*A Massive Star Odyssey, from Main Sequence to Supernova*
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# The ejecta of $\eta$ Carinae

Theodore R. Gull
*NASA's Goddard Space Flight Center, Code 681, Greenbelt, MD 20771, USA*

Kris Davidson
*Department of Astronomy, University of Minnesota, 116 Church Street SE, Minneapolis, MN 55455, USA*

Kazunori Ishibashi
*Center for Space Research, Massachusetts Institute of Technology, 77 Massachusetts Avenue, NE80-6011, Cambridge, MA 02139, USA*

and the $\eta$ Carinae *HST*-STIS Team

**Abstract.** Since New Year's Eve 1998, we have been studying $\eta$ Carinae and the surrounding complex ejecta with the *HST*-STIS instrument. Angular resolution of 0.1″ and spectral resolving power $R = 5\,000$ - $118\,000$ have revealed a multitude of emission and absorption lines identified from many heavy elements. Some data was obtained during the 1998.0 spectral minimum and now we have an *HST* Treasury proposal accepted to follow the star and ejecta changes across the 2003.5 minimum. To date, we identify the Homunculus as an outer reflection nebula, an internal ionized Little Homunculus, a very small shell (0.″4 in diameter), the Weigelt-blobs, and a peculiar structure called the strontium emission filament. More recently an even smaller extended structure (0.″14 diameter) has been found to surround the Central Source as seen in the ultraviolet.

## 1. Introduction

As we probe in new spectral regions and with increasing angular resolution, the structure around $\eta$ Carinae is gradually being peeled back much like an onion. In the eighties, Viotti *et al.* (1989) studied the ultraviolet spectrum from 1180 Å to 3100 Å and an aperture of 10″×16″. Ground-based spectroscopy was done by many observers, but most notably Gaviola (1953), Thackeray (1967) and Hillier & Allen (1992). Spectral coverage was limited by the photographic emulsion, detector photocathodes and most notably, the Earth's atmosphere. Angular resolution was not better than a few arcseconds due to seeing conditions. With *HST*-STIS near-diffraction-limited angular resolution became possible over the spectral region from 1175 Å to one micron. Long, narrow apertures, small apertures, resolving powers from 500 to 180 000 became possible. We were more than eager to begin peeling back the onion. Multiple contributed papers and refereed papers have already appeared summarizing STIS results. Many more will be forthcoming.

## 2. The observations

The observations with the STIS began New Year's Eve 1998, just as the spectroscopic minimum began as predicted by Damineli (1996) to occur every 2020 d. *RXTE* observations demonstrated that the X-ray flux from $\eta$ Car built up to a maximum in late December 1997, then plummeted. Several months later, the X-ray flux partially recovered and today, as we approach the next minimum, expected to be in early July 2003, the X-ray monitoring by *RXTE* has demonstrated a slow, consistent build-up (however, a 50% increase in X-ray flux occurred in late March and continues). The $52'' \times 0\farcs1$ aperture, combined with the CCD modes G230MB, G430M and G750M, has provided the bulk of the observations as we obtain $R = 7\,000$ with $0\farcs1$ angular resolution. Several complete spectra have been obtained of the Central Source and Weigelt-blobs B and D. Over 2500 nebular emission lines have been identified by Zethson (2001) for Weigelt-BD, combined. Comparison of the spectra recorded during the minimum in 1998 and during the maximum in 1999 and 2000 demonstrate that the doubly-ionized species and highly-excited levels of singly-ionized species disappear during the minimum in the Weigelt-blobs and in an ionized structure which we label the Little Homunculus, a $2''$ radius structure within the neutral Homunculus. The very interior surface of the Homunculus shows no nebular hydrogen emission but has many singly-ionized species, including Ni II, Fe II, and Ca II. A very peculiar extended structure, which we call the strontium filament, has been found to have nearly a thousand nebular emission lines from Sr II, Fe I, Fe II, Ti I, Ti II, Ca II, Na I, C I, and V II. No hydrogen nor helium emission is identified. Moreover, the Fe II lines at 2507 Å and 2509 Å, found to be optically pumped in many parts of the ejecta immediately around $\eta$ Car are not present. An extended H II sphere $0\farcs4$ in diameter surrounds $\eta$ Car. Immediately around $\eta$ Car is a ultraviolet shell $0\farcs14$ in diameter seen in continuum in the echelle-dispersed spectrum.

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