3D modelling of the colliding winds in Eta Carinae - evidence for radiative inhibition

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The X-ray emission from the super-massive star Eta Carinae is simulated using a three dimensional model of the wind-wind collision. In the model the intrinsic X-ray emission is spatially extended and energy dependent. Absorption due to the unshocked stellar winds and the cooled postshock material from the primary LBV star is calculated as the intrinsic emission is ray-traced along multiple sightlines through the 3D spiral structure of the circumstellar environment. The observable emission is then compared to available X-ray data, including the lightcurve observed by the Rossi X-ray Timing Explorer (RXTE) and spectra observed by XMM-Newton. The orientation and eccentricity of the orbit are explored, as are the wind parameters of the stars and the nature and physics of their close approach. Our modelling supports a viewing angle with an inclination of ~ 42 degrees, consistent with the polar axis of the Homunculus nebula (Smith 2006), and the projection of the observer's line-of-sight onto the orbital plane has an angle of ~ 0 - 30 degrees in the prograde direction on the apastron side of the semi-major axis.

However, there are significant discrepancies between the observed and model lightcurves and spectra through the X-ray minimum. In particular, the hard flux in our synthetic spectra is an order of magnitude greater than observed. This suggests that the hard X-ray emission near the apex of the wind-wind collision region (WCR) `switches off' from periastron until 2 months afterwards. Further calculations reveal that radiative inhibition significantly reduces the preshock velocity of the companion wind. As a consequence the hard X-ray emission is quenched, but it is unclear whether the long duration of the minimum is due solely to this mechanism alone. For instance, it is possible that the collapse of the WCR onto the surface of the companion star, which would be aided by significant inhibition of the companion wind, could cause an extended minimum as the companion wind struggles to re-establish itself as the stars recede. For orbital eccentricities, e <~ 0.95, radiative braking prevents a wind collision with the companion star's surface. Models incorporating a collapse/disruption of the WCR and/or reduced preshock companion wind velocities bring the predicted emission and the observations into much better agreement.

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