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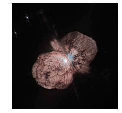
The HST Treasury Program on Eta Carinae

What happened to Eta Carina in early 2007?



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Eta Car Grows Steadily Brighter

For the last decade, the super-massive star Eta Carina has been brightening in nearly all wavelengths at an accelerated rate of about 0.2 mag /yr. Ground-based photometry is unable to resolve the star from the bright ejecta surrounding it. HST observations that resolve the star show that it has grown brighter [(1)] (Fig 1 & 5), which is surprising since the star is at or exceeds the Eddington limit and cannot physically increase its luminosity without a catastrophic outcome.

As a result, the decade long brightening is best explained by a drop in local circumstellar extinction [(2)]. Our line of sight lies along a boundary between a cooler slower denser wind at the poles and a faster hotter more rarified wind between latitudes ±50° [(3)] (Fig 2). The structure of the wind evolves as the star continues to recover rotationally and thermally from its Great Eruption (1837-1858). As that occurs the density of material along our line-of-sight should decrease as the star's surface rotation speeds up throughout the recovery.

During a spectroscopic event (regularly occurring every 5.5 years) the fast rarified equatorial wind becomes more like the slow dense polar wind [(3)]. At those times the star grows fainter due to increased opacity and the high excitation emission disappears from its spectrum.

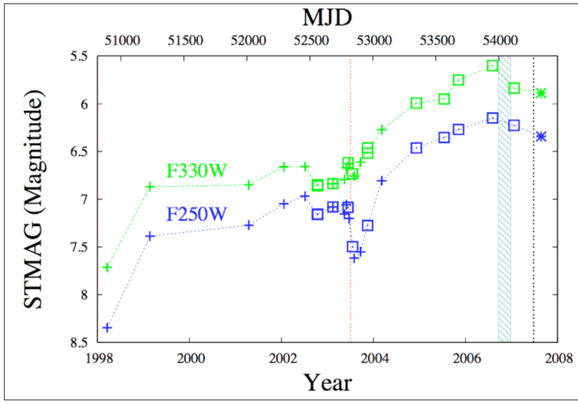

Figure 1. Brightness of the central star from HST data. Crosses are photometry synthesized from STIS CCD spectra. Boxes are photometry from ACS HRC images (Martin et al., 2006). The * at the end of each curve is data from WFPC2 images that is transformed to the same scale as the ACS and STIS data. The time of the 2003.5 spectroscopic event is noted by the vertical dotted orange line. The black dashed line notes the the time of the Gemini/GMOS spectrum. The blue cross-hatched area highlights the same time span as in Fig 3 when the star's brightness began to change dramatically.

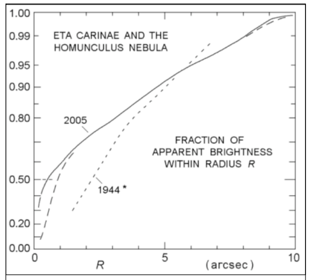

Figure 5. Over the past fifty years Eta Car's brightness profile (including the surrounding reflection nebula) has become more centrally concentrated. The star has grown brighter as a result of decreased opacity along our line of sight.

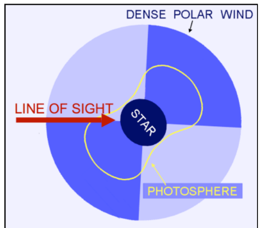

Figure 2. Our line of sight lies along the boundary between the hot fast equatorial wind and the slow dense polar wind.

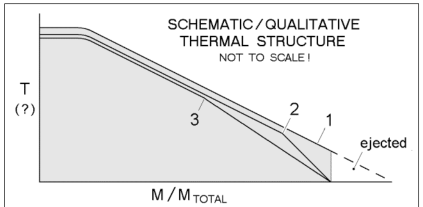

Figure 4. Eta Car is still recovering thermally and rotationally from losing about 10 M_{sun} of its envelope during its Great Eruption (1837-1858). Its fluctuations in brightness indirectly track the recovery through changes to the structure of Eta Car's wind.

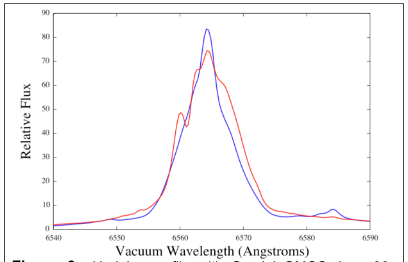

Figure 6. H-alpha profile with Gemini GMOS June 30, 2007 (blue) compared with HST STIS data recorded at the same spectroscopic phase in January 2002 (red). The profiles are consistent when accounting for differences in slit width and spectral resolution between the observations.

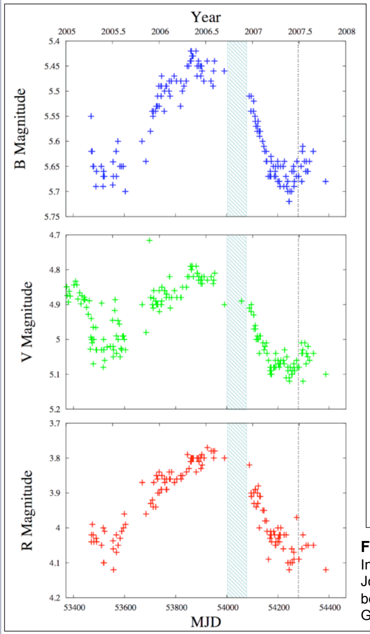

Figure 3. Ground-based broadband photometric data from the AAVSO International Database gathered by Girgio DiScala and Raymond W Jones[(4)]. The blue cross-hatched area highlights when Eta's brightness began to dramatically decrease. The black dashed line notes the time the Gemini/GMOS spectrum was observed.

Eta Continues to Surprise….

In early 2007 ground-based photometry indicated that Eta was rapidly decreasing in brightness: a behavior typical of a spectroscopic event (Fig 3). However 2007.0 was mid-cycle. The last event was in 2003.5 and the next one is not expected until 2009.0. After 4 to 6 months Eta had decreased in brightness about 20%.

We obtained HST ACS/HRC images of Eta Car one month before and during the precipitous drop in brightness. We followed that up seven months later with WFPC2 images in similar filters. (Fig 1)

Davidson, Humphreys, and Martin used Gemini South GMOS director's discretionary time to obtain spectra of Eta Car in late June 2007, which we can compare with spectra obtained at the same phase last spectroscopic cycle with the HST STIS CCD.

What Happened?

Our HST observations show that the decrease in brightness occurred in the star itself (Fig 1). Interestingly, the decrease in F330W (Balmer continuum) was steeper than the drop in F250W (near UV). There are no prominent emission features in either of those bands.

The Gemini/GMOS spectrum (Fig 6) from late June 2007 is nearly identical to an earlier spectrum obtained by the HST STIS at almost the same phase of the spectroscopic cycle in January 2002 (when the star was roughly 0.8 mag fainter). This makes it unlikely that the sudden drop in brightness was caused by changes in the strong emission lines from the stellar wind. Whatever caused the star to grow fainter affected the emission lines and the continuum equally as a continuous opacity source. Therefore the most likely explanation for the drop in brightness is a sudden rapid increase in dust production.

We expect some chaotic variation in brightness from viewing the star directly along the unstable boundary between the low and high latitude wind. However, this episode has more in common with a shell ejection or temporary reorganization of the wind structure as seen in a spectroscopic event. Unlike those events there were no significant changes in the emission lines.

References

(1) Martin, J.C. & Koppleman, M.D. 2004, AJ, 127, 2352.

(2) Martin, J.C., Davidson, K., & Koppleman, M.D. 2006, AJ, 132, 2717.

(3) Smith, N., Davidson, K., Gull, T.R., & Ishibashi, K. 2003, ApJ, 586, 432.

(4) Henden, A.A., 2007, Observations from the AAVSO International Database, private communication. (http://www.aavso.org)