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NUMERICAL MODELS FOR THE 19TH CENTURY OUTBURSTS OF η CARINAE

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We present here 2D hydrodynamical simulations of the eruptive events of the 1840s and the 1890s eruptions suffered by the massive star η Car. We assume a colliding wind scenario to explain the shape and kinematics of the bipolar nebulae formed from these events. We also find the formation of some tenuous, equatorial, high-speed features that seem to be related to the observed equatorial skirt of η Car.

Located at a distance of 2.3 kpc, one of the most massive stars in our Galaxy ever discovered, η Car is a well-known example of the evolved and unstable luminous blue variable (LBV) stars. This star underwent a giant eruption around the 1840s, and a fainter eruptive event during the 1890s. These eruptions resulted in the formation of a symmetric, bipolar nebula known as the "Homunculus" (H), and a smaller nebula, "the little Homunculus" (LH), embedded within it.

In this work, we consider a simplified interacting wind scenario, in which a nonspherical outburst collides with a slow wind also with asymmetric density and velocity distributions. Both, the mass loss rate and the ejection velocity were drastically increased during the main eruption of the 1840s. During the smaller event of the 1890s, we also suppose that the mass loss rate is suddenly increased, but observations of η Car at this epoch give evidence that the expansion speed of the wind decreased during this eruption. Consequently, the LH would be formed –unlike previous numerical models (González et al. 2004a,b)– when the eruption ended.

Figure 1 shows a density map (obtained with the adaptative-grid Yguazú-A code, originally developed by Raga et al. 2000) of the η Car nebulae at a time $t = 169$ yr of evolution after the great eruption (present day structure). The simulations were computed on a five-level binary adaptative grid with a maximum resolution of 3×10^{14} cm. We assumed different equator-to-pole velocity (v_θ) and density (ρ_θ) contrasts (see González et al. 2010) for the different phases of the interacting winds.

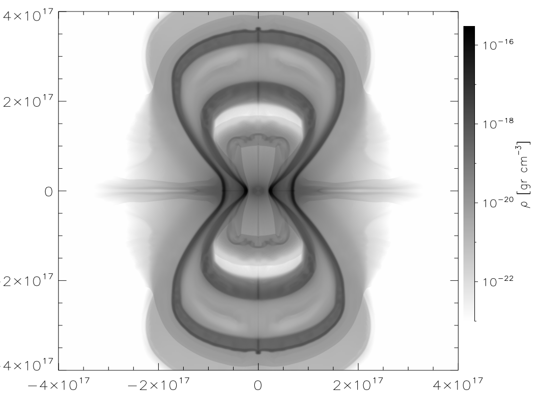

Fig. 1. Density map of the present day structure of the η Car nebulae. The inner and outer Homunculus and a tenuous equatorial skirt are depicted. A thick dense layer between both Homunculi is also observed.

The formation of the H with a double-shock structure is shown. Besides, the LH becomes Rayleigh-Taylor unstable due to the interaction of the low-density fast post-outburst wind that accelerates the high-density slow outflow eruption. The polar lobes of the LH resemble the observed spatial structures by Smith (2005). The formation of a tenuous equatorial outflow with both low and high velocity features is also noteworthy.

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