

# COMPARISON OF IUE FLUX EXTRACTION BY INES AND NEWSIPS

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## Abstract

IUE low dispersion flux extraction by INES has been compared quantitatively with NEWSIPS flux extraction. A boxcar extraction was used as a minimum-flux criterion to appraise those cases where significant discrepancies between the two extraction methods were found.

Generally the extracted fluxes of INES and NEWSIPS agree for individual wavelengths to within  $\sim 2\sigma$ . But in many cases, *systematic* differences of up to  $\sim 2\sigma$  occur over much of the spectrum. Very significant ( $\sim 10\sigma$ ) underestimates of line fluxes are seen in some narrow emission-line spectra extracted in NEWSIPS, especially those with weak continua.

In all discrepant cases the boxcar extraction favours the INES results over NEWSIPS.

**Key words:** Flux Extraction; INES; NEWSIPS; IUE.

## 1 INTRODUCTION

The INES flux extraction algorithm, Rodríguez Pascual et al., 1997, was developed because low-dispersion IUE spectra produced with NEWSIPS, Garhart et al., 1997 (Chapter 9), were seen to have problems under certain conditions. For example, inconsistent emission line ratios and unreliable flux extraction in regions of continua with saturated pixels were found by Rodríguez Pascual, 1996. A detailed analysis showed that for narrow line spectra the extraction profile used in NEWSIPS can cause unreliable flux values. In addition, a comparison of the distribution of flux values obtained for single wavelengths with the errors given by NEWSIPS of repeated observations of non-variable stars, demonstrated that the noise models used in NEWSIPS were inadequate for certain ranges of wavelengths and FN values, Schartel, 1996.

In order to overcome these problems a new extraction algorithm was developed called IUE newly extracted spectra (INES), (Rodríguez Pascual et al., 1997). INES incorporates an enhanced noise model, Schartel & Rodríguez-Pascual, 1998. In INES, the spatial extraction profile is determined in blocks of total  $S/N > 30$  along the dispersion direction, from

a minimum of 7 wavelength steps. This provides an improved alignment of the extraction profile, particularly with strong emission lines on a weak continuum. An extensive study based on repeated observations of non-variable stars demonstrates that the errors given by INES establish an improved and consistent treatment of the noise in the extracted spectra, Schartel & Rodríguez-Pascual, 1998, and Rodríguez Pascual et al., 1997.

The purpose of the current study was to ensure the quality of the final INES spectra. This was done by an extensive quantitative comparison of spectra extracted by INES and NEWSIPS.

## 2 METHOD

Our comparison is based on approximately 2000 low dispersion observations selected from different IUE classes (dwarf novae, planetary nebulae, quasars, etc.). Because no further selection criteria were introduced, observational parameters such as FN-values, observation date, exposure time and background level, are well covered.

In INES, unlike NEWSIPS, all spectra taken with the same camera have identical wavelength scales. Therefore, it was necessary to re-grid the NEWSIPS spectra for comparison of the extracted fluxes. The re-gridding onto the INES wavelength scale was done by quadratic interpolation. The quantity  $\mathcal{E}(\lambda)$  was used to quantify the differences between the two extractions:

$$\mathcal{E}(\lambda) = \frac{[\mathcal{F}_I(\lambda) - \mathcal{F}_N(\lambda)]}{\sigma_I(\lambda)} \quad (1)$$

where  $\mathcal{F}_I$  is the flux extracted with INES,  $\mathcal{F}_N$  is the flux extracted with NEWSIPS, and  $\sigma_I$  is the error obtained with INES.

Because both algorithms are rather complex it is necessary to introduce an independent criterion for cases where significant discrepancies between INES and NEWSIPS extractions were identified. We used an unweighted boxcar extraction, which was made from the corresponding SILO file, as a minimum-flux criterion to appraise such cases.

## 3 RESULTS

NEWSIPS smooths through distinct features in the background, whereas INES does not. However, this leads to only small differences in the extracted fluxes, mostly under  $\sim 1\sigma$ . In the majority of cases, the agreement between the INES and NEWSIPS extractions is excellent. The main differences are:

- Although for individual wavelengths the agreement in the extracted fluxes of INES and NEWSIPS is better than  $\sim 2\sigma$ , in many cases, particularly for weaker spectra, *systematic* differences of up to  $\sim 2\sigma$  occur over much of the spectrum, with INES registering more flux than NEWSIPS. The boxcar extraction, albeit noisier, favours the systematically *higher* flux extractions.

- Very significant ( $\sim 10\sigma$ ) underestimates of line fluxes extracted by NEWSIPS are seen in several narrow emission-line spectra, especially those with weak continua. INES and the boxcar extractions consistently register more line flux in these cases.
- INES propagates quality flags more liberally than does NEWSIPS (compare Rodríguez Pascual et al., 1997). Examples are seen where a substantial part, or even all of a spectral feature is flagged by INES, but not at all by NEWSIPS.

Figure 1 illustrates the underestimation of line fluxes for the Planetary Nebula NGC6302 (SWP30986). Not only does INES register up to  $14\sigma$  more flux in the lines (Figure 2), but line *ratios* are also different. INES also registers systematically  $\sim 1 - 2\sigma$  more flux in the continuum. Figure 3 shows that the boxcar extraction deviates from the net NEWSIPS spectrum in the same sense as INES, both in the continuum and in the lines.

The different propagation of quality flags is illustrated in Figure 4 for the symbiotic star BF CYG (SWP35768);OIII] emission at  $1666\text{\AA}$  is flagged in INES, but not in NEWSIPS.

## 4 DISCUSSION

It is emphasized that in the majority of cases, the agreement between the INES and NEWSIPS extractions is excellent.

The most noteworthy differences occur in the case of strong, narrow emission-line spectra with weak continua, where the INES extractions appear to be consistently more reliable.

For those cases in which systematic differences are seen, the differences are not significant on a *per wavelength* basis. However, if such spectra are binned into N-element bins, the statistical significance of the *binned* differences will of course be enhanced by a factor of  $\sim \sqrt{N}$ .

Finally, in the case of spectral features flagged in INES and not in NEWSIPS, it is noted that flagged contiguous wavelengths can indicate a significant systematic effect in that feature.

## References

Garhart M.P., Smith M.A., Levay K.L., Thompson R.W., 1997, *International Ultraviolet Explorer New Spectral Image Processing Information Manual-Version 2.0*, see INES Document 3.2.9

Rodríguez-Pascual P.M., 1996, ESA Internal Report

Rodríguez-Pascual P.M., Schartel N., Wamsteker W., Pérez-Calpena A., 1998, *Extraction of Low Dispersion Spectra for INES*, INES Document 4.3

Schartel, N., 1996, ESA Internal Report

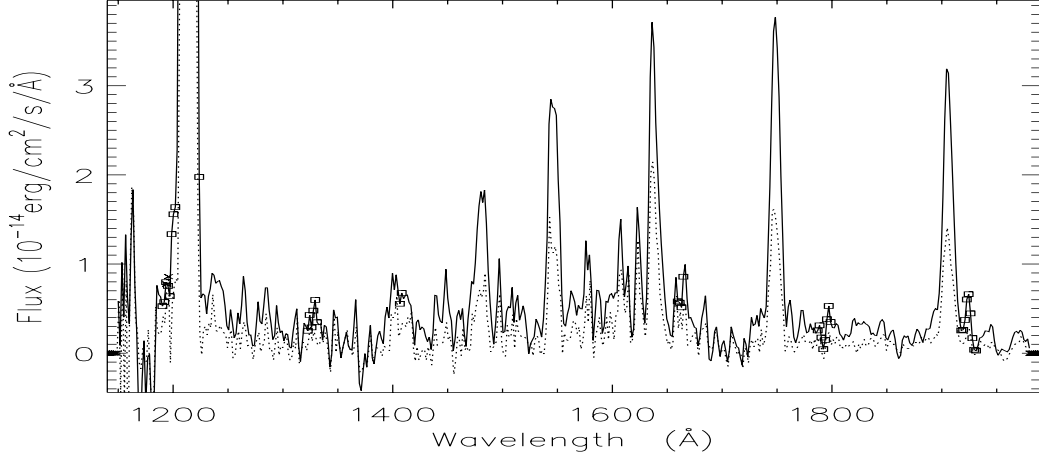


Figure 1: Overlay of INES (solid line) and NEWSIPS (broken line) extracted fluxes for the planetary nebula NGC 6302 (SWP30986). Bad quality flags are indicated by  $\square$  (INES) and  $\times$  (NEWSIPS).

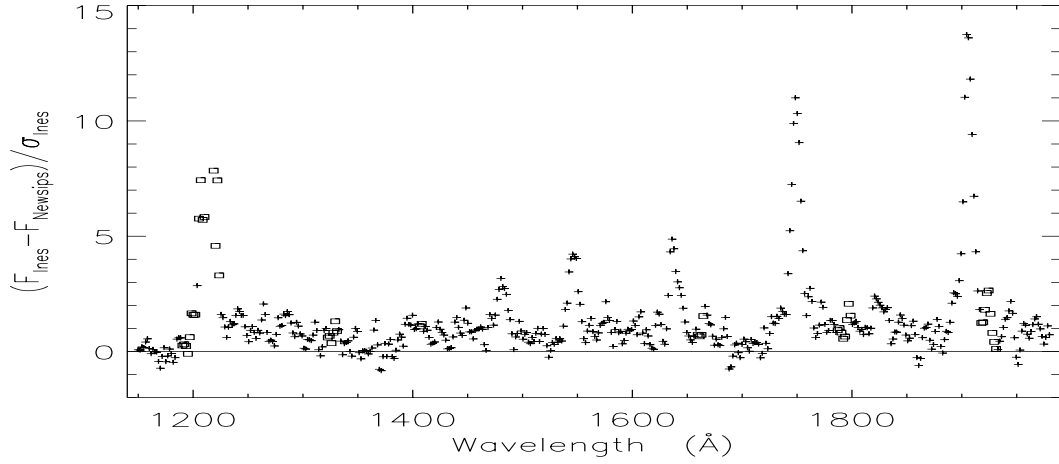


Figure 2: Error-normalized differences in the INES and NEWSIPS flux extractions for SWP30986. Note that there are up to  $14\sigma$  differences in the lines and also that the continuum is systematically different by  $1-2\sigma$

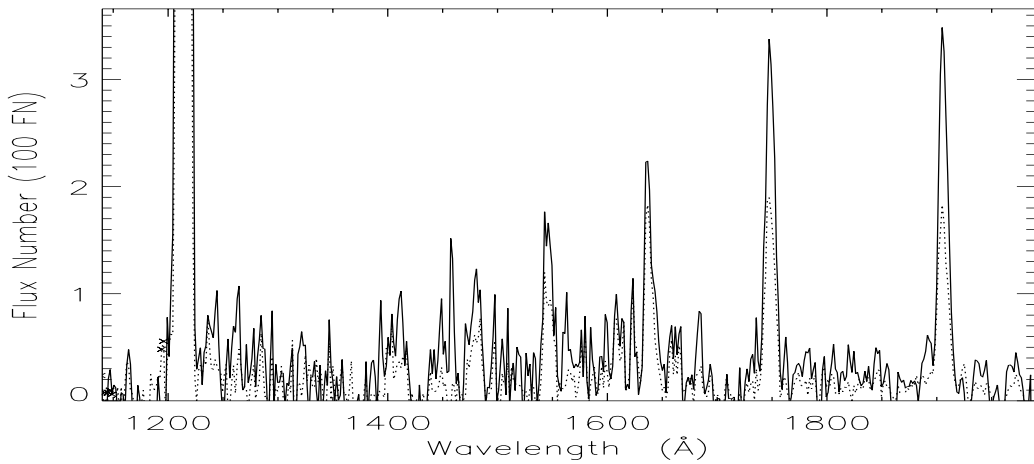


Figure 3: Overlay of boxcar (solid line) and net NEWSIPS (broken line) extractions for SWP30986. Bad quality flags are indicated by  $\times$  (NEWSIPS).

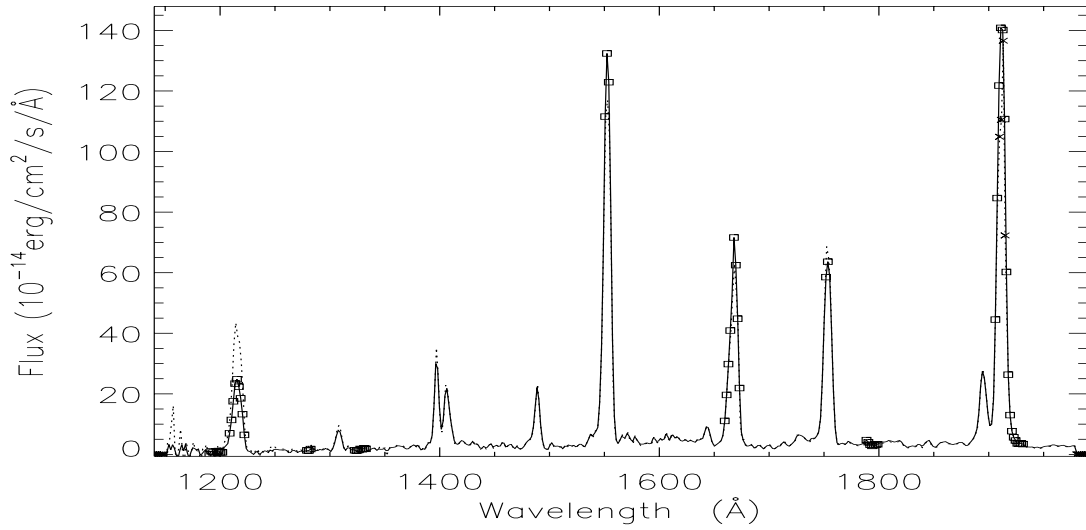


Figure 4: Overlay of INES (solid line) and NEWSIPS (broken line) extractions for the symbiotic star BF CYG (SWP35768). Bad quality flags are indicated by  $\square$  (INES) and  $\times$  (NEWSIPS). The extracted fluxes are in excellent agreement, but the entire 1666Å OIII] feature is flagged in INES and not at all in NEWSIPS.

Schartel, N., Rodríguez-Pascual P.M., 1998, '*INES Noise Model*', INES Document 4.2