A high-resolution study of η Carinae's outer ejecta

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Abstract. η Car is a very luminous and unstable evolved star. Outflowing material ejected during the star's giant eruption in 1843 surrounds it as a nebula, which consists of an inner bipolar region, coined the Homunculus, and the Outer Ejecta. The outer ejecta is very filamentary and shaped irregularly. Kinematic analysis, however, shows a regular bi-directional expansion, despite of the complex morphology. Radial velocities in the outer ejecta reach 2000 km s\(^{-1}\) and give rise to X-ray emission, as first detected by ROSAT. We will present a detailed study of the outer ejecta based on HST images, high-resolution echelle spectra for kinematic studies, images from Chandra-ACIS and HST-STIS spectra.

1. Morphology, kinematics and the soft X-ray emission

The outer part of the nebula around η Car contains a countless number of knots, bullets and filaments and manifests the so-called Outer Ejecta (diameter 60″ or 0.67 pc). A kinematic analysis, using high-resolution echelle spectra, showed that the outer ejecta expand with velocities between \(-600\) km s\(^{-1}\) and \(+600\) km s\(^{-1}\) on average (e.g., Meaburn et al. 1996; Weis 2001a,b). Various filaments nevertheless show much higher radial velocities, e.g., \(\sim 2000\) km s\(^{-1}\) (Weis 2001a,b). It is still unclear what triggered the outburst in 1843 and which mechanism not only formed η Car's nebula, but also the amazingly high expansion velocities.

With velocities that high, X-ray emission from η Car is expected and was indeed detected (e.g., Chełowski et al. 1984; Corcoran et al. 1997). With ROSAT and Chandra we are now able to separate between a harder, nearly point-like emission from the central source and an extended softer emission from η Car's outer ejecta, which is roughly hook-shaped (e.g., Weis et al. 2001). Interestingly, an overlay of the optical image and the X-ray emission shows only a few correlations between the optically emitting gas and the hot X-ray gas (see Figure 1).
A much stronger conformance was found in comparison with the radial expansion velocities. The expansion velocities are derived from our optical echelle spectra (FWHM \( \sim \) 14 km s\(^{-1}\)) and overplotted in Figure 1 with negative velocities underlined. Areas with higher X-ray emission show in general higher expansion velocities. The faster the gas is expanding, the more intense is the X-ray emission. The extended soft X-ray emission from \( \eta \) Car and especially the morphology of the X-ray nebula can, therefore, be explained by faster moving filaments which form X-ray emitting shocks. The temperature of the gas (using thermal equilibrium models) is \( \sim 0.65 \) keV (Weis et al. in preparation) indicating post-shock velocities of around 750 km s\(^{-1}\), in very good agreement with the detected expansion velocities of the bulk of the gas.

References


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