CALIBRATIONS OF WAVELENGTHS IN SWP ECHELLE SPECTRA

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1.0 Introduction

In order to obtain high quality radial velocity measurements of emission lines in the far ultraviolet with IUE, it is crucial to minimize sources of random and systematic errors in the echelle wavelength scales. In addition to the systematic shift owing to the Earth and satellite motions, which is easily rectified, the major sources of velocity shifts which can affect echelle spectra are: offsets of the image from the aperture center; inaccurate laboratory wavelengths; failure of the assigned dispersion relations to faithfully model the dispersion properties of the particular image; and read beam deflections caused by accumulations of charge on saturated portions of the vidicon target. Inaccuracies of the maneuver of the stellar image into the center of the aperture can be minimized by careful observing techniques. However, the fidelity of the dispersion relations, and the related question of nonlinearities induced by read beam deflections, are a cause for concern. For example, the deflections could, in principle, induce effective nonlinearities in the derived wavelength scales which would be "hidden" by the systematic nature of the effect because only a single exposure time is used for the standard calibration spectra.

In addition to the foregoing problems, the two-minute integration time of the standard wavelength calibration images is long enough to guarantee that the strongest Pt II emission lines at the long wavelength end of the spectrum will be exceedingly overexposed. Unfortunately, the remaining Pt II emission features not only are intrinsically quite faint, with the result that their laboratory wavelengths might be less reliable than those of the stronger Pt II lines, but also the unsaturated features are rather sparsely distributed. Hence, the dispersion relations in the spectral region longward of 1300 angstroms are dependent upon Pt II features that are less than optimum.

Here we address these questions by analyzing wavelength calibration spectra secured from our own observing programs and from the IUE Archives.

2.0 Observations

Our investigation began with the analysis of six 120 second (standard) wavelength calibration spectra obtained in mid-December of 1982 in connection with a fifth year observing program. These results were presented at the "IUE - Observing at the Limit" meeting in August of 1983. Subsequently, we have supplemented the original investigation with an examination of seventeen calibration spectra spanning approximately one year (1982) taken from the Archives (PHCAL program). Further, a series of seven non-standard (18 second) wavelength images also have been secured from a sixth year observing program.

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These short exposure wavecals are far less saturated longward of 1800 angstroms than the standard wavecals, and therefore provide many more features with which to undertake the registration of the wavelength scales in that region. (An additional advantage of a shorter wavecal exposure is that it need not be followed by an XPREP.)

3.0 Data Analysis
The spectra were reduced using standard software at the IUE Regional Data Analysis Facility in Boulder. The platinum lines were measured using an interactive procedure incorporating a least squares Gaussian fitting algorithm. The measurements were stored in a disk file for subsequent processing.

The two sets of line position data for the 120 second and 18 second wavecals were then analyzed by two different statistical methods. For both methods, line displacements were expressed in terms of the equivalent velocity shift (i.e. [observed wavelength minus laboratory wavelength] divided by observed wavelength times the speed of light). For Method "One", a mean velocity of each image was calculated by averaging the velocity shifts of the individual lines (103 lines [120 seconds] or 64 lines [18 seconds]). Residual velocities (line velocity minus mean image velocity) were then determined for each line. Finally, a mean residual velocity was calculated for each line by averaging over the set of wavecals. Method "Two" is similar to Method One except lines within the same order were first averaged to provide a mean order velocity. The goal of Method One is to investigate systematic behavior of the individual line velocities from image to image; Method Two accomplishes the same goal, but for the individual orders.

4.0 Conclusions
* The standard deviation of the PHCAL wavecals (+/- 1.1 km/sec using 1982 data only) is less than was found for the 6 wavecals (+/- 3.1 km/sec) obtained on consecutive days in December of 1982 in our previous study. The latter were taken under less than optimum conditions. We conclude that it is essential to obtain nearly contemporaneous wavecals to register velocity scales of stellar high dispersion observations.

* The standard deviation of the mean residuals of the orders averaged over 1982 is 2.2 km/sec, which can be interpreted as the internal consistency of the IUE SW wavelength scales. However, the order residuals are very stable. The stability suggests that the IUE wavelength scales might be improved. In particular, if one can determine the origin of the systematic behavior of the line and order residuals, for example systematic errors in the laboratory wavelengths of the calibration lines, then the dispersion relations could be modified to account for these deviations.

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FIGURE 1a - Mean velocity of images for 1982 and early 1983. Time is days after 1982.0.

FIGURE 1b - Method One: Mean residual velocities (see text) of individual lines for 120 second wavecals.

FIGURE 1c - Method Two: Mean residual velocities (see text) of individual orders for 120 second wavecals.

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FIGURE 2a - SAME AS FIGURE 1a FOR 13 SECOND WAVECALS.

FIGURE 2b - SAME AS FIGURE 1b FOR 13 SECOND WAVECALS.

FIGURE 2c - SAME AS FIGURE 1c FOR 13 SECOND WAVECALS.