

# Proper Motions of $\eta$ Carinae's Outer Ejecta and Its Eruptive History

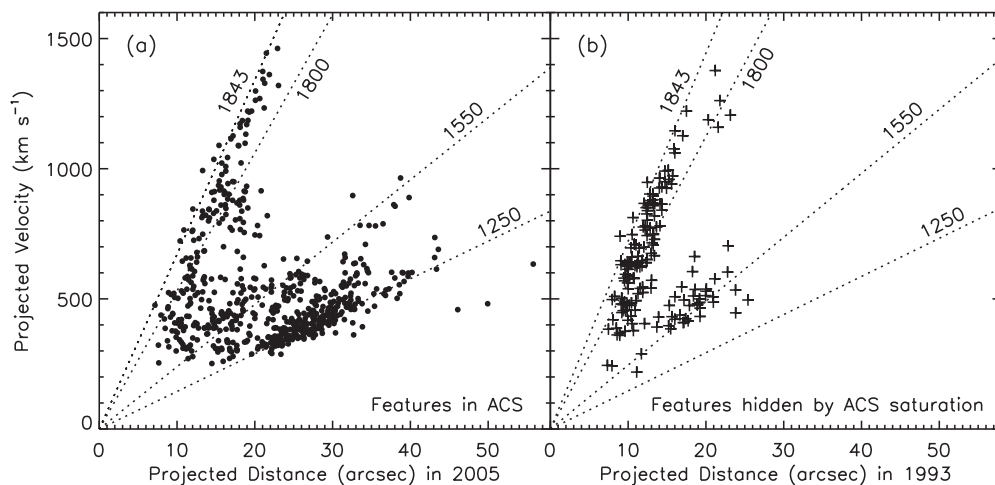
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**Abstract.**  $\eta$  Carinae, the most extreme luminous blue variable in our Galaxy, underwent a Great Eruption in the 1800s and ejected significant mass into the well-known bipolar Homunculus. But  $\eta$  Car's outer ejecta, a spread of dense, nitrogen-rich knots outside the Homunculus, have led to suspicion that the Great Eruption was not this star's first major mass-loss event. We have measured proper motions for nearly 800 distinct features in the outer ejecta using 21 years of *HST* WFPC2 and ACS imaging. With motions measured across sixteen baselines, we find that the outer ejecta are expanding ballistically and belong to three age groups: one dating to the mid-1200s, another to the mid-1500s, and a third to the early 1800s, associated with but perhaps predating the peak of the Great Eruption. These three age groups are separated in space and radial velocity. There is no evidence for interaction between the dense ejecta that could be powering  $\eta$  Car's soft X-ray shell, which is instead likely driven by fast, rarefied ejecta from the Great Eruption striking the older dense ejecta. The thirteenth-century event was strikingly asymmetric, ejecting mass almost entirely to one side of the star. The sixteenth-century event displays bipolar symmetry, but along a different axis than the current Homunculus. These observations provide constraints on theoretical models of  $\eta$  Car's behavior, as viable models must explain the repetition, timescale, and asymmetry of these major mass-loss events. For more details, see Kiminki, Reiter, & Smith (2016, *MNRAS*, 463, 845).

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**Figure 1.** (a) Transverse velocity versus projected distance from  $\eta$  Car for all ejecta detected in ACS imaging. Dotted lines show the expected positions of material ejected at the labeled dates. (b) Same as (a), but for ejecta in a section that was saturated in ACS but visible in WFPC2 images. Note the lack of thirteenth-century features in this section.