ON THE TRAIL OF PERIODIC VARIATIONS

It is well known that the superb versatility of IUE allows the observer to obtain trailed low-dispersion spectra of his (brighter) targets if he so desires. Brief discussions of the technique are given by Clavel (1980) and Heck (1981). The original standard procedure enables the trail rate (within the range 0.03 - 60 arcsec/sec) and the number of interations, or passes, to be specified. The satellite then trails the target automatically backwards and forwards along the large aperture.

One rather special case for which trailing is useful is the study of objects exhibiting rapid periodic intensity variations. If the trail rate is chosen so that the time taken for a pass across the aperture is equal to the target period, then the full intensity variation will be spatially encoded perpendicular to the dispersion line of the resulting spectrum. In practice, of course, such targets are not as bright as one might hope and it is usually necessary to superimpose a number of synchronised uni directional trails to build up the signal-to-noise ratio. Since the original trail procedure was not designed for this purpose attempts at using it for such have caused considerable frustation. Recently, however, the trail procedure has been modified to allow a series of synchronised unidirectional trails to be carried out without causing the telescope operator to foam at the mouth.

At the beginning of the trail procedure the target is moved from the reference point and positioned at a start point a short distance from the aperture. The new procedure is identical to the original one until the first pass has been completed. Then, instead of returning the target to the start point by executing a reverse pass at the specified trail rate, the new procedure temporarily halts the exposure and returns the target directly to the start point, taking it rapidly across the aperture. Any positional errors are corrected at this point before the command is given to restart the exposure and commence the next iteration. Experience has shown that the start of each pass can be timed to within a few seconds, which is quite adequate if the period of the target is in excess of 100 seconds.

The number of passes, N, required for a target with period T and untrailed exposure time t is given by:

$$N = \frac{3.2t}{T}$$

The required trail rate is simply 20/T, where 20 refers to the length of the large aperture in arcsec. The limits on the trail rate remain as quoted above.

Having obtained such an image one is left with the non-trivial problem of analysing it for intensity variation. A simple form of analysis would be to take 3 well separated samples each more than 8-10 pixels apart. There is, however, still some residual contribution, of the order of 10-15% from adjacent samples due to a weaker, broader gaussian component of the point-spread-function (PSF). To tackle the problem thoroughly one needs to apply a deconvolution process to the data, such as the Maximum Entropy Method (see Gull and Daniell, 1978, for an introduction). Using this approach, time resolution down to 15-20% of the period has been achieved, although one must be careful with the changing form of the PSF with wavelength and camera head amplifier temperature (de Boer et al., 1980 Cassatella et al., 1983).

The technique has been applied to a search for UV variability in X-ray pulsators, which are accreting binary systems incorporating spinning neutron stars. Some results are shown in Figures 1 and 2. It can be applied equally well to other types of source having a known, coherent short period and enables some degree of high time resolution to be achieved with IUE.

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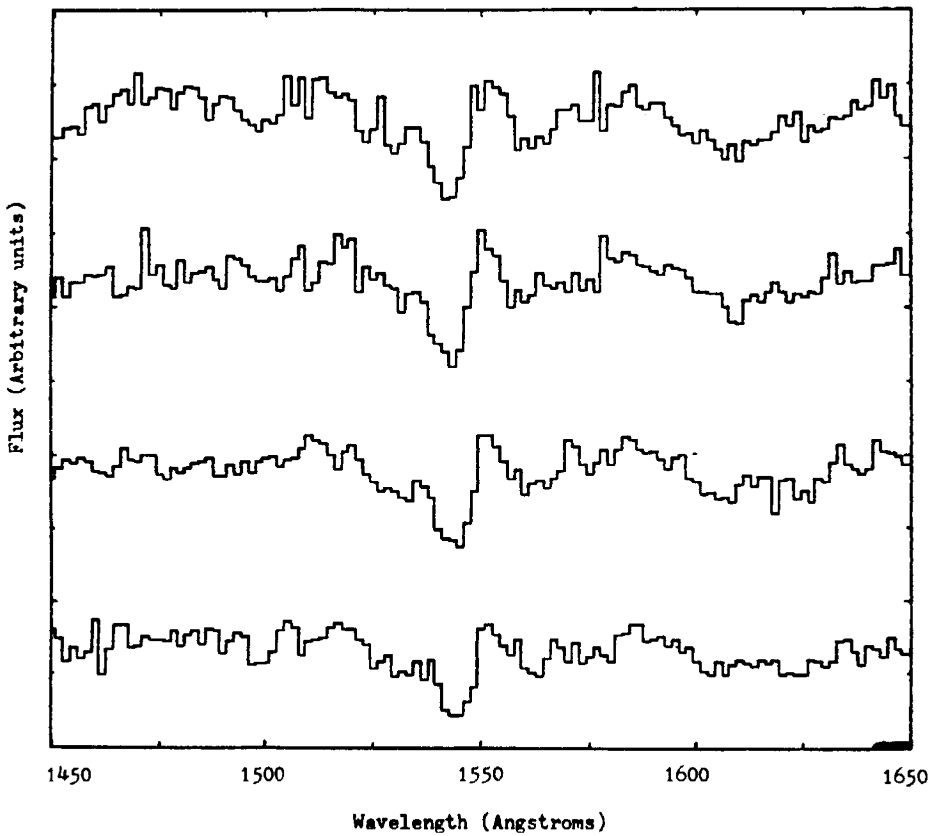

FIGURE 1:

Section of an IUEDR (see IUE Newsletter no. 17, page 53) line-by-line image centered on the C IV line. The spectra shown are individual pseudo-orders taken from a trailed image of the binary pulsator Vela X-1. Consecutive orders represent the spectrum in consecutive time intervals of about 15 seconds.

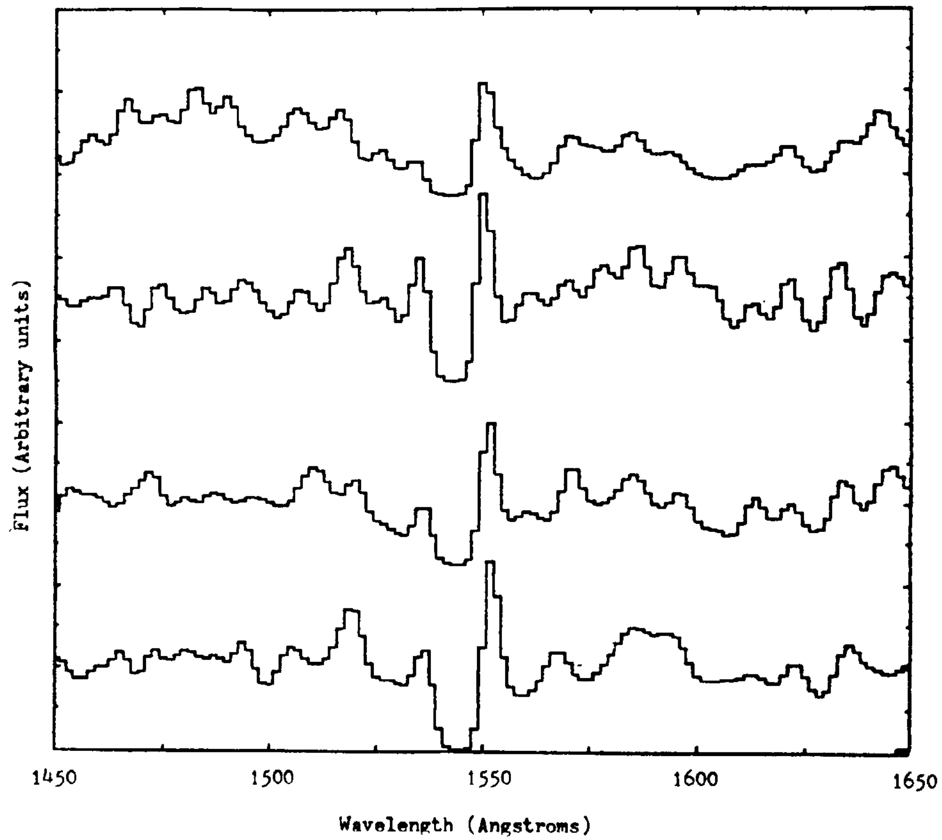

FIGURE 2:

The same diagram after deconvolving the SWP camera point-spread function from the data using a program based upon the Maximum Entropy technique. Changes in the line profiles from one pseudo-order to the next can clearly be seen.