

## A Spitzer IRS Survey of Wolf-Rayet Stars at 10–20 Microns

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**Abstract.** We report on a mid-infrared survey of Wolf-Rayet stars using the Spitzer IRS/SH instrument for types WN4-WN7 and WC4-WC7. Strong emission line spectra are seen, including forbidden emission lines. Surprisingly, the WN stars appear to show broad emission “bumps” that may be consistent with silicate dust grains.

We observed eight Wolf-Rayet (WR) stars using the Spitzer IRS in the SH band. Power-law continua were fit to the spectra, and continuum-normalized spectra are shown in Fig. 1. Following Hillier, Jones, & Hyland (1983) and Ignace, Quigley, & Cassinelli (2003), we extended an analytic solution for the flux of free-free continuum and He II recombination lines to include a power-law variation of the clumping factor with radius. For the mid-IR emission from WR winds, the continuum flux distribution is a power law in frequency with

$$f_\nu \propto \nu^{2(u+m+1)/(3+m)}, \quad (1)$$

where  $m$  is the power law exponent for the clumping factor  $D_{\text{cl}} = \langle \rho^2 \rangle / \langle \rho \rangle^2 \propto r^{-m}$ , and for the Gaunt factor we assume  $g_\nu \propto \nu^{-u}$  with  $u = 0.23$  (Carciofi & Bjorkman 2006). Note that values of  $m = 0$  indicate a constant clumping factor, whereas  $m > 0$  corresponds to decreasing clumpiness with radius, and  $m < 0$  increasing clumpiness.

The results so far are that we observe several forbidden emission lines with [Ne III] 15.56  $\mu\text{m}$  notably present throughout all types,  $m$ -values either near 0 or positive, and broad emission bumps in the WN stars (centered near 12 and 17 microns). We tentatively associate the emission bumps with warm silicate dust grains (Koike et al. 2006). If true, this surprising occurrence of dust in WN stars may be related to the clumpiness of their winds.

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### References

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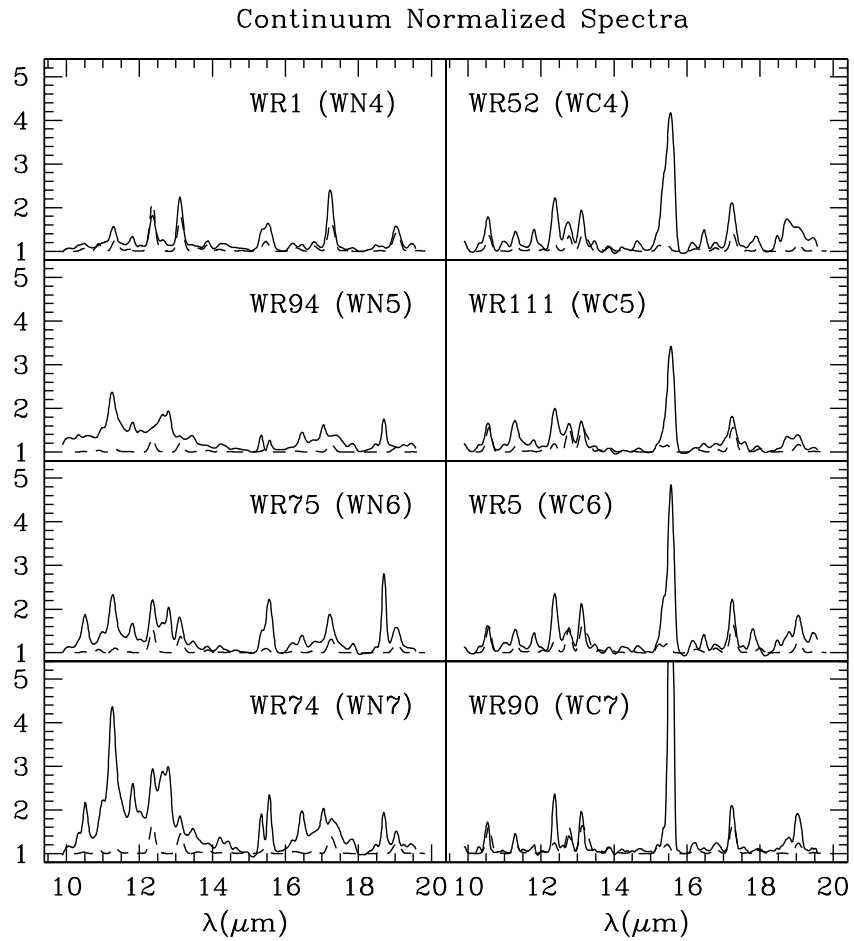


Figure 1. Observed IRS/SH spectra for our WR star targets, shown as the solid line. The dashed line is for a model fit described in the text. The spectra are continuum normalized. The dominant line in the WC spectra is [Ne III].