

An IRAF Port of the New IUE Calibration Pipeline

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Abstract. The calibration pipeline that was used for the *IUE* final archive, NEWSIPS, is being ported to IRAF. This port will enable archival researchers to optimize the spectral processing for their scientific needs.

1. Introduction

A new spectral image processing system (NEWSIPS) was constructed for a final, archival reprocessing of the *IUE* data archive. NEWSIPS incorporates many improved processing algorithms and calibrations which greatly enhance the quality, and hence the scientific utility, of *IUE* data for archival research. However, the perceived need to produce a homogeneous archive precluded custom processing options and special calibrations that are essential for many science programs. In addition, limited resources prevented the completion of certain useful calibrations, and limited the scope of efforts to characterize the complex echelle background and ripple correction. Unfortunately, it is not practical for researchers to make use of the production NEWSIPS system, mostly because it depends on vendor-specific software and hardware, and it would have been impossible for users to maintain or enhance the pipeline over the long term.

We are porting the NEWSIPS software to the IRAF environment. The ported pipeline will enable recalibration from the raw data or from certain intermediate stages, will allow for different choices of reference files, and will accommodate the use of more appropriate processing techniques at intermediate stages. We are removing the dependencies of NEWSIPS on licensed vendor software, and replacing them where necessary with existing or new IRAF libraries. Our goal is to retain a high degree of compatibility with the archival NEWSIPS pipeline, given the same input parameters. Placing the NEWSIPS software in the public domain will allow *IUE* archival researchers much greater flexibility for meeting their particular scientific needs, while also promoting greater understanding of the NEWSIPS system by current and future users of *IUE* data. The IRAF system is a good choice for ensuring the longevity, portability, and wide accessibility to the user community of the software, while also providing a very rich environment for analysis of *IUE* data by future archival researchers.

2. Why Recalibrate?

There are many reasons for re-running all or part of the NEWSIPS calibration pipeline, even after all the improvements that have been realized by the original NEWSIPS processing. For example, the spectral extraction processing for low dispersion uses an “optimal” or signal-weighted extraction technique (SWET) to optimize the S/N ratio and exclude outliers. However, this technique is inappropriate if the ionization structure is spatially resolved—e.g., for many planetary nebulae or H II regions. Figure 1 shows how outlier rejection in SWET can cause unexpected results; the solution is to re-extract using a different method.

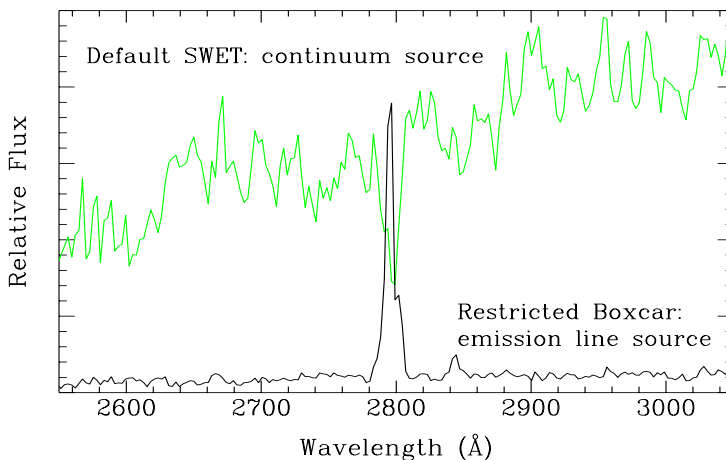


Figure 1. Low dispersion spectrum from LWP 17531 of α Her showing the SWET extraction (*upper*), which excludes a spatially resolved emission feature that can be recovered with a boxcar extraction (*lower*).

The high-dispersion extraction uses a simple boxcar weighting, and as such does not exclude outliers. Figure 2 illustrates the effect of a prominent, grazing cosmic ray that affected several adjacent orders in the SWP high-dispersion spectrum of BD+75°325. Cosmic rays like this could easily be excluded using either a more sophisticated extraction or, when two or more images are available in the archive, by rejecting cosmic rays from the LI image during calibration.

For images obtained in high-dispersion, an imperfect model of the background determination can under some circumstances result in an under- or over-correction. These problems are illustrated in Figure 3, where the SWP spectrum of HD 149438 shows what should be a saturated absorption feature at Ly α . An under-correction of the inter-order background causes this absorption feature not to fall to zero flux in the line core. The opposite problem occurs for HD 163181, where an over-correction for the inter-order background shortward of 1250 \AA results in negative fluxes. Improvements in the background estimation will require either a more sophisticated model or a semi-empirical approach.

More ambitious users may need to improve upon the calibration reference files to extract the best science from their data. For example, the most appropriate flat-field data for late-epoch SWP images may be that obtained during the 1992 ITF campaign. But a lack of resources precluded the construction,

testing, and implementation for final archive processing. For cases like this, the only option is for users to reprocess their images with improved calibrations.

3. Software Details

The NEWSIPS pipeline, various ancillary utilities, and the calibration reference files will be distributed as an IRAF layered package called **iae**. The complete calibration pipeline, *caliae*, will be a high-level script that executes several tasks that comprise major modules of the pipeline. These tasks, listed in Table 1, can also be run independently. The choice of what calibration steps will be performed, and of which calibration reference files will be used, will be managed through a set of keywords stored in the image header, or alternatively through parameters of the constituent tasks. A feature of this approach is that the ported pipeline will be re-entrant—i.e., it will be possible to use different (perhaps user-written) software to perform one or more of the calibration steps, then run the remainder of the standard pipeline tasks.

Table 1. Major Tasks in the **newsips** Pipeline.

Task	Description
<i>ns_init</i>	Populates the raw image header with control keywords
<i>rawscreen</i>	Flags missing data and cosmic rays
<i>ttdc</i>	Computes time- and temperature-dependent dispersion corrections
<i>xcorr</i>	Registers the science image with the ITF
<i>photom</i>	Applies the photometric correction
<i>iaegeom</i>	Rectifies the 2-D spectra and linearizes the dispersion
<i>nsextract</i>	Extracts the 1-D spectrum from the image

One of the goals of this project is to reorganize and better document the calibration reference files used in NEWSIPS, and to provide them to the community in FITS format. The **iae** package will also include tools for constructing the calibration reference files, which will enable archival users to improve upon or extend the calibrations derived for the final archive. The ported pipeline will support FITS format for all input and output files natively, eliminating the dependency on MIDAS-format files. Other enhancements include improved memory management by a factor of $\sim 10^3$ or more, which will enable reprocessing multiple images at once for large archival projects. Finally, an essential element in this port is to eliminate the dependency of NEWSIPS on vendor-proprietary software so that it may be distributed freely to the community.

4. Availability

The first release of the **iae** layered package is planned for early 1998. This release will contain the low-dispersion portion of NEWSIPS pipeline, including some custom processing options. It will also include utilities for creating various calibration reference files. Subsequent releases during 1998 will include the

high-dispersion portion of the processing pipeline, additional custom processing options, and new utilities. The **ie** package, including the software, documentation, calibration reference files, and all updates, will be available from the NEWSIPS home page¹. Note that the **ie** package will require that IRAF V2.11 and TABLES V2.0 (or later) be installed. The *IUE* archive is being re-hosted to the Space Telescope Science Institute, where support for *IUE* archival data and this NEWSIPS port will continue for the foreseeable future.

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¹<http://ra.stsci.edu/newsips/>

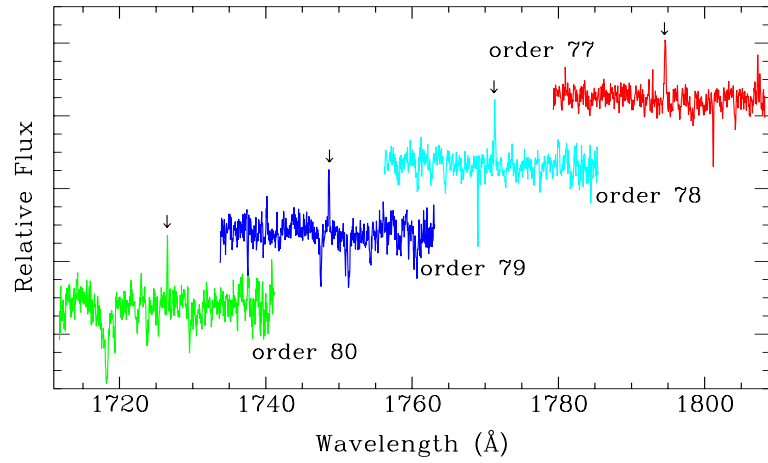


Figure 2. Several adjacent spectral orders are affected by a grazing cosmic ray hit (marked with arrows) on the high dispersion image SWP 35674 of BD+75°325.

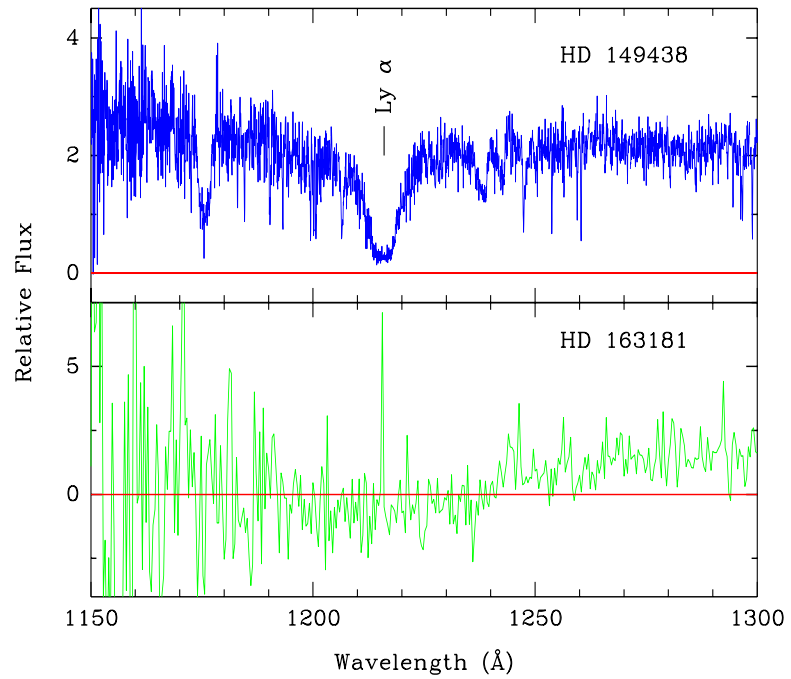


Figure 3. High dispersion SWP spectra of two stars, illustrating the consequences of an imperfect background model in NEWSIPS.