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Dissertation Summary

Infrared Interferometry and Spectroscopy of Circumstellar Envelopes

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This thesis reports on two experiments designed to reveal fundamentally new information about the inner dust and gas envelopes around mass-losing stars. The mid-infrared infrared spatial interferometer was outfitted with an RF filterbank to allow interferometric observations of molecular absorption features (NH_3 and SiH_4) with very high spectral resolution ($\lambda/\Delta\lambda \sim 10^5$). These new data permitted the molecular stratification around carbon star IRC +10216 and red supergiant VY CMa to be investigated. For IRC +10216, it was determined that both ammonia and silane form in the dusty outflow significantly beyond both the dust formation and gas acceleration zones ($\gtrsim 20R_*$). More specifically, ammonia was found to form before silane in a region of decaying gas turbulence, while the silane is produced in a region of relatively smooth gas flow much farther from the star ($\gtrsim 80R_*$). The depletion of SiS on grains soon after dust formation may fuel silane-producing reactions on the grain surfaces. For VY CMa, a combination of interferometric and spectral observations suggests that NH_3 is forming near the termination of the gas acceleration phase in a region of high gas turbulence ($\sim 40R_*$).

The second half of the thesis describes a novel aperture-masking experiment which converted the Keck I 10 m primary mirror into a separate-element interferometric array. High signal-to-noise images were reconstructed of bright near-infrared sources at the diffraction limit ($\sim 0''.050$ at 2 μm) using VLBI techniques. The inner dust shells of IRC +10216 and VY CMa are shown to be highly clumpy and inhomogeneous, a finding inconsistent with current (simple) models of mass loss. For IRC +10216, spatial resolution on the scale of the star itself was attained, and proper motion of dust clumps within $10R_*$ was detected, revealing the dynamics of the outflow directly. Unexpectedly, carbon-rich dust shells around some late-type Wolf-Rayet stars were resolved into highly collimated, spinning "pinwheel" nebulae, formed from the interacting winds of embedded short-period (~ 1 yr) binaries (see Fig. 1). Precise orbital parameters and wind velocities are determined from the multiepoch spiral morphology; important implications on binary and stellar evolution are discussed.

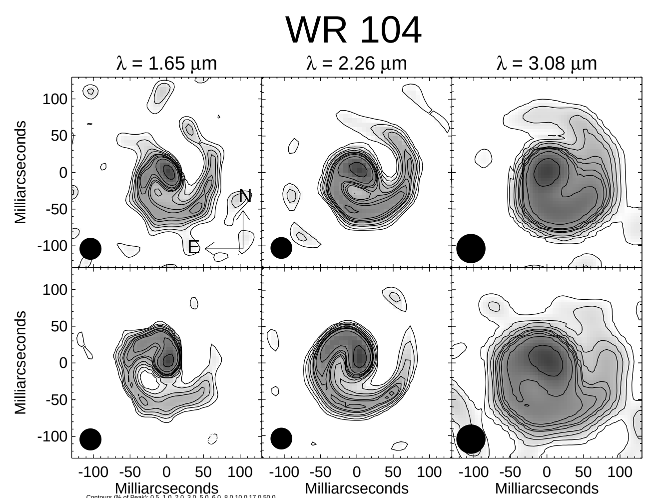

Fig. 1.—Two epochs of near-infrared images of WR 104 at three wavelengths. A spiral nebula is detected and observed to "rotate" between observations.