IUE Calibration Progress Report - Plans for the Future

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This calibration report is divided up into three sections. The first section summarizes the highlights of recent (within about the last 6 months) calibration work. The second section summarizes the plans for calibrations to be included in the December 1989 pilot reprocessing effort and the final section summarizes the work that needs to be completed for the final archival reprocessing.

I. Highlights of Recent Calibration Work

1. Low-dispersion absolute calibration

The new LWR low-dispersion absolute calibration is complete. Further testing is needed to determine the subset of LWR data that would benefit from this absolute calibration. About 25 low-dispersion images will be reprocessed with the new LWR ITF in order to perform this study.

Derivation of the new SWP absolute calibration is in progress. Approximately 80 out of 180 images have been reprocessed with the new ITF. Initial image quality checks are being conducted and procedures to automate the process are being developed.

2. High-Dispersion Ripple Correction:

A revised SWP ripple correction has been derived from high-dispersion spectra obtained between March 1982 through January 1988 (Grady and Garhart, 1988). The SWP ripple correction shows no significant change over six years for spectra which have been similarly exposed and which were obtained at the same camera head temperature (THDA). The ripple correction is weakly sensitive to THDA, with increased camera THDA resulting in systematically increased K parameters. The revised ripple correction was based upon images with an average THDA of 10.5 C, which is more typical of current SWP camera temperatures. The revised ripple correction will be implemented in IUESIPS in the near future.

In the course of a study to derive new LWP and LWR ripple corrections, two problems with the extraction and background handling were discovered. These problems are responsible for significant deviations from the sinc-squared dependence with wavelength predicted for an echelle grating. First, the currently implemented background filters introduce spurious spectral features into the data. Alternate background smoothing techniques are being investigated, which bin the data into 2-angstrom bins and fit a low-order polynomial through the mean flux in each bin. Second, comparison of spectra extracted directly from the photometrically corrected image with IUESIPS spectra indicates that the extraction slit for both the gross and interorder spectra are misplaced at the short end of each order. It is possible that use of a more extensive library of comparison lines, especially one with a better representation of lines in the wavelength region of interest, will redress this problem. However, this suggestion would entail entirely new wavelength calibrations for the LWP and LWR cameras. Detailed discussions of these problems were given by Grady, Garhart and Smith during this meeting.

3. Camera Artifacts

Fifty-one sky background images were used to look for artifacts in low-dispersion SWP spectra: the artifacts appear as emission features in spectra with long exposures (Bruegman and Crenshaw 1988). The existence of most of the artifacts discovered by Hackney, Hackney and Kondo (1984, 1985) is confirmed. The most prominent artifacts occur at the following wavelengths: 1279, 1288, 1492, 1517, 1537, 1662, 1699, 1734, 1750, 1770, 1821, 1847, and 1958 angstroms. Most of the artifacts have been with the camera since the launch of the IUE satellite. There is a prominent continuum hump between 1450 and 1570 angstroms which is increasing in time. The existence and strength of certain features depends on whether point-source or extended-source processing is used.

A similar study is in progress for the LWP and LWR cameras and will be completed shortly.

4. Wavelength Calibration

An algorithm was devised to correct errors in the low-dispersion wavelength assignments for data processed at GSFC between June 20, 1984 and April 1, 1988 (Thompson, 1988a). The time correction for wavelength shifts during this period resulted in systematic errors that increase with time. The corrections are as large as 5 Angstroms for LWR spectra and 3 Angstroms for SWP spectra; there is no error for LWP spectra. Beginning April 1, 1988, the time dependent errors in wavelength assignment are no longer present due to implementation of new dispersion constants and corrrelation coefficients in production processing at GSFC (Thompson, 1988b).

5. FES Sensitivity

FES count data have been analyzed for eight IUE calibration stars in order to determine the time dependence of the sensitivity (Imhoff, Fireman and Taylor, 1988). Two straight lines provide a better fit to the data than an exponential function. There seems to be no significant sensitivity change from 1978 to 1981. After 1981, the sensitivity decreases by about 3.5 percent per year.

II. Pilot Reprocessing:

It was agreed at the September 1988 Three Agency Meeting to start reprocessing a sub-set of the IUE data in December 1989. This "pilot" reprocessing will not include any improvements in image processing or spectral extraction determined by the Signal-to-Noise Working Group (SNWG), but rather is intended to provide a more uniform archive prior to the beginning of the reprocessing for the Final Archive. Therefore a high priority has been assigned to calibration tasks that can and should be completed before the reprocessing begins on this date. The choice of which calibrations to include in the December 1989 reprocessing is affected by the time available, the potential improvements to be gained, and the effect that the signal-to-noise studies may have on the new calibrations. The following is a tentative list of the calibrations to be included in the December 1989 processing:

Priority 1 (LWP):

- New ITF (implemented December 1987)
- New low-dispersion absolute calibration (implemented December 1987)
- New high-dispersion ripple correction
- New high-dispersion absolute calibration

The LWP was chosen as slightly higher priority than the SWP and LWR because the new calibrations are most likely to improve all the LWP data, much of which was processed with the old LWP ITF, which had only one image per level for a number of the levels. In addition, the LWP labels are in better condition because they were not acquired during the first few years of IUE operations. The LWR and SWP case is not so clear-cut.

Note that the ability to derive a new ripple correction and a new high-dispersion absolute calibration depends upon solving the LWP "extraction" problem, which was described in section I above.

Priority 2 (to be done if time is available and analysis warrents):

- Update the wavelength calibration if needed

- New SWP ITF - completed
- New SWP low-dispersion absolute calibration
- New LWR ITF - completed
- New LWR low-dispersion absolute calibration

III. Final Reprocessing:

After the SNWG determined the optimal way to geometrically and photometrically correct IUE images and extract the spectral data and these new methods have been coded into IUESIPS, the various camera calibrations will have to be completed before the final reprocessing effort can begin. The magnitude of this task depends strongly on what effect the signal-to-noise work will have on the previously derived calibrations. The low-dispersion calibrations are least likely to be affected because the calibrations are derived by the binning of many pixels. The ripple-corrections might be have to be revised, especially if the flat-field characteristics change. If the ripple-corrections change, then the high-dispersion calibrations may also have to be revised. At worst case <u>all</u> the calibrations might have to be rederived. A <u>brief</u> outline of the steps to a camera calibration are discussed below. This outline is intended to provide a general idea of the magnitude of each task and is not to be used as a "recipe". See also Imhoff, et al. (1988) for a discussion of future calibration plans.

Which ITF/calibration should be used for the various epochs, is one question that will need to be addressed. Do we use the old ITF's and calibrations for the early data (1978-80) and the new calibrations for the later data, or just the new ITF's for all the data. If two epoch calibrations are needed how do we handle the discontinuity epoch between them? There is some evidence that the camera characteristics (especially the LWR linearity: Oliversen, 1984) changed during the initial period of camera useage. A report from the last signal-to-noise meeting implies that the proper allignment of the

ITF with the raw data image pixels is more important than which ITF is used (Nichols-Bohlin, 1988). However, once properly aligned there are significant differences between the different ITFs. Test results from the last SNWG meeting indicate that the old ITFs are applicable for 1978-80; after that the new ITFs seem to take over. In addition, there are significant differences in the S/N ratio between the old and new ITFs. It would, of course, be simpler if a single ITF could be used for a given camera. This would greatly simplify the completion of the calibration analysis and implementation in IUESIPS. This question will need to be addressed when the new geometric correction method becomes available and when/if the ITF's have to be re-derived.

Outline of the Camera Calibration Procedure

1. ITF (Exact procedures may change)
   - Geometrically correct about 100 UVFLOOD and null images
   - Remove bright spots
   - Model UVFLOOD lamp response (60%)
   - Determine effective exposure times for a given level
   - Coadd images in a given level
   - Create ITF

2. Low Dispersion Absolute Calibration
   - Step 1 (and 5) must be completed first
   - Process about 150 standard star images
   - Extract FN's
   - Correct for THDA variations
   - Divide by the effective exposure time (FN/sec)
   - Coadd spectra for a given star and type (i.e. point-source LGAP, trailed, SMAP, and 2X overexposed spectra)
   - Construct a merged spectrum from 2x overexposed and optimum data
   - Construct average LGAP/trail and LGAP/SMAP ratios
   - Use LGAP/trail ratio to derive bright standard star pseudo point-source LGAP spectra
   - Bin merged spectra
   - Compare average FN/sec to standard star spectra to determine inverse sensitivity curve for point-source LGAP and trailed spectra

3. High-Dispersion Ripple Correction
   - Step 1 (and 5) must be completed first
   - Process about 80 standard star images
   - Extract FN's
   - Fit orders with a sinc-squared function and/or adjust "K" values to minimize differences between orders (Barker, 1984).
   - Verify performance of derived ripple correction, and perform trend analysis for time or THDA effects.

4. High Dispersion Absolute Calibration
   - Complete steps 1, (and 5), 2 and 3
   - Geometrically and photometrically correct about 50 standard star images
   - Apply ripple correction to extracted extracted net Flux (FN)
   - Compare low- and high-dispersion spectra of same standard star star to derive the high-resolution calibration function (C) (see Cassatella, et al. 1981)

Other possible improvements to be included in the final archive:

5. Wavelength Calibration
   - Enlarge line library in IUESIPS
   - Geometrically correct about 300 wavelength calibration images
   - Determine dispersion relation for each image
   - Extract each wavecal as if it were a standard image
   - Derive analytical fit giving dispersion relations as a function of camera, time and THDA

6. Low-Dispersion Sensitivity Correction
   - Complete steps 1 and 2 above
   - Process about 250 standard star images
   - Two methods (Analytical fit or interpolation)
   - Coadd spectra for a given star from single time period (6 months?)
   - Construct table of camera response, relative to a reference epoch as a function of wavelength and date
   - Interpolate between table entries for IUESIPS processing (extra file/record on GO tape)

7. Correct for THDA-induced Camera Sensitivity Variations
   - This information is derived from sensitivity monitoring data

8. Correct for aperture-dependent response of camera.
   - This information is derived from Step 2 above

9. High-Dispersion Sensitivity Correction
   - TBD

References

Barker, T. 1984, A. J., 89, 899.

Bruegman, O. and Crenshaw, D. M 1988. Report presented at the September 1989 IUE Three Agency Meeting; to appear in an upcoming NASA IUE Newsletter.

Cassatella, A., Ponz, D., and Selvelli, P. 1981. NASA IUE Newsletter, No. 14, p. 170.

Grady, C., and Garhart, M. 1988. Report presented at the September 1988 IUE Three-Agency Meeting. To appear in an upcoming NASA IUE Newsletter.

Hackney, R., Hackney, K., and Kondo, Y. 1984. NASA CP-2238, 335.

Imhoff, C., et al. 1988. in "A Decade of UV Astronomy with IUE", Proc. Celebratory Symposium, Vol. 2, p. 341, ESA SP-281.

Imhoff, C., Fireman, G., and Taylor, M. 1988. Report presented at the September 1988 IUE Three-Agency Meeting.

Nichols-Bohlin, J. 1988. NASA IUE Newsletter, No. 36, p. 28.

Oliversen, N. 1984, NASA IUE Newsletter, No. 24, 50.

Thompson, R. 1988a, NASA IUE Newsletter, No. 35, 133.

Thompson, R. 1988b, NASA IUE Newsletter, No. 35, 108.