The Extended Winds of Eta Carinae

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Emission structure due to the winds of Eta Carinae extend on the scale of 0.7”~1600 AU. We can trace the outer wind structure and infer the wind-wind interaction geometry. Coupled with X-ray data and scattered wind profiles off of selected areas of the Homunculus, we gain considerable knowledge of the binary system, including orbit geometry.
As recorded by VLT/UVES R=80,000, 1-2”
η Car and HST/STIS

STIS repaired during SM4!!!
HST/Treasury programs 1998-2004.3 provided a wealth of info.

- Advantage of HST/STIS: R=8000, 0.1” angular resolution separates the spectrum of Eta Carinae from the nebular spectra.
But…..
….. It samples only part of the wind structure.
Comparison of VLT/UVES (1” seeing) to STIS (0.1” resolution) line profiles

STIS sees only a slice of the extended wind structures
HST/STIS spatially resolved the winds!
Variations with ionization potential

- Hα
- [Fe III]
- [He I]
- [Ne III]
- [N II]
- [Fe II]
- [Ar III]
- [S III]
- Fe II
Forbidden emission lines from wind interface

[Fe III] from wind-wind interface:

[Fe III] from wind-wind interface:

[Fe II] from primary wind
Variations with orbital phase at constant position angle = -28°

[Fe III] disappears during low state
[Fe II] strengthens during low state
Changes from high to low state

[Fe III] disappears, [Fe II] backfills... due to drop in far-UV from hot secondary star

[Fe III] 4659  [Fe III] 4703  [Fe II] 4815
Wind structure changes with ionization:
HI , Fe II <0.1”
[Fe II] 1.4” +/- 500 km/s range
[Fe III], [S III], [Ar III] 0.7”, +200 to -500 km/s
Structure of central region: [Ar III] and [Fe II] spectral slices as function of position angle across the broad maximum
The doubly-ionized, forbidden emission changes with phase and position angle due to shifting of the wind-wind structure which bounds the FUV from the hot secondary.
SPH simulation of interacting winds

[Fe III], [Ar III], [Ne III], [S III] originate from the wind-wind boundaries where illuminated by the FUV of Eta Car B
Simple paraboloidal fit to observed [N II] profiles.... Latitude wind dependence must be added.
The cavity carved out by the secondary wind shifts in a prograde direction from the binary orbital axis due to the huge buildup of primary wind during periastron passage.
Eta Carina has brightened at visible wavelengths. Is all getting brighter?

No! The obscuration in the primary wind is dropping.
1. The emission line spectrum of the Weigelt condensations B and D has the same intensity at the same orbital phase.
2. The scattered starlight off of Weigelt B and D is narrower and has not changed in brightness while the broad primary wind profiles have brightened along with continuum.
**Hα Spectroimages extending across Eta Carinae and Weigelt B & D**

**Left: high state**

**Right: low state**

The strong P Cygni absorption is nearly absent in the light scattered by Weigelt B & D.
**Hα Profiles**

**Left: Eta Carinae  Right: Weigelt D**

**Weigelt D reflects profile of secondary star?**

![Graphs showing Hα profiles](image)
Ongoing ground-based photometry:

LaPlata Observatory, Argentina
UBVRI beginning in 2003.0 to present.
--photometry sees ingress and egress!

See posters by Fernández-Lajus et al. and by Madura et al.
Extended forbidden emission describes the structure of the primary wind and the wind interaction. SPH and a simple geometric model of a paraboloid qualitatively describes the forbidden emission. Radiative transfer with 3-D hydro code is needed to fully describe the structures and how they vary with phase. The structures are consistent with periastron on the far side with orbital plane aligned with the Homunculus skirt.