The η Carinae HST Treasury Project and the HST/STIS

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Improved Data-processing

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 the Spring 2004 STScI Newsletter, and you can find details in our “Technical Memos” at: http://etacar.umn.edu/technicalmemos

These specifically concern STIS/CCD, but some have broader applications. (Users should be aware that the Tech Memos on our site are updated from time to time.)

- 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. Fig. 1 indicates the improvement in a spectrum extraction, for example, but this technique can and should be applied to all non-dithered STIS, WFC2/PC, and ACS data. See our Technical Memo #1.

- Subtleties concerning noise. Many astronomers use the “ERR” arrays in HST data files, but this can be dangerous. For instance, Fig. 2 (above) 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 may be too subtle to explain here, but for most practical purposes the standard ERR array is wrong -- one cannot estimate the true statistical noise from it. Our special resampling technique mentioned above avoids this pitfall, and the ERR arrays in our archived Treasury Project data will be carefully and unambiguously defined. All this is explained in T.P. Technical Memos 1 and 7, which apply to any data that have been resampled, corrected for distortions, etc.

- Low-level wings of the STIS/CCD spatial p.s.f. The left part of Fig. 3 (top of next column) 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 Fig. 3 below shows the before/after effect of this correction in a real STIS spectrum of an isolated star. Note that some complex structure remains, which we have not yet quantified. See our Technical Memo 6.

- Asymmetry in the core of the p.s.f. At long wavelengths the STIS/CCD spatial p.s.f. has a very noticeable bump on one side, close to the peak and much stronger than the wings mentioned above (Fig 4, below). 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.

- 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 varied across the CCD. Therefore we must employ special convolution techniques to make two adjoining spectral samples (using successive grating tilts) match in their overlap.

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

Many techniques developed for this project are useful for HST data in general, not just η Car. This is especially true for any existing STIS/CCD data where spatial resolution is important.

Figure 1: Slight off-center stellar continuum, extraction with at width of 0.1".

Figure 2: The ERR array in pipeline-processed STIS data, see “Subtleties concerning noise.” There is a mathematical pattern for the pattern, but for most purposes it gives wrong answers.

Figure 3: Left panel: the level of extended wings from a point source at different wavelengths. The peak of the p.s.f. core is at about log(r) = 4. Right panel: an example of the before/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 p.s.f. The flux scale is linear so the wings from Fig 3 are not discernable.

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

The “H-alpha ghost”. Since the star’s Hα emission line is extremely bright, scattering or reflection within the instrument produced an obvious, extended ghost image nearby (Fig 5, above). To a useful extent we can remove this ghost in order to clarify faint underlying nebulosity. This problem is described in Technical Memo 10.

Oversized 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).

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.

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