**Eta Car: The Good, the Bad and the Ugly of Nebular and Stellar Confusion**

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**Abstract.** Observations in the far-UV provide a unique opportunity to investigate the very massive star η Car and its hot binary companion, η Car B. η Car was observed with FUSE over a large portion of the 5.54 year spectroscopic period before and after the 2003.5 minimum. The observed spectrum is defined by strong stellar wind signatures, primarily from η Car A, complicated by the strong absorptions of the ejecta surrounding η Car plus interstellar absorption. The Homunculus and Little Homunculus are massive bipolar ejecta historically associable with LBV outbursts in the 1840s and the 1890s and are linked to absorptions at −513 and −146 km s⁻¹, respectively. The FUSE spectra are confused by the extended nebulosity and thermal drifting of the FUSE co-pointed instruments. Interpretation is further complicated by two B-stars sufficiently close to η Car to be included most of the time in the large FUSE aperture. Followup observations partially succeeded in obtaining spectra of at least one of these B-stars through the smaller apertures, allowing potential separation of the B-star contributions and η Car. A complete analysis of all available spectra is currently underway. Our ultimate goals are to directly detect the hot secondary star if possible with FUSE and to identify the absorption contributions to the overall spectrum especially of the stellar members and the massive ejecta.

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**INTRODUCTION**

Eta Car has bewildered astronomers since its sudden outbursts in the 1840s and 1890s. We now understand that η Car is in a short evolutionary stage referred to as the Luminous Blue Variable (LBV) phase. The LBV phase precedes the much longer Wolf Rayet phase and is characterized by repeated mass ejection events. The LBV phase is not fully understood. The reason for η Car’s eruptions remains a mystery. However, LBV events are responsible for η Car’s ejecta and its geometry as shown in Figure 1:left. Eta Car is located fairly nearby (2300 pc [1]), making it the best example of an object close to becoming a supernova. Consequently, investigations of η Car, can give insight about other peculiar objects such as supernova impostors and gamma ray bursters. Eta Car is a binary system with a spectroscopic period of 5.5 years [2], but the companion star, η Car B, has so far not been sufficiently characterized. The far-UV FUSE wavelength region is the best spectral region for detection the hot companion star. Iping et al. [3], in a previous FUSE spectrum analysis, observed far-UV flux that they attributed to η Car B. The analysis of the η Car FUSE spectra is not straight forward and includes many ob-
FIGURE 1. Left: HST/ACS Image of \( \eta \) Car with the FUSE apertures over-plotted. The \( \eta \) Car spectrum in Figure 2 (left) is recorded with the 1.\arcsec 25 \times 20\arcsec HIRS aperture, while the adjacent B-star Tr 65 with the 4\arcsec \times 20\arcsec MDRS aperture. With the MDRS aperture there may pointing problems as the aperture drifts to include flux from \( \eta \) Car. The 30\arcsec \times 30\arcsec LWRS aperture engulfs the whole \( \eta \) Car system. Right: The spectrum of Tr 65 (solid), recorded with the FUSE MDRS aperture, can almost entirely be described by the ISM H\(_2\) spectrum (dashed).

stacles. This paper discuss the current and future work on the \( \eta \) Car FUSE spectrum.

THE CURRENT STATUS AND THE FUTURE

The analysis of the \( \eta \) Car FUSE spectrum is challenged by factors that complicate and delay the analysis. The \( \eta \) Car FUSE spectrum must be corrected for space craft related effects including, but not limited to, drift of the FUSE apertures and the background radiation including the contribution from the nearby B-stars (see Figure 1:left).

The \( \eta \) Car spectrum, corrected for instrumental effects, is a composite of the wind spectrum from the central radiative source (including \( \eta \) Car A and B) with spectral features from the circumstellar nebulae and the interstellar medium (ISM) superimposed. Eta Car’s dramatic history with eruptions in the 1840s and the 1890s formed the ejecta, including the Homunculus, the Little Homunculus and the Weigelt condensations. The large FUSE apertures include contributions from the surrounding nebulae. It is difficult to disentangle the spectral features originating from different parts of the \( \eta \) Car system.

To understand the influence of the ISM H\(_2\), we used a H\(_2\) template from McCandliss [4] with a \( b \)-values and column densities for the lowest energy states from Lee et al. [5]. Lee et al. investigated the ISM H\(_2\) contribution in line-of-sight towards the Carinae nebula and reported two velocity components: one hot component at \(-20\) km s\(^{-1}\) with \( b=5 \) km s\(^{-1}\) \( N=7 \times 10^{19} \) cm\(^{-2}\) and one foreground cool component at 4 km s\(^{-1}\) with \( b=4 \) km s\(^{-1}\) \( N=1 \times 10^{20} \) cm\(^{-2}\). A template, to be applied to the \( \eta \) Car spectrum, was created by modeling the ISM H\(_2\) spectrum towards the B-star Tr 65, as shown in Figure 1:right. Eta Car’s spectrum can, as shown in Figure 2:left, only partly be explained by the ISM H\(_2\). Metal absorption in the Homunculus and the Little Homunculus also modify \( \eta \) Car’s spectrum [6]. In particular, the iron-group elements absorb a large portion of the \( \eta \) Car spectrum at FUSE wavelengths. Some absorption lines have been attributed to metals, and more lines are expected to be identified in the future analysis. Smith [7]
FIGURE 2. Left: $\eta$ Car spectrum recorded with the FUSE HIRS aperture (solid). The $\eta$ Car spectrum is fitted with an $\text{H}_2$ template [dashed, 4], similar to the one for Tr 65 (see Figure 1:right). The $\text{H}_2$ absorption does not explain the entire $\eta$ Car spectrum. Additional absorption from the foreground ejecta plus the wind spectra are required to mimic the needed opacity. Right: HIRS $\eta$ Car spectrum (solid) with $\text{H}_2$ model [3,4]. The $\text{H}_2$ spectrum has been observed at $-513 \text{ km s}^{-1}$ in the mid-UV [5] and is likely present in the FUSE spectrum. The dashed spectrum includes the ISM $\text{H}_2$ plus an $\text{H}_2$ column density of $10^{18} \text{ cm}^{-2}$ and a $b$-value of 3 km s$^{-1}$ at $-513 \text{ km s}^{-1}$.

demonstrated the presence of $\text{H}_2$ in the Homunculus and Nielsen et al. [8] showed its impact in the $-513 \text{ km s}^{-1}$ spectrum at near-UV wavelengths. The $\text{H}_2$ spectrum is predicted to be strong in the FUSE spectrum, but so far, it is not established to what extent the $\text{H}_2$ ground transitions are present in the spectrum. A component with a total column density $N=10^{18} \text{ cm}^{-2}$ is used to see the potential $\text{H}_2$ contribution in the FUSE spectrum, as shown in Figure 2:right. We have used a $b=3$ for the $-513 \text{ km s}^{-1}$$\text{H}_2$ spectrum. There are indications that the $\text{H}_2$ spectrum may have a velocity dispersion between $-350$ and $-500 \text{ km s}^{-1}$.

The main goal of the analysis is to find spectral signatures from $\eta$ Car B. When we master the contribution from the ejecta and the ISM, we can start the analysis of the underlying wind spectrum and in particular spectral contributions from the companion star.

REFERENCES