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The η Carinae Treasury Project and the HST/STIS

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Abstract. The HST Eta Carinae Treasury Project made extensive use of the HST/STIS from 1998 to the time of its failure in 2004. As one of the most prolific users of that instrument, the Treasury Project used the cross-dispersed spatial resolution of the STIS as few projects did. We present several enhancements to the existing STIS data reduction methods that are applicable to non-Treasury Project data in the STIS archive.

1. Introduction

η Car is an unusually demanding target for HST. The standard software is inadequate for several reasons. We mentioned some of these problems in an article in Davidson (2004a), and you can find details in our Technical Memos at our website[1]. These items specifically concern STIS/CCD, but some have broader applications. STIS users should be aware that the Tech Memos on our site are updated from time to time.

2. Oversized Pixels

HST instruments generally have marginal or poor spatial sampling – e.g., each STIS/CCD pixel was about 50% wider than it should have been for the optical system. Dithering can improve the sampling but is cumbersome and is not always feasible. We have devised a special interpolation method to minimize the bad effects that occur when one applies distortion corrections, rotations, etc., to poorly sampled data. Figure 1 indicates the improvement in a spectrum extraction, for example, but this technique can and should be applied to all non-dithered STIS, WFPC2(PC), and ACS data. See the paper by Davidson (2006) in this volume and our Technical Memo 1 (Davidson 2004b) for more details.

3. Subtleties Concerning Noise

Many astronomers use the ERR arrays in HST data files, but this can be dangerous. For instance, Figure 2 shows the ERR array in a pipeline-reduced STIS/CCD spectral image. The beautiful pattern does not represent any fundamental instrument effect; it is a processing artifact related to pixel resampling. The cause is too subtle to explain here, but for most practical purposes the standard ERR array is wrong and one cannot estimate the true statistical noise from it. Our special interpolation technique mentioned above avoids

[1] `http://etacar.umn.edu/treasury/techmemos`

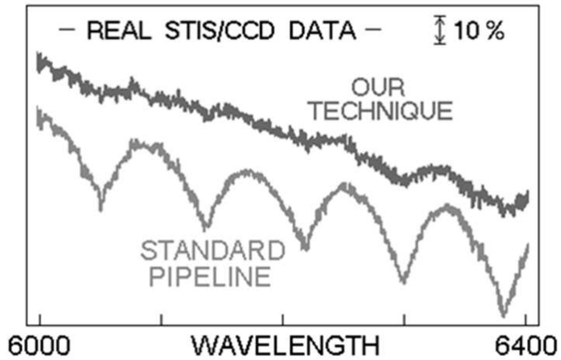

Figure 1: Slight off-center stellar continuum, extraction with a width of $0.1'' = 2$ STIS/CCD pixels.

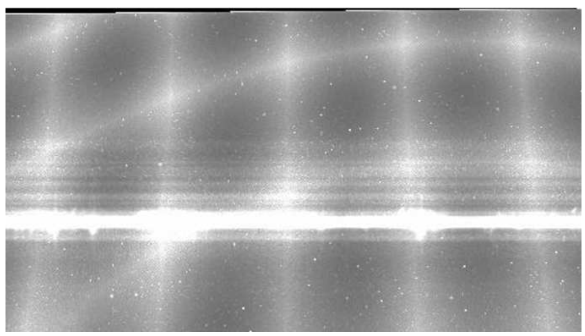

Figure 2: The ERR array in pipeline-processed STIS data, see Section 3.. There is a mathematical reason for the pattern, but for most purposes it gives wrong answers.

this pitfall, and the ERR arrays in our archived Treasury Project data will be carefully and unambiguously defined. All this is explained in Treasury Project Technical Memos 1 and 7 (Davidson 2004a, 2004c), which apply to any data that have been resampled, corrected for distortions, etc.

4. Low-level Wings of the STIS/CCD Spatial Point Spread Function (PSF)

The left part of Figure 3 shows three typical log-scale plots of the weak but extensive response wings along the STIS slit. Since these matter in the case of η Car, we have assessed the parameters and developed a correction routine. The right-hand part of Figure 3 shows the before and after affect of this correction in a real STIS spectrogram of an isolated star. Note that some complex structure remains, which we have not yet quantified. See our Technical Memo 6 (Martin 2005a).

5. Asymmetry in the Core of the PSF

At long wavelengths the STIS/CCD spatial PSF has a very noticeable bump on one side, close to the peak and much stronger than the wings mentioned above (Figure 4). We have parametrized this effect and we will soon produce a simple routine to remove it if a user so desires. See Technical Memo 2 (Martin 2004).

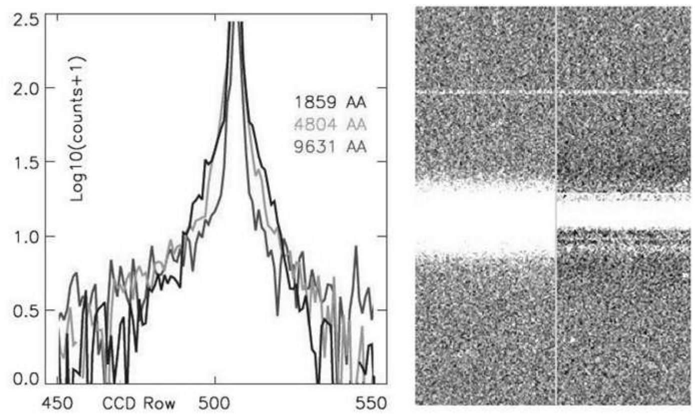

Figure 3: Left panel: the level of extended wings from a point source at different wavelengths. The peak of the PSF core is at about $\log(10^4) = 4$. Right panel: an example of the before and after effect of removing these wings.

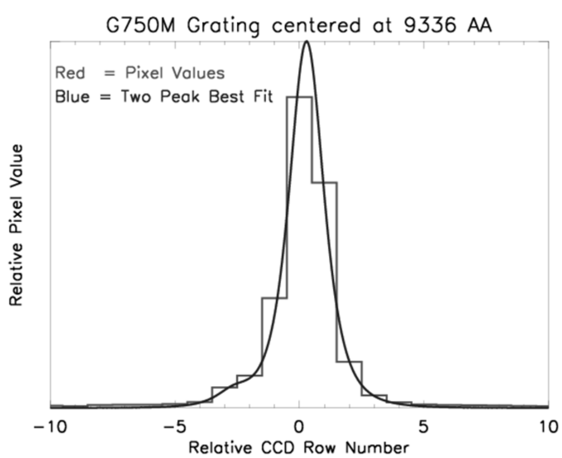

Figure 4: A cross cut of a point source spectrum on the STIS/CCD showing the asymmetry in the PSF. The flux scale is linear so the wings from Fig 3 are not discernible.

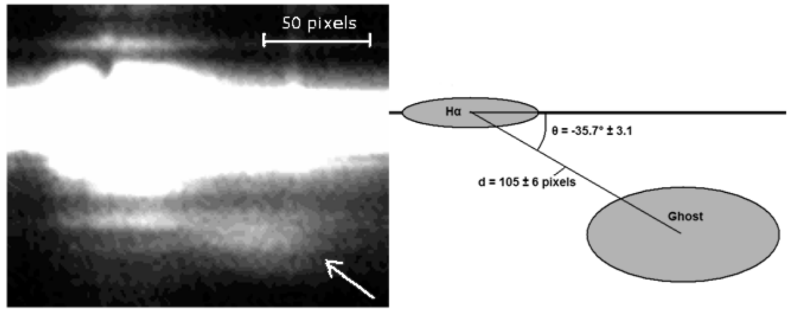

Figure 5: A demonstration (left) and diagram (right) of the H-alpha ghost.

6. The "H-alpha Ghost"

Since the star's Ha emission line is extremely bright, scattering or reflection within the instrument produced an obvious, extended ghost image nearby (Figure 5). To a useful extent we can remove this ghost in order to clarify faint underlying nebulosity. This problem is described in Technical Memo 10 (Martin 2005c).

7. Bad pixels

We supplement the familiar "CR split" method for identifying cosmic ray hits with a second technique that does not require two independent exposures. This method will be described in another Technical Memo (not yet available).

8. Saturated pixels

In the Hα emission line and in a few long integrations, the Treasury Project data contain many saturated pixels. In most such cases we obtained shorter integrations which allow patching. The archive will include both patched and unpatched versions. See Technical Memo 8 (Martin 2005b).

9. Splicing data taken with successive grating tilts

Naturally we wish to produce unified two-dimensional spectral images spanning the entire CCD wavelength range from 1700 Å to 10000 Å. Unfortunately the instrument focus varies across the CCD. Therefore we must employ special convolution techniques to make two adjoining spectral samples (using successive grating tilts) match in their overlap. This will be completed by Spring 2006.

10. Other effects

The above is by no means a complete list! We are working on other details and structural problems.

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[2]`http://etacar.umn.edu/treasury/techmemos/pdf/tmemo001.pdf`

[3]`http://etacar.umn.edu/treasury/techmemos/pdf/tmemo007.pdf`

[4]`http://etacar.umn.edu/treasury/techmemos/pdf/tmemo002.pdf`

[5]`http://etacar.umn.edu/treasury/techmemos/pdf/tmemo006.pdf`

[6]`http://etacar.umn.edu/treasury/techmemos/pdf/tmemo008.pdf`

[7]`http://etacar.umn.edu/treasury/techmemos/pdf/tmemo010.pdf`