Using SPYBALs to Improve Pipeline Wavelength Calibrations for the First-Order Gratings of the GHRS[1]

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Abstract

The previous paper showed that wavelengths produced by PODPS can be significantly in error compared to the solution that would result from obtaining a WAVECAL in conjunction with a science exposure. This *Report* illustrates how the information contained in a Spectrum Y Balance (SPYBAL) exposure, which is routinely obtained before many GHRS exposures, can be used to correct the default wavelengths so that they are nearly as good as if a WAVECAL had been specified. This procedure can also be used with archival data.

I. Introduction

Users of the GHRS depend on the wavelength scale to draw astrophysical conclusions from their observations. Many users rely on the default wavelength scale that is provided by the pipeline data reduction system (PODPS). Other observers may obtain exposures of the wavelength calibration lamp just before they observe a celestial object, especially if their science goals demand reliable and precise wavelengths or velocities.

But in other cases an observer may only wish wavelengths that are better that the routine reductions provide and which are largely free of systematic error. Also, an Archival Researcher may find that the default wavelength scale for an existing observation is not fully adequate for his or her needs.

GHRS *Instrument Science Report 52* demonstrates that the routine wavelengths provided by PODPS are mostly within the nominal specifications (see the GHRS *Instrument Handbook*), but that there are clear and significant departures from true wavelengths that are systematic in nature. These departures arise from, for example, effects of the geomagnetic field, thermal effects within the instrument, possible long-term changes, and so on. Many of these effects can be parameterized in principle by correlating them with quantities recorded in the engineering data stream.

However, many GHRS science exposures are preceded by a SPYBAL. A SPYBAL is an exposure made with the spectrum calibration lamp, but instead of being made at the same wavelength as the science exposure (as would be the case for a WAVECAL) a SPYBAL is performed at a wavelength that is fixed for each grating. That means

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that a carrousel rotation occurs between the SPYBAL and the science exposure, of course, which means that a SPYBAL cannot provide the precision provided by a WAVECAL. But a comparison of the actual wavelength zero-point seen in the SPYBAL, compared to the nominal expected, offers an opportunity for improving the default wavelengths.

II. A Comparison of SPYBAL Wavelengths to the Default Scale

We wish to see if corrections to wavelengths measured from SPYBAL exposures can significantly improve the default wavelengths from PODPS. To do that, we searched the data archive and identified 55 instances of GHRS usage when a SPYBAL and WAVECAL were both obtained in conjunction with a science observation. The WAVECAL exposure enabled us to determine how much the default wavelengths were in error for the science exposure. We concentrate here on correcting the zero-point of the wavelengths because we showed in ISR 52 that is the predominant error, with uncertainty in the wavelength scale (dispersion) being nearly insignificant. We can also compare the wavelengths measured from the SPYBAL to the nominal wavelengths expected for it.

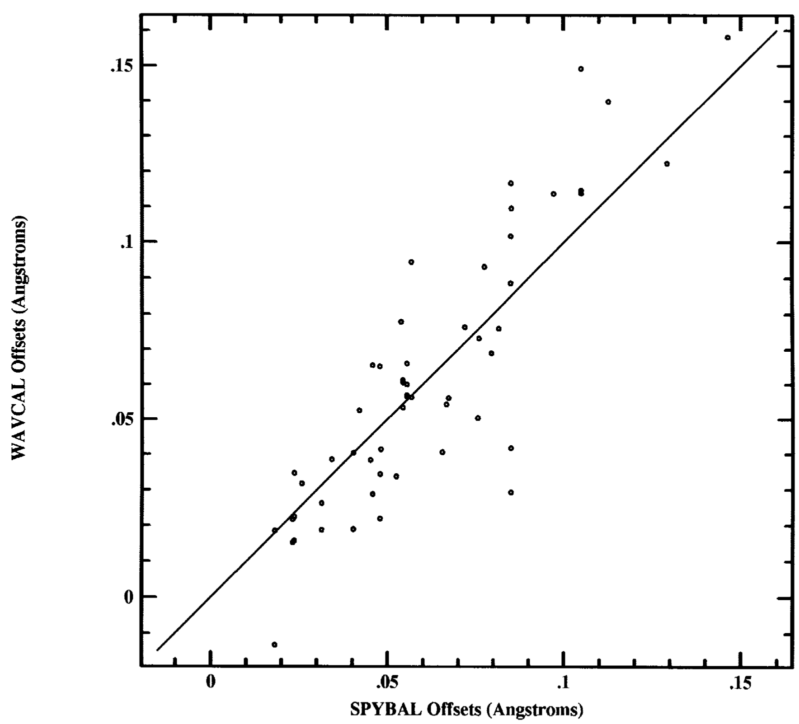

Figure 1: Comparison of wavelength offsets.

The relationship between these two wavelength offsets is illustrated in Figure 1. Note that the points scatter about the line of equality; a formal fit confirms that $y = x$ is consistent with these data. Thus, on average, a zero-point correction computed from a SPYBAL is equivalent to one determined from a WAVECAL. The scatter about the line then indicates the uncertainty associated with using a SPYBAL in place of a WAVECAL. The rms scatter in Figure 1 is 19 mÅ, which corresponds to 3 km/sec at

1900 Å. This is a substantial improvement over the default wavelengths. Note that Figure 1 shows the deviations measured for all Side 2 gratings.

III. Using SPYBALs to Improve the Default Wavelengths.

The procedure for applying this technique to currently-obtained or archival data is straightforward:

- Determine if a SPYBAL was obtained in connection with the science exposure or exposures whose wavelengths are to be corrected. If no SPYBAL exists then no improvement can be made, of course. The existence of a SPYBAL can be determined most easily from the OBSMODE keyword. OBSMODE will have the value of SPYBAL in this instance. (Note: currently, PODPS is filling OBSMODE with SPYBAL for ***any*** observation that makes use of the spectral cal lamps. Thus, both WAVECALs and SPYBALs are labeled as SPYBALs. This problem is currently being worked.) Additionally, one should check the carrousel position (found in the CARPOS keyword) of the SPYBAL since the SPYBALs are always obtained at the same carrousel position (for a given grating), see Table 1.

- Extract the SPYBAL and process it in the same manner as a science exposure.

- Use the STSDAS task, WAVECAL, to determine the zero-point shift between the calibrated wavelengths and the laboratory wavelengths.

- Apply this difference in wavelength to the science exposures using either of the STSDAS tasks, IMARITH or IMCALC. We see no systematic trend in this shift with increasing wavelength and so it appears inappropriate to apply the correction as a velocity shift, for example.

Table 1: Default Carrousel Positions for SPYBALs

GRATING	CARPOS
G160M	50764
G200M	25672
G270M	9140
ECH-B	39156