NuSTAR monitoring of Eta Carinae

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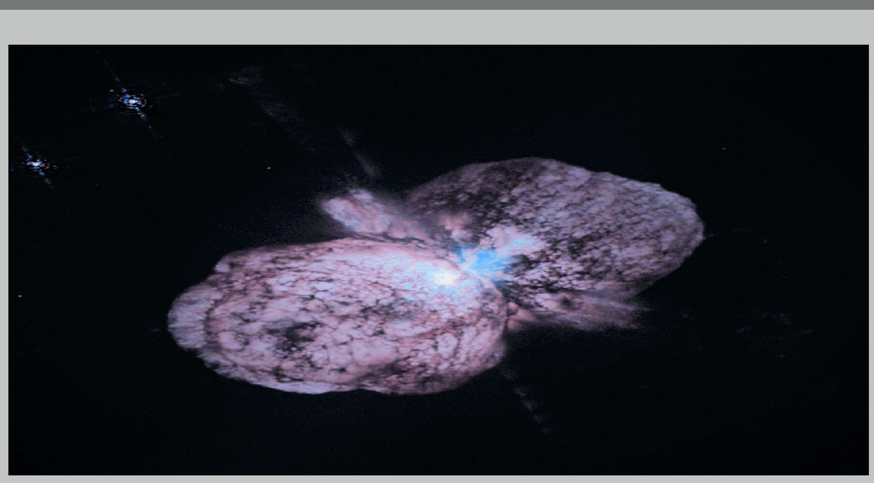
Introduction



The highly eccentric binary system **eta Carinae** hosts one of the most massive stars featuring the highest known mass-loss rate. This dense wind encounters the much faster wind expelled by the stellar companion, dissipating mechanical energy in the shock and accelerating particles. In this work we used the NuSTAR observations of the source to:

- investigate the variability of the wind-wind collision (WWC) emission and the origin of the observed minimum
- simulate the observed Spectral Energy Distribution of the source by a thermal plasma emission.

NuSTAR observations of eta Carinae

NuSTAR monitored eta Carinae both before and after the 2014 periastron. In total, 10 observations were performed from March 31, 2014, to July 16, 2015, with an exposure range of 23.6 to 81.4 ks. We used the standard analysis tool (NuSTARDAS version 1.6.0) to produce the spectrum and the light curve of the source. The X-ray flux varied in a similar way as observed during the previous periastrons, increasing to a maximum a few days before periastron and decreasing steeply to a deep minimum before recovering.

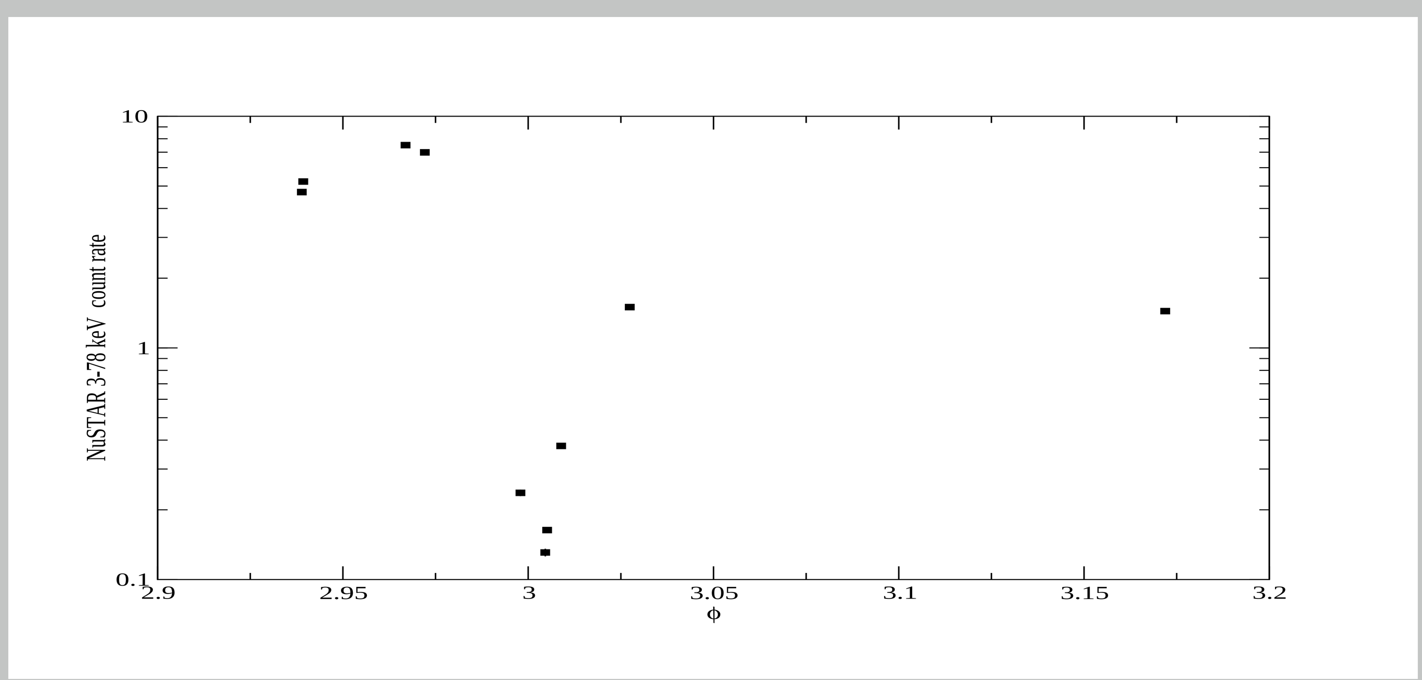


Figure: *The full-time NuSTAR lightcurve of eta Carinae. The x axis denotes the phase of each observation. The y axis denotes the 3-78 keV count rate of the source and it is in logarithmic scale. The errors on the observed fluxes are not distinguishable due to their small value.*

Data Analysis

We fitted the WWC spectral distribution by an absorbed two-temperature plasma emission plus two gaussian lines to account for the observed Fe Kα and Kβ emission lines. We also added a power-law component to account for the high-energy power-law emission, observed in eta Carinae 's spectra by INTEGRAL and Suzaku. Interestingly, the 1-σ upper limit of power-law normalization was found to be 7.3e-6 $photons/s/cm^2/keV$, which is a few orders of magnitudes less than what found in previous studies. Using the best-fit model we estimated the absorption and obscuration corrected emission of the WWC. For the obscuration we used the column density given in Parkin et al. (2011).

References

1. Balbo and Walter (in press)
2. Parkin E. R., Pittard, J. M., Corcoran, M. F., et al 2011, ApJ, 726, 105

Results

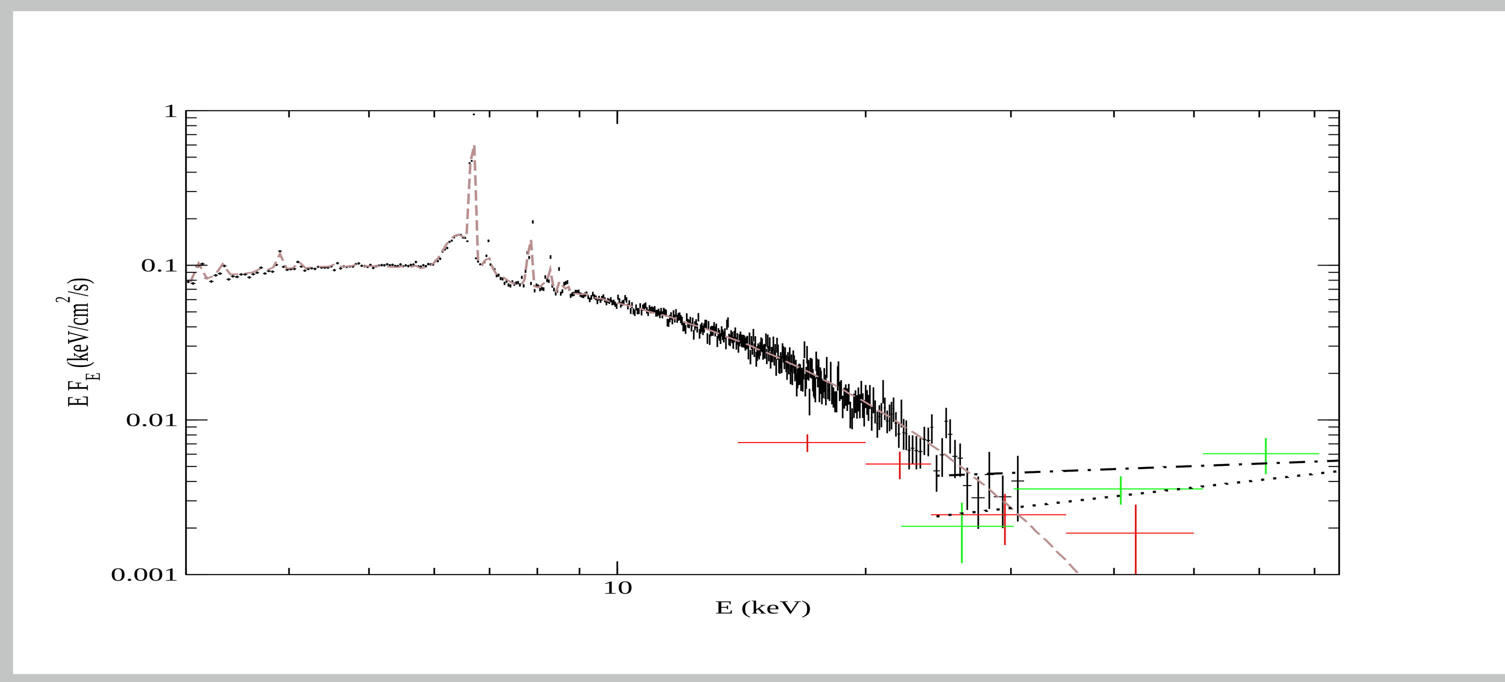


Figure: *The Spectral Energy Distribution of eta Carinae. The black dots correspond to the spectrum of the third NuSTAR observation and the red and green dots correspond to the BAT and INTEGRAL average spectra, respectively. The NuSTAR best-fit model is plotted as a brown dashed line. The dotted and the dot-dashed lines correspond to the best-fit power law models that have been found by previous studies using Suzaku and INTEGRAL observations, respectively. Both axes are in logarithmic scale.*

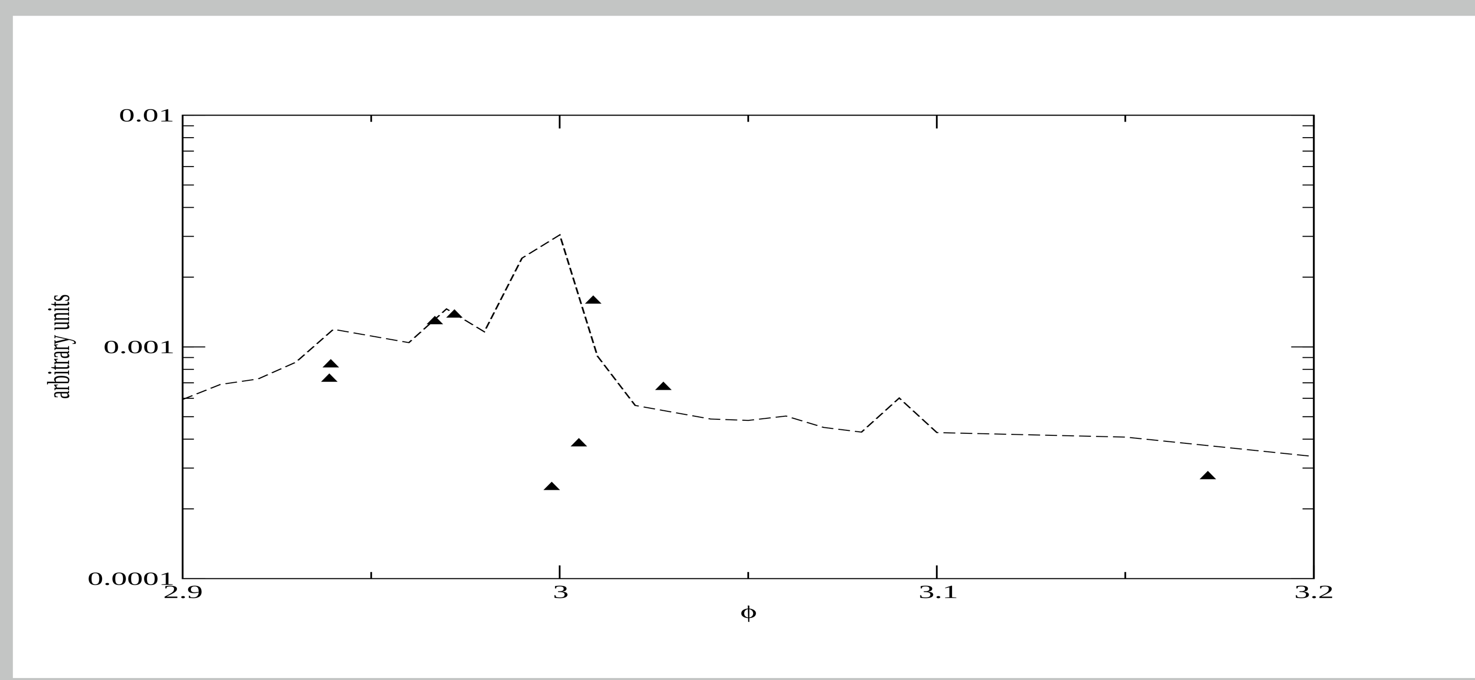


Figure: *A comparison between the absorption and obscuration corrected flux (filled triangles) and the flux deduced by simulation of the source (dashed line), as given in Balbo and Walter (in press). The x axis denotes the phase of each observation and the y axis is scaled in arbitrary values to allow for a direct comparison of the lightcurves.*

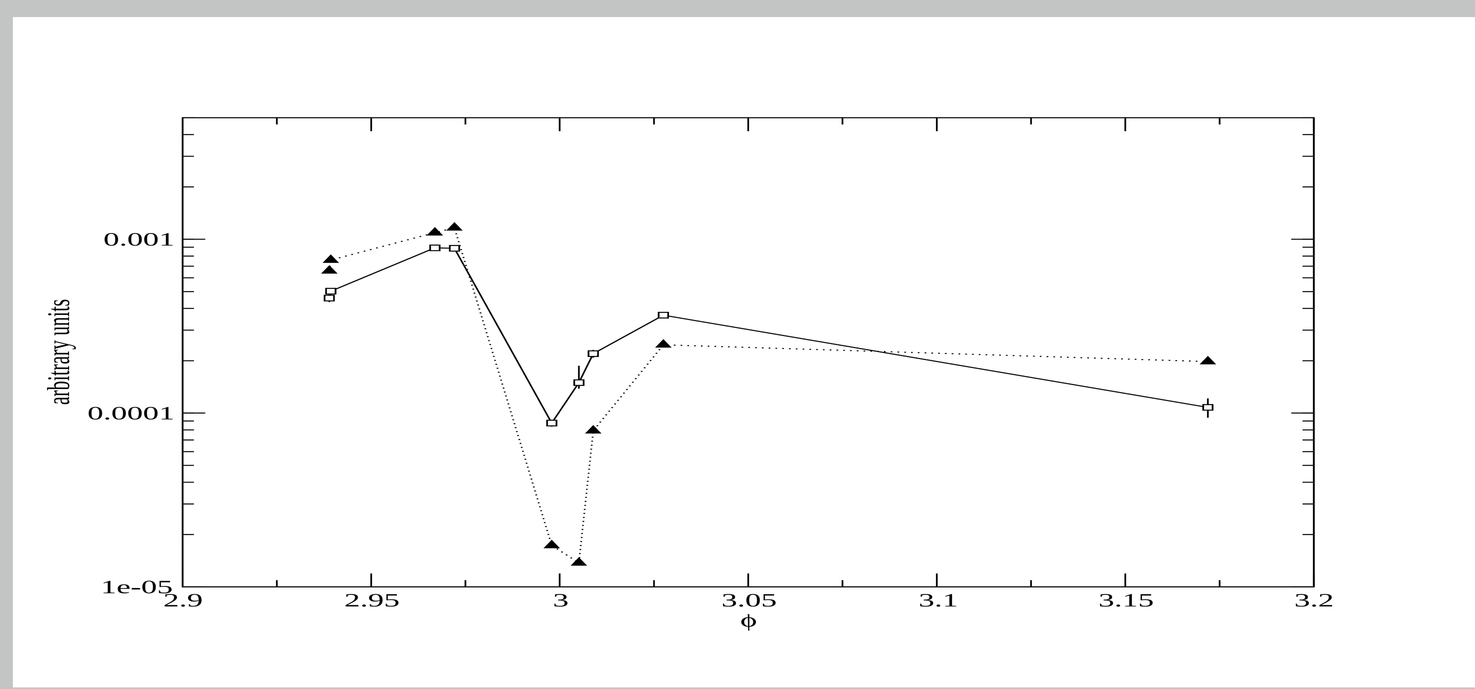


Figure: *A comparison between the continuum observed flux (filled triangles) and the Fe Kα line normalization (open squares).*

Conclusions

1. The X-ray emission up to energies ~35 keV can be fully explained by the thermal radiation of the WWC region. Thus, the power-law emission, observed in previous studies, is important only at higher energies.
2. Even corrected for the absortpion and obscuration, the WWC flux during periastron is 10 times lower than the theoretically estimated intrinsic flux. This indicates that during periastron the WWC source is temporarily vanished, which may be explained if the primary wind collapses onto the secondary star's surface.
3. The Fe line is produced mainly due to the interaction of the WWC emission with the surrounding matter and the corresponding region is located near ($\lesssim 14.57$ lightdays) the WWC region. The smaller variability of the Fe line compared to the continuum emission may be explained by anisotropies in the distribution of matter around the WWC and by the fact that a constant emission is also expected to contribute to the Fe line.