A Technique for Identifying and Removing Bright Spots in IUE Low Dispersion Spectra of Point Sources

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Abstract

A techique is presented by which one can identify and remove bright spots (hits) using the spatially resolved spectral information provided by IUESIPS. The method depends on examining the goodness of fit of the observed distribution of signal perpendicular to the dispersion line with the expected point spread function. The wavelength and the distance of the hit from the dispersion line are determined. The pixels in the vicinity of the detected hit are visually examined and all pixels judged to be affected are flagged. The low dispersion spectrum is then re-extracted with the hits removed by replacing the observed value of the contaminated pixels with the value determined from the other pixels at the same wavelength and the known PSF. Results of the technique are presented for several test cases processed with programs available at the GSFC RDAF.

a) Introduction

The vidicon cameras which record the IUE spectra are sensitive to particles as well as photons. During long exposures (i.e. more than several hours) one can expect several strong particle-induced bright spots ("hits") to occur close enough to the dispersion line to contaminate the stellar spectrum. The photometrically and geometrically corrected image segment provided by IUESIPS for low dispersion spectra (the so-called ESSR or LBLS file) supplies spatial information which can be used to identify and remove some of the hits.

b) identification of hits

An objective test of the presence of hits can be obtained by checking the degree of consistency with the expected point spread function perpendicular to the dispersion (PSF). Hits which occur somewhat off the dispersion line will be particularly noticeable from the lack of symmetry. A hit occuring exactly on the dispersion line would be noticeable if it is sharper or broader than the PSF. Of course, given the relatively low signal/noise of the vidicon detectors and the great variety in the shapes of the hits, one can never expect to positively identify all hits without recourse to more than one spectrum of the same object. Even then, hotspots and warmspots in the detector can be mistaken for spectral emission lines. In principle, these could be mapped from sky exposures, or by offsetting the star within the aperture.

Ideally, one would establish a chi-square test for consistency with the PSF. Unfortunately, at the present there is too little information on the statistics of the detector noise (e.g. with reference to dependence on signal level or background level, variation across the face of the detector, etc.) to make a rigorous test. Hence, we adopt a technique for a subjective identification which is guided by a measure of the goodness of fit with the expected PSF. At each wavelength along the spectrum, the PSF is scaled to provide the best fit to the observed pixel values, where the centroid and shape of the PSF are assumed to be known a priori (i.e. the fit depends only on the total signal). The root-mean-square (rms) deviation then provides a measure of the goodness of fit. As one runs along the spectrum, sharp hits would be evident because of the sharp increase in the rms deviation.

This technique can be generalized to determine the distance of the hit from the dispersion line. The rms deviation is recomputed for a fit which omits a given pixel (i.e. the contribution of that pixel is determined from the value of the other pixels and the assumed shape of the PSF, instead of using the observed value). When a pixel which is contaminated by a hit is omitted, the rms deviation of the fit is greatly decreased. This identifies the location of the hit perpendicular to the dispersion.

Thus, the criterion for detection of a hit is (i) an increase in the rms deviation of the fit relative to the value at neighboring wavelengths (ii) an improvement in the fit (decrease in rms deviation) when a pixel is deleted. Visual inspection of the surroundings of the hit is made, and all pixels judged to be affected are flagged (at the RDAF this can be done on the COMTAL). Of course, this technique works best for very sharp hits or for hits well away from the dispersion line.

c) removal of hits

Pixels which are flagged are then corrected as suggested above, i.e. by replacing the observed value with the value determined from the unaffected pixels at the same wavelength and the assumed shape of the PSF. Let PSFi = PSF evaluated at the ith pixel s.t. SUM(PSFi)=1.0, and Fi = the observed signal in the ith pixel. Then

Flux (with ith pixel removed) = SUM(Fj)/SUM(PSFj)
Epsilon (with the ith pixel removed) = SUM(PSFj) where both sums are over all j except j=i

Epsilon provides a measure of the quality of the data point.
Study has shown that the PSF is well approximated by a Gaussian.
A representative value for the FWHM is given by 3.7 for the SWP and 3.0 for the LWR (Panek, report to IUE Users Committee Fall 1982, units are pixel separation in the raw image). However, measurements show that the FWHM varies by about 20% along the spectrum, and also depends on the focus of the telescope. Also, the centering of the extraction region upon the spectrum can vary by several tenths of a pixel, and residual geometric distortions of this magnitude remain even in the geometrically corrected image. In a well exposed spectrum, the centering and the FWHM are readily evaluated by computing the first and second moment of the distribution of signal perpendicular to the dispersion.

Xo= centroid = SUM(Xi*Fi)/SUM(Fi) where Xi = distance of the ith pixel from an arbitrary reference (e.g. line 28)

FWHM = 2.355 * SQRT(SUM(Xi*Xi*Fi)/SUM(Fi) - Xo*Xo) (assumes Gaussian shape)

The centroid and FWHM are then smoothed or filtered as a function of wavelength. One finds that using the representative values instead of the true values for centroid and FWHM will introduce errors in the flux of the order of 20%. This is not much greater than the expected error in poorly exposed images.

IDL>; LINES 29, 30, AND 31 IN SWP15098
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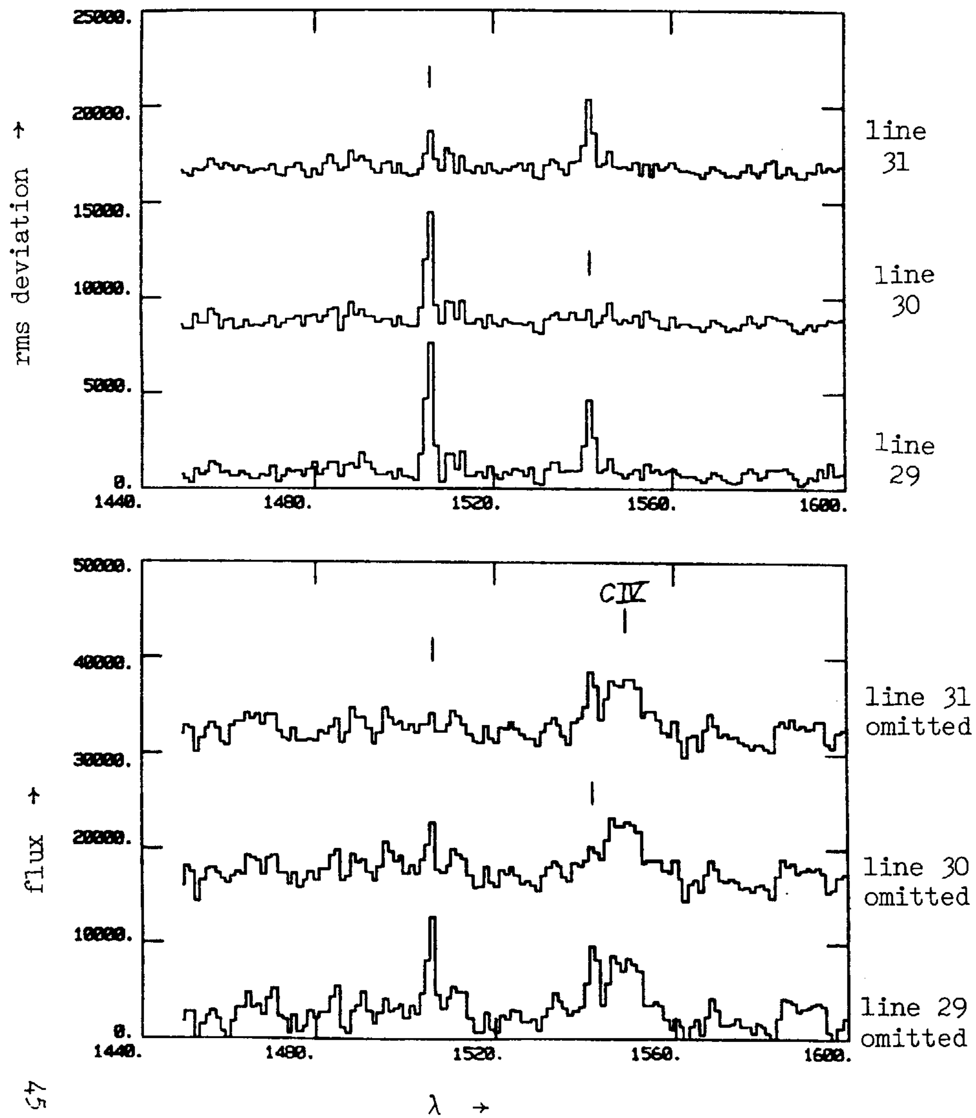

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