(This article was prepared for the Spring 2002 issue of the STScI Newsletter, which contained brief descriptions of the three original HST Treasury Programs.)

The Hubble Treasury Program on Eta Carinae

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Our Hubble Treasury project to observe Eta Carinae involves a web of motives and applications. Though primarily focused on a mysterious spectroscopic event expected to occur in mid-2003, the data are also useful independent of the event and will become resources for several branches of stellar and nebular astrophysics. Moreover, the emission line spectrum will provide reference measures of instrumental characteristics pertinent to other archived data from the Space Telescope Imaging Spectrograph (STIS). In several respects, *this is the most intensive spectroscopic project yet attempted with the HST.* We are 'pushing the envelope' for both spatial and spectral resolution on a cmplex target. The resulting data will be widely useful and impressive in volume.

A combination of circumstances has made Eta Car one of Hubble's most scientifically productive targets ever since 1991. It is the most luminous evolved star that can be easily observed. It has a history of titanic outbursts and exhibits an extraordinarily dense wind. In addition to the star, Eta Car has a surrounding 'Homunculus' nebula of ejected material, in which a STIS slit spectrogram finds at least five distinct types of emission-line spectra—three of them unlike any other known object! Because it is spatially complex, spectrally complex, and bright enough to obtain excellent data rapidly, the Homunculus has famously demonstrated Hubble's capabilities.* Our Hubble Treasury observations with STIS will use about 30 grating-tilt combinations to cover the entire CCD wavelength range, from 170 to 1000 nm, several times. The Eta Car spectrum is so rich that we dare not omit any wavelength region.

Many of the problems associated with Eta Car are unsolved at a surprisingly basic level, including unfamiliar aspects of stellar structure, stellar winds, diffuse gas dynamics, dust formation and destruction, and exotic nebular excitation processes. For this reason, each data set on Eta Car, imaging or spectroscopic, has application to a variety of topics.

Recently, the discovery of a puzzling secular variation added another dimension to Eta Car's roster of enigmatic characteristics. In 1996 Augusto Damineli recognized that certain brief spectroscopic episodes, occasionally reported in the past, recurred at 5.5-year intervals. He predicted that the next episode would occur near the end of 1997. Alerted X-ray astronomers monitored a tremulous rise in the hard X-ray flux from Eta Car, which then crashed to near zero in mid-November of 1997. While ground-based spectroscopy showed complex changes in the following weeks, we weren't able to obtain STIS observations until the first day of 1998. Thus began the project to explore the entire 5.5 year period, which has obtained STIS observations in each subsequent year.

So far there is no satisfying explanation for Eta Car's 5.5-year cycle, although it may be regulated, somehow, by a companion star with that orbital period. Our spatially resolved observations of the next event, in mid-2003, should assist interpretations—and, we hope, discover the cause—by obtaining unique information on the physical state of Eta Car and its ejecta. We plan to make repeated STIS observations from April to August 2003. We will supplement these observations with WFPC2 and ACS imaging and additional STIS spectroscopy before and after the event.

> **These observations will probably be the last comprehensive spectroscopy of an Eta Car event for a long time**, since the HST's high spatial resolution and ultraviolet capabilities are required. The survival of the HST/STIS long-slit capability until the next event in late 2008 is uncertain -- even unlikely -- and no other instrument with the required capabilities is even on the horizon. The 2003 STIS data may still be unique twenty years from now.

Our core data product will be a series of processed STIS spectrograms covering the UV-to-near-IR wavelength range with a spatial extent of at least 10 arcsec. Each combined spectral image will be a roughly 30,000 x 500 FITS file. In addition to the new observations, we plan to include the data obtained on about 10 occasions from 1998 through 2002. Each giant spectrogram will include a number of useful components, including the stellar wind, several distinct types of very rich, highly non-routine emission line spectra, and the spectrum of the star reflected by dust in the Homunculus, which 'sees' this non-spherical star from a range of directions. We expect that the radiatively excited emission lines will be useful for diverse research topics, e.g. the UV spectra of quasars or AGN's.

Experienced STIS users will appreciate how challenging our data processing task will be. Largely motivated by our earlier observations of Eta Car, the STIS instrument team has improved some of the procedures, such as distortion correction, to enable high spatial resolution. They have also improved the wavelength calibrations by using Eta Car's ejecta, which exhibit more than 2,000 identified, narrow emission lines. More recently, some of us preparing for the Treasury Project have been developing much-needed improvements in re-binning and interpolating pixels. Thus our data products have already begun to improve the processing of STIS data on other objects, and the Treasury Program archives will be a unique resource concerning the instrument itself.

In addition to the 'core' data products, we plan to provide supplementary STIS observations, including CCD data in limited wavelength intervals, MAMA (Multi-Anode Microchannel Array) echelle data in the UV, and new WFPC2 and ACS images.

Recognizing that future users of our data sets will want practical results with minimal fuss, we plan to make them as user-friendly as possible. We hope to provide convenient tools for viewing and extracting and an appropriate meta-database.

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*For information and references see Davidson, K., 2000, in "Cosmic Explosions," AIP Conf. 522, ed. by S. Holt & W. Zhang, p. 421, and many papers in "Eta Carinae and Other Mysterious Stars," ASP Conf. 242, ed. by T.R. Gull et al., 2001..