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The HST Treasury Program on Eta Carinae

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<u>REMOVAL OF THE Hα GHOST IMAGE FROM STIS CCD DATA</u>

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1. Introduction

Previous work by the STIS Instrument Development Team has established that the optics of the STIS generate ghost images on the CCD (Gull et al., 2002; Hill, 2000). Hill (2000) developed a comprehensive empirical model of the ghost's behavior. However, the origins of the STIS ghosts are as yet unidentified.

In the case of the CCD spectra gathered for the Eta Carinae HST Treasury Project, the ghost is most noticeable as a diffuse bright region which appears below and to the right (smaller row number & increasing wavelength) of Eta Carinae's strong Hα emission feature. This ghost can at times interfere with diffuse emission from the surrounding Homunculus nebula. In this document we further characterizes this ghost and discusses an algorithm for its removal.

It is very important to note that in this document we are discussing the Hα ghost as it appears in the *reduced* STIS CCD data which has been interpolated and "rectified." This is in contrast to the *raw* data which the work of Hill (2000) focuses on. Therefore, the information contained in this document is in most cases highly specialized to specific circumstances and may not be completely applicable to other STIS CCD data.

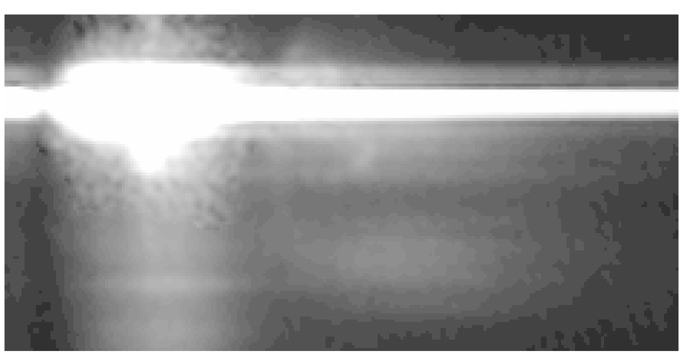

Figure 1. An example of an Hα observation where the ghost appears below and right of the feature

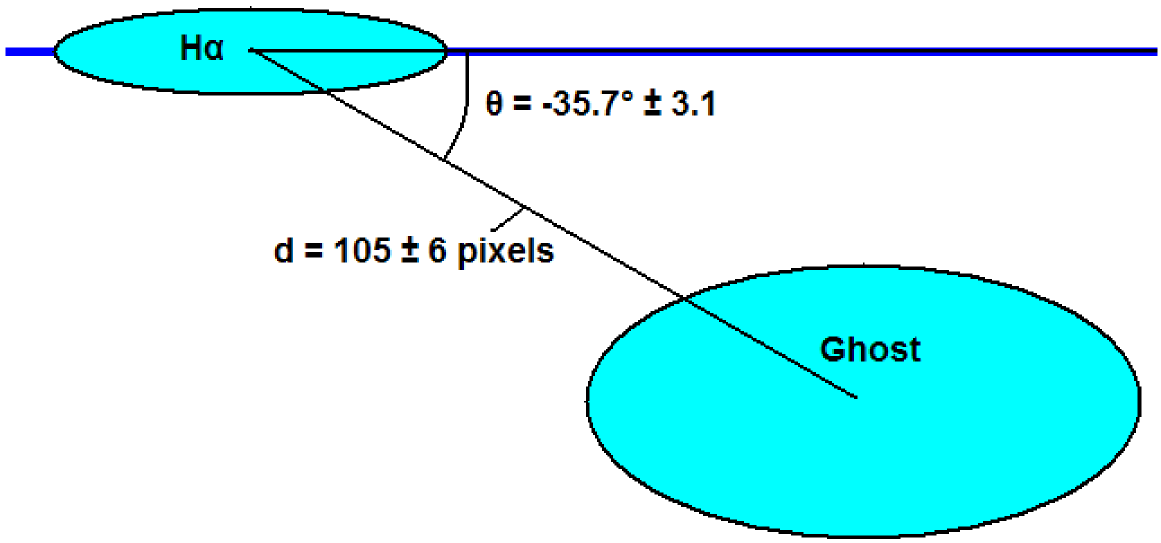

Figure 2. A sketch of the circumstances of the Hα ghost in the STIS CCD data. d is given in reduced pixels which are half the size of original pixels in the raw data.

2. Characteristics of the Hα Ghost

Figure 2 shows a schematic sketch of the Hα ghost. The information in this figure was generated my measuring the relative positions of Hα and its ghost in forty nine (49) observations of Hα made by the Eta Carinae HST Treasury Project. The position angle of the ghost and its distance from the main image are entirely consistent with the measurements which Hill (2000) made of similar phenomenon on the same general part of the CCD in raw STIS data.

3. Modeling the Hα Ghost

Initially, we tried to remove the ghost by modeling it as a complex of overlapping rings as described by Hill (2000). However, this did not provide satisfactory results probably because the pixels in the data we are working with have already been interpolated and rectified, transmuting and blurring the properties of the ghost. Therefore, instead we took the approach of fitting the ghost with a two dimensional Gaussian with the following form:

$$F(r,c) = a \times e^{-\left[\frac{(r-r_0)}{\sigma_r}\right]^2} \times e^{-\left[\frac{(c-c_0)}{\sigma_c}\right]^2}$$

Where r is the row number and c is the column. This model depends on five independent parameters:

a = The amplitude (peak brightness) of the ghost

r_0 = The reduced CCD row of the center of the ghost

c_0 = The reduced CCD column of the center of the ghost

σ_r = The FWHM of the ghost on the y-axis (along the reduced CCD rows)

σ_c = The FWHM of the ghost on the x-axis (along the reduced CCD columns)

We modeled the ghost in forty nine (49) separate exposures in the Eta Carinae Treasury Project database where Hα was not overexposed. The five independent parameters above have no discernable dependence on observation date or exposure length. The time dependant variation in the line profile for Hα itself appeared to have some affect on the model parameters. Therefore, it was decided that any method to remove the ghost should attempt to fit the parameters for the ghost interactively rather than relying on static average values.

3. Removing the Hα Ghost

The code to remove the Hα ghost from the STIS CCD data does so interactively starting with some assumptions about the shape and location of the ghost (as described in the previous sections of this document) and performing a regression analysis to determine the best fit parameters. Users should note that this automated method does a passable job of removing the ghost under most circumstances. However, better results can be achieved by using the manual overrides to tweak the parameters of the model to a more perfect fit. In particular, we suggest that you manually adjust the peak brightness (a) of the ghost model to achieve the best results.

The source code for the removal process is available for download on the Treasury Project web site (http://etacar.umn.edu).

References:

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