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Eta Carinae

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ABSTRACT
The purpose of this document is to collate publications regarding the Eta Carinae stellar system. With particular attention to the mean wavelengths of interest, narrowest measured linewidth of those wavelengths, as well as associated temporal periodicty and intensity behaviour.

Key words: Instrumentation: Interferometers – Line: Identification – Techniques: Spectroscopic

1 SORT BY PAPERS

Abstracts in HBT.bib via Jabrev.

Book on The Astrophysics of Emission-Line Stars (Kogure & Leung 2007). Page 279, the stellar emission lines characterised by a narrow component and asymmetric broad wing extending to 500 km/s

Book on Astrophysical Lasers (Letokhov & Johansson 2008)

Book on Eta Carinae and the Supernova Impostors (Hamann 2012) Weigelt blobs B, C, D have several magnitudes less extinction than blob A which is the actual primary star. Debated whether it is a binary star system. They are separated less than 0.3 arcseconds apart. 5.54-year period. Ground based spectroscopy has seeing-limited angular resolution of about 1 arcsecond, and thus cannot resolve the Weigelt blobs. High ionisation emission lines are known to disappear on time scales of 1 to 6 weeks before recovery on even longer time scales, for Ne III, Fe III, Ar III and He I. 2003.5 minimum event, from 163 nm to 1010 nm, spectral resolution 40 km/s, angular resolution 0.1 arcsecond. Fluorescent lines of O I, Cr II, Fe III, Ni II, Mn II as well. Their upper energy states are over populated due to accidental wavelength coincidences with H I Lyman lines. Fe II lines are pumped by Ly alpha, with primary cascade in 180 nm to 300 nm and 800 nm to 1000 nm. Strongest lines at Fe II 250.8 nm and 250.9 nm, secondary cascade at O I 844.6 nm. 0.04 angstroms is 12 km/s, so 1 picometre is 3 km/s or 1 km/s is 1/3 picometre wavelength difference/width.

The VIIth Catalogue of Galactic Wolf-Rayet stars van der Hucht (2001). Contains 227 WR stars, mentions line-width FWHM, line-strengths, equivalent width and ratios, narrow vs broad, but difficult to find precise numbers describing each star and wavelength. Equivalent width appears to be a measure of intensity, being the effective width if the spectral feature is normalised to the continuum height.

The Stellar Association around Gamma Velorum and its Relationship with Vela OB2 (Jeffries et al. 2009). Spectral resolution of 25000, which gives 0.026 nm at 656 nm. H alpha at 656 nm, Li I at 670.8 nm. Tables quote equivalent width measurements though, not actual.

The Outer Wind of Gamma Velorum (Roche et al. 2012). Narrow-band mid-infrared spectroscopy, 8 to 13 microns. Forbidden transitions? weaker narrower lines?

The Optical Wind Line Variability of Eta Carinae During the 2009 Event (Richardson et al. 2015) Eta Carinae A (HD 93308) orbits a hot massive binary companion Eta Carinae B in a 5.54 year period, modulating many of the emission spectral features. Surrounded by an hourglass shaped nebula called Homunculus. Is Weigelt blob A, surrounded by Weigelt blobs/knots B, C, D which reflects off the starlight? Check. More than 1500 lines from 306 nm to 1043 nm in the stellar ejecta, Weigelt knots and stellar wind. Wind lines tend to be broad, similar to Wolf-Rayet stellar wind? Counter check. He I narrow emission from the Weigelt knots can disappear. Other transitions are H beta, He I, N II, Si II, Fe II. "We measured the equivalent widths of ten optical wind lines during the time of the photometric minimum... because the profiles have complicated shapes in general, we simply performed a numerical integration across the entire blue absorption trough and red emission peak".

The Gamma Velorum Binary System II WR Stellar Parameters and the Photon Loss Mechanism (Marco et al. 2000). Spectral resolution of 20000 or about 0.03 nm. The base emission lines are broad, but have narrow features on them? Check on Line Profile Variability.

The Binarity of Eta Carinae Revealed from Photoionization Modeling of the Spectral Variability of the Weigelt Blobs B and D (Verner et al. 2005). Hubble Space Telescope/Space Telescope Imaging Spectrograph (HST/STIS) spectra of the Weigelt Blobs B and D. From 164 nm to 1040 nm, spectral resolution? Broad P-Cygni features are associated with the expanding stellar wind and starlight scattered within the Homunculus nebula. Narrow emission lines are produced in the slow-moving nebular condensations known as the Weigelt Blobs or Knots. Check Davidson 1995 and 1997 using HST with Faint Object Spectrograph, which

has lower resolution than STIS Counter check with Gull 2001 using HST STIS.

Possibility of Measuring the Width of Narrow Fe II Astrophysical Laser Lines in the Vicinity of Eta Carinae by means of Brown-Twiss-Townes Heterodyne Correlation Interferometry (Johansson & Letokhov 2005). Target Fe II optical lines in the Weigelt Blobs or Knots, predicted to be between 30 to 100 MHz, with the blobs angular separation requiring 0.1 arcsecond resolution. Based on the measurements by Gull 2001 using the HST/STIS, which could spatially resolve the blobs but not the emission lines. But this paper prediction is in the 0.9 to 2.0 micron NIR regime, check for shorter wavelengths.

Physics of the Inner Ejecta (Hamann 2012). "The spectroscopic event that occurred in mid-2003 was studied at wavelengths ranging from radio through X-rays.6 Here we summarize key results for the inner ejecta, especially the almost-resolved (approaximately 0.1 arcsecond) spectra of blob D that were obtained as part of the HST Treasury program on Eta Car. This publicly available dataset provides the most complete and reliable existing information of this type. The 2003.5 HST observations covered roughly 163 nm to 1010 nm at resolution about 40 km/s and; no better data on an event are expected in the forseeable future." Footnote in the paper: "The only instrument with adequate spatial resolution, HST/STIS, was inoperative during the subsequent event in 2009. Moreover, the star rising brightness progressively makes the Weigelt blobs harder to observe. Thus it is very conceivable that no one will ever obtain new event spectra of these objects as good as the 2003.5 STIS data."

Photonic Astronomy and Quantum Optics (Dravins 2007). Eta Car via Johansson and Letokhov, 961.7 nm and 991.3 nm Fe II lines in blob B. V1016 Cyg at 682.5 nm and 708.2 nm Schmid HM (1989) Identification of the emission bands at 6830, 7088. A&A 211:L31-L34

Photon Correlation Spectroscopy for Observing Natural Lasers (Dravins & Germanà 2008). Eta Car, Fe II lines at 961.7 nm and 991.3 nm. WR 6, He I lines at 492.1 nm and 667.8 nm and He II line at 468.6 nm. Gamma Velorum, but which lines?

Laser action in stellar envelopes (Varshni & Nasser 1986). Model calculations for laser action in He I at 728.1 nm and 667.8 nm, and less so, in 492.2 nm and 504.8 nm. Table II compares with some Wolf-Rayet stars having emission lines at these wavelengths.

High-Resolution 6450-24500 Angstroms Spectra of Eta Carinae (Hamann & DePoy 1994) Resolution from 3000 to 8600, from 645 nm to 2450 nm. 170 emission lines upwards of 878 nm. With additional measurements of the strongest forbidden lines and Fe II features down to about 670 nm. Lower resolution than HST and STIS?

High-excitation emission lines near eta Carinae, and its likely companion star(Mehner et al. 2010). The first HST spectra of Eta Car showed that the narrow [Fe ii] lines originate in the vicinity of the Weigelt knots, a set of three condensations 0.1 to 0.3 arcseconds northwest of the star (Davidson et al. 1995, 1997; Weigelt and Ebersberger 1986). These knots move outward rather slowly (v about 40 km/s), probably near the equatorial plane of the system (Hofmann and Weigelt 1988; Weigelt et al. 1995; Davidson et al. 1997; 729 730 MEHNER ET AL. Vol. 710 Zethson et al. 1999; Dorland et al. 2004; Smith et al. 2004). Later, Space Telescope Imaging Spectrograph (HST/STIS) data confirmed that low-excitation lines collectively account for much of the integrated brightness in that region (e.g., Gull et al. 1999; Johansson et al. 2000; Zethson et al. 1999). STIS could not resolve an individual Weigelt knot, but in cases where its slit crossed one of them, the spatial distribution of [Fe ii] brightness peaked at the knot position." He I at 668 nm is narrow. Which narrow lines are present? but with broad components? And changes with time?

Eta Carinae Linelist for the Emission Spectrum of the Weigelt Blobs in the 1700 to 10400 Angstroms Wavelength Region (Zethson et al. 2012). This should be one of the best measurements, along with Gull 2001 and HST STIS

Detection of He II 468.6 nm in eta Carinae (Steiner & Damineli 2004).

Astrophysical Lasers Operating in optical Fe II Lines in Stellar Ejecta of Eta Carinae (Johansson & Letokhov 2004) Gull using HST STIS measured eta carinae blob b, 999.7 nm line. Pumped by H Ly alpha at 121.5 nm.

A Wolf-Rayet-like progenitor of SN2013cu from spectral observations of a stellar wind (Gal-Yam et al. 2014). "The stronger lines (Ha, Hb, NIV (7115A wavelength) and He II 5411) exhibit acomplex profile (Fig. 2) consisting of a relatively broad base (2500 km/s full width at zero intensity (FWZI)) on which prominent narrow, unresolved lines (FWZI<3A ; velocity dispersion„150km/s) are superimposed. This is consistent with predictions for Wolf-Rayet pre-supernova wind velocities"

Time variations of the narrow Fe II and H I spectral emission lines from the close vicinity of Eta Carinae during the spectral event of 2003 (Hartman et al. 2005).

Sr II Emission in the Ejecta of Eta Carinae (Zethson et al. 2001) "The anomalous lines discussed below are unresolved in width" 393.6 nm, 419.6 nm, 676.8 nm, 985.1 nm?

Eta Carinae across the 2003.5 Minimum Analysis in the visible and near infrared spectral region (Nielsen et al. 2009). "We note that the narrow component of the emission lines recorded with high-resolution (R about 80,000) VLT/UVES are narrower than seen in the high-spatial, but lower spectral, resolution HST/STIS spectra." "Most wind line profiles appear with a broad (±550 km/s) profile, often with P-Cygni absorption, plus a narrow (±15 km/s centered at -47 km/s) emission component, originating from the Weigelt condensations." VLT/UVES resolution approximately 80000, which is 0.009 nm at He I 706.7 nm. Measured ±15 km/s which is 0.07 nm?

http://etacar.umn.edu/ The HST Treasury Program on Eta Carinae

https://archive.stsci.edu/prepds/etacar/ Kris Davidson is the PI for an HST Treasury Program to observe Eta Carinae. The team has developed an extensive website at http://etacar.umn.edu/. Two HST programs are associated with this project: (9420; 9973). Data from other programs has also been included for creation of this set of HLSP including: (7302 (Davidson); 8036 (Gull); 8327 (Davidson); 8483 (Gull); 8619 (Davidson); 9083 (Davidson); 9337 (Davidson))

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