

Constraining the Absolute Orientation of Eta Carinae's Binary Orbit: A 3-D Dynamical Model for the Broad [Fe III] Emission

Thomas I. Madura(1), Theodore R. Gull(2), Stanley P. Owocki(3), Jose H. Groh(1), Atsuo T. Okazaki(4), and Christopher M. P. Russell(3)

1 - Max Planck Institute for Radio Astronomy, Bonn, Germany

2 - NASA/GSFC, Greenbelt, MD, USA

3 - University of Delaware, Newark, DE, USA

4 - Hokkai-Gakuen University, Toyohira-ku, Sapporo, Japan

We present a three-dimensional (3-D) dynamical model for the broad [Fe III] emission observed in Eta Carinae using the Hubble Space Telescope/Space Telescope Imaging Spectrograph (HST/STIS). This model is based on full 3-D Smoothed Particle Hydrodynamics (SPH) simulations of Eta Car's binary colliding winds. Radiative transfer codes are used to generate synthetic spectro-images of [Fe III] emission line structures at various observed orbital phases and STIS slit position angles (PAs). Through a parameter study that varies the orbital inclination i , the PA (θ) that the orbital plane projection of the line-of-sight makes with the apastron side of the semi-major axis, and the PA on the sky of the orbital axis, we are able, for the first time, to tightly constrain the absolute 3-D orientation of the binary orbit. To simultaneously reproduce the blue-shifted emission arcs observed at orbital phase 0.976, STIS slit PA = +38 degrees, and the temporal variations in emission seen at negative slit PAs, the binary needs to have an $i \sim 130$ to 145 degrees, $\theta \sim -15$ to +30 degrees, and an orbital axis projected on the sky at a PA ~ 302 to 327 degrees east of north. This represents a system with an orbital axis that is closely aligned with the inferred polar axis of the Homunculus nebula, in 3-D. The companion star, Eta B, thus orbits clockwise on the sky and is on the observer's side of the system at apastron. This orientation has important implications for theories for the formation of the Homunculus and helps lay the groundwork for orbital modeling to determine the stellar masses.

Reference: Accepted for publication in MNRAS. Pre-print available on astro-ph.

Status: Manuscript has been accepted

Weblink: <http://arxiv.org/abs/1111.2226>

Comments:

Email: tmadura@mpifr-bonn.mpg.de