Multiwavelength Observations of NaSt1 (WR 122): Equatorial Mass Loss and X-rays from an Interacting Wolf-Rayet Binary

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NaSt1 (aka Wolf-Rayet 122) is a peculiar emission-line star embedded in an extended nebula of [N II] emission with a compact dusty core. This object was characterized by Crowther & Smith (1999) as a Wolf-Rayet (WR) star cloaked in an opaque nebula of CNO-processed material, perhaps analogous to Eta Car and its Homunculus nebula, albeit with a hotter central source. To discern the morphology of the [N II] nebula we performed narrowband imaging using the Hubble Space Telescope and Wide-field Camera 3. The images reveal that the nebula has a disk-like geometry tilted 12 degrees from edge-on, composed of a bright central ellipsoid surrounded by a larger clumpy ring. Ground-based spectroscopy reveals radial velocity structure (~10 km/s) near the outer portions of the nebula's major axis, which is likely to be the imprint of outflowing gas. Near-infrared adaptive-optics imaging with Magellan AO has resolved a compact ellipsoid of Ks-band emission aligned with the larger [N II] nebula, which we suspect is the result of scattered He I line emission (2.06 um). Observations with the Chandra X-ray Observatory have revealed an X-ray point source at the core of the nebula that is heavily absorbed at energies <1 keV and has properties consistent with WR stars and colliding-wind binaries. We suggest that NaSt1 is a WR binary embedded in an equatorial outflow that formed as the result of non-conservative mass transfer. NaSt1 thus appears to be a rare and important example of a stripped-envelope WR forming through binary interaction, caught in the brief Roche-Lobe overflow phase.

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