figure 1 presents a typical example, ξ Dra as observed with LL2 in Campaign P. A comparison to the assumed spectrum for this source (dotted line) reveals three divots, a large one from 14.2 to 16.1 $\mu$m and two smaller ones at 16.6 and 16.9 $\mu$m. This analysis concentrates on the edge of the larger divot, right at 16.0–16.1 $\mu$m in an effort to see why some wavelength elements produce reasonable results and others do not.

*Infrared Spectrograph Science Center, Cornell University

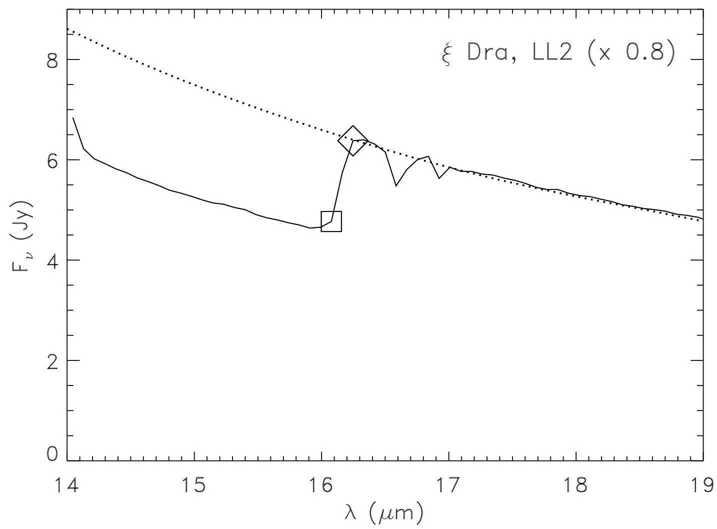


Figure 1 — The spectrum of ξ Dra, Campaign P, LL2, compared to its spectral template (dashed line). The problems in the spectrum from 14 to 17 μm are readily apparent as three divots (14.2–16.1, 16.6, and 16.9 μm). The diamond and rectangle mark the approximate location of the pixels to be considered in the following analysis.

# 2 Analysis

The observations of ξ Dra (HR 6688) come from two AORs in the spectrophotometric calibration activity (IRS-070) in Campaign P, namely 7836416 and 7836672. The observed artifacts have appeared in each subsequent pipeline version examined at Cornell, S8.9, S9.1, and S9.5.

Figure 1 starts with the final spectrum, as calibrated using the K giants HR 6348, HD 166780, and HD 173511. IRS TR-04002 describes the details of the processing and calibration, but as will be shown below, these artifacts appear in the pipeline before spectra are extracted from images.

One problem already identified and being corrected in the SSC pipeline involves an inconsistency in how slopes are determined for different integration times. The calibrators for ξ Dra were observed using 30-sec ramps, which are 16-sample ramps, while ξ Dra itself was observed with 6-sec ramps, which are only 4 samples. The resulting error in flux can be corrected by multiplying the spectrum of ξ Dra by (16/15) / (4/3) = 0.80. As Figure 1 shows, this correction brings the observed spectrum right into line with the spectral template.

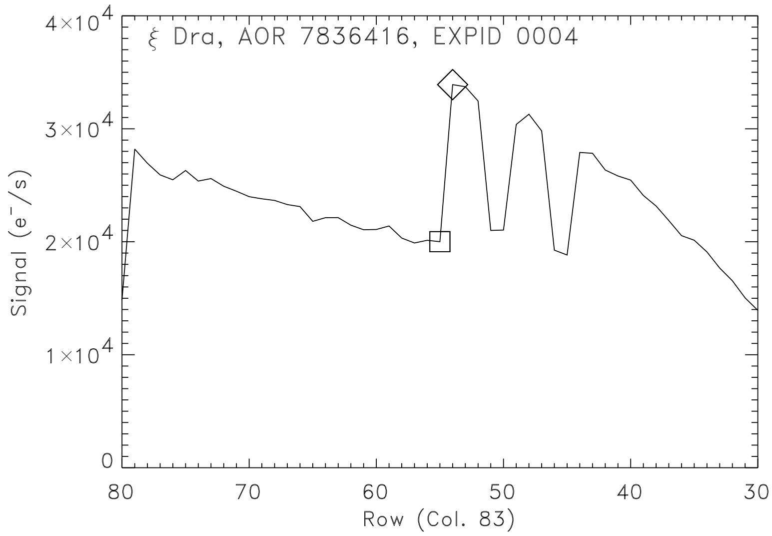


Figure 2 — The brightest column (83) in one of the *bcd_fp.fits* images of ξ Dra, AOR 7836416, EXPID 0004, DCE 0000. All three divots seen in Fig. 1 appear here as well. The diamond and rectangle mark the values in columns 54 and 55 respectively. Fig. 4 and 5 plot the signal ramps from these two pixels.

Figure 2 plots the signal in the brightest column from one of the ξ Dra images used to generate the spectrum in Figure 1. All of the images behave similarly; this image is AOR 7836416, EXPID 0004, DCE 0000. All three divots in Figure 1 also appear in Figure 2. The changes in the depth and width of the divots is due primarily to the manner in which the pipeline sums flux from adjacent pixels when extracting spectra from two-dimensional images. The diamond and rectangle in the figure enclose the data points considered below, pixels (83,54) and (83,55), which are at 16.2 and 16.1 $\mu$m respectively.

The data in Figure 2 are from the final two-dimensional product produced by the pipeline, the *bcd_fits* image. The data displayed here were processed using the offline pipeline version S9.5, but previous pipeline versions, both online and offline, produced similar results for this object.

Data from all two-dimensional images generated by the pipeline also show the same artifacts, including, as Figure 3 shows, the *imagest.fits* image. This image is the first two-dimensional image produced by the pipeline, and even at this stage in the pipeline, the divots are already present. The differences between Figures 2 and 3 are readily explained by spectral structure in the LL flatfield (e.g. the structure in Figure 3 to the left of pixel 62).

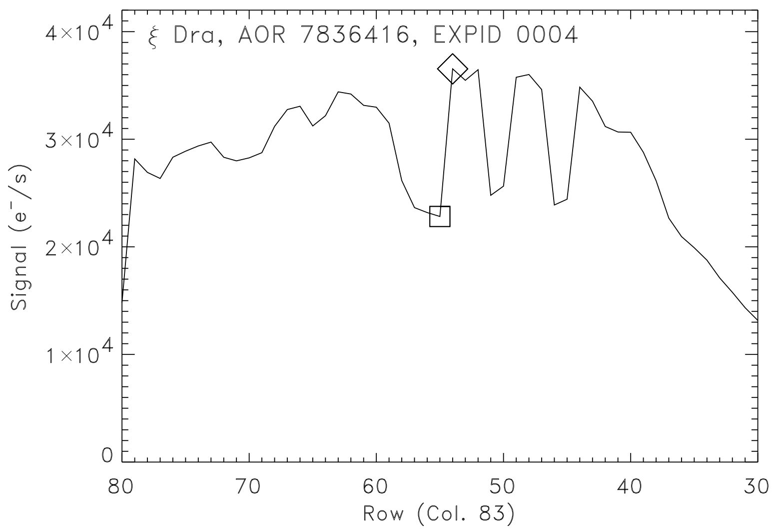


Figure 3 — As Fig. 2, except that column 83 of the *imagest.fits* image of ξ Dra is plotted. The divots seen in Fig. 1 and 2 are apparent in this image, which is the first two-dimensional image created by the pipeline. The flatfield is responsible for the differences between Fig. 2 and 3, e.g. the rise in signal from column 62 to 58, which is flatfielded away in Fig. 2. As before, the diamond and rectangle mark the pixels plotted in Fig. 4 and 5.

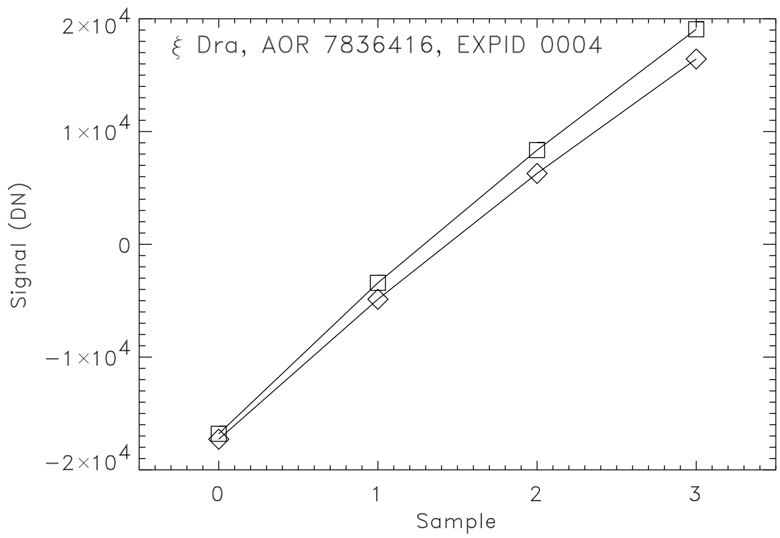


Figure 4 — The signal ramps from the two pixels marked in Fig. 2 and 3. Diamonds plot pixel (83,54), rectangles plot pixel (83,55). It is the latter pixel which has an erroneous signal in the first two-dimensional image produced by the pipeline.

We focus on pixels (83,54) and (83,55) because these two pixels are adjacent in the image and yet they produce dramatically different results (signals of 33908 and 20005 $e^-$ respectively in Fig. 2). As Figure 4 shows, their ramps in unprocessed data cubes are similar. Figure 5 shows the same two ramps after linearization, and in Figure 4, both ramps seem well-behaved and fully recoverable. The ramps for the two figures are taken from the *mipl.fits* and *lineariz.fits* data cubes, respectively.

# 3 Discussion

The ramps plotted in Fig. 4 and 5 appear robust and recoverable, yet the brighter ramp produces a slope in the initial two-dimensional image which is too low by roughly 40%. This incorrect slope then propagates through the pipeline and eventually appears as a divot in spectra for this source.

The only difference between the two ramps is that one is slightly brighter than the other, and it is this brighter ramp which ultimately leads to an erroneous slope. Both ramps have the same flag set in the final *bmask* image (1024). If the brighter ramp is above some threshold and has triggered some separate correction in the

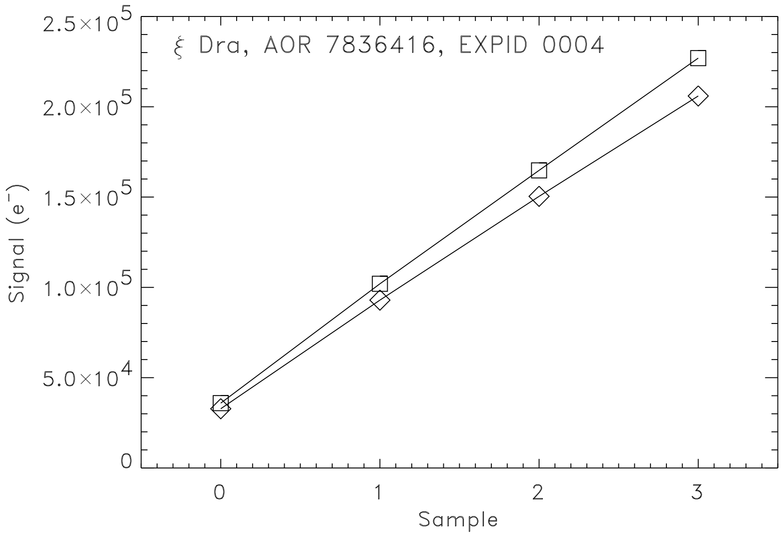


Figure 5 — As Fig. 4, except the data are from the linearized data cube.

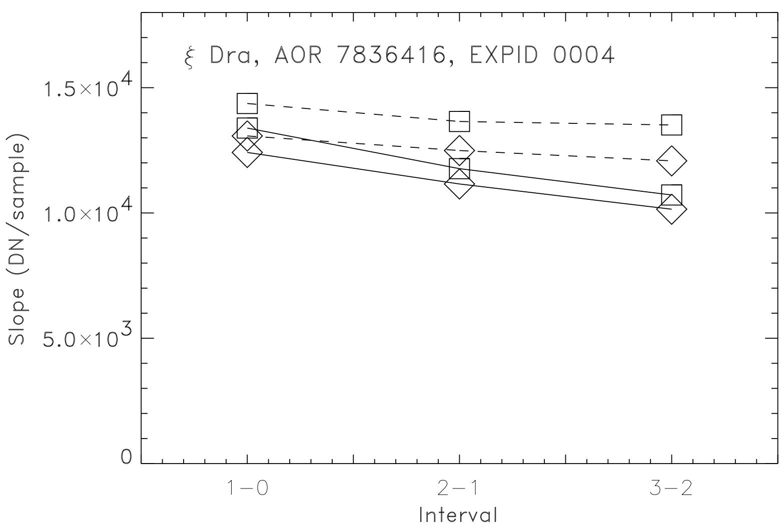


Figure 6 — The slopes of the ramps in Fig. 4 and 5. As before, diamonds plot pixel (83,54), and rectangles plot pixel (83,55). The solid lines are the slopes before linearization, the dashes lines are after linearization. The linearized ramps are improvements over the raw ramps, but they are still not fully linearized.

pipeline, it is curious that it is flagged identically to the fainter ramp.

Since the data in the *lineariz.fits* file are valid and some of the data in the *imagest.fits* image are invalid, the error must occur in the *imagest* step in the pipeline. In version S9.5 of the pipeline, the *radhit* module originally planned to appear between *lineariz* and *imagest* has been omitted, so it cannot be responsible.

The fact that the ramps in Figure 5 are not completely linearized raises a separate but equally important issue. Figure 6 compares the slope of the ramps from the pixels examined in Figures 4 and 5. The linearized ramps (dashed lines) are clear improvements over the raw ramps (solid lines), but even they are not fully linearized. While the residual non-linearities are noticeable, they are not of the magnitude needed to explain the divots in the spectrum in Figure 1.

The divots in the spectrum likely arise when the signal crosses some threshold value. The fringing in LL2 has probably driven some parts of the spectrum of $\xi$ Dra over this threshold on the long wavelength side of 16.1 $\mu$m, and this explains the divots at 16.6 and 16.9 $\mu$m.

# 4 Conclusion

The analysis of data cubes, images and extracted spectra for the bright source $\xi$ Dra reveals that (1) this source produces nonlinear ramps, (2) these ramps are not fully linearized, and (3) a separate problem produces divots in the initial slope-fit image which then propagate into the final extracted and calibrated spectrum.

# References

Sloan, G.C., IRS-TR 04002: Discontinuities between the Low-Resolution Modules on the IRS