A Massive Star Odyssey, from Main Sequence to Supernova
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New neon-abundance results in Galactic WN and WC stars

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1. Introduction

The fast, dense winds which characterize Wolf-Rayet stars obscure their underlying cores, and complicate the verification of evolving core and nucleosynthesis models. A powerful technique for probing WR core evolution involves measuring abundances of wind-borne nuclear processed elements. Neon, in particular, undergoes a remarkable change in abundance during the later stages of a WR star's lifetime. By the end of the WC phase, it becomes the fourth most abundant element, after He, C and O (Maeder 1983).

Early low-resolution neon abundance measurements by Aitken *et al.* (1982) of the brightest nearby WR star, γ^2 Velorum (WR 11, WC8+O7.5III-V) were confirmed by van der Hucht & Olnon (1985) using *IRAS* spectra, and both results agreed very well with the WR core evolution models, which predict Ne/He $\simeq 12\times$ the cosmic value of 5.5×10^{-4}. Barlow *et al.* (1988) revised the abundance downwards, putting it quite close to cosmic levels. This serious discrepancy persisted until recently, when Dessart *et al.* (2000) used updated distance and mass-loss rates and *ISO* data to bring the Ne abundance again within 30% of the predicted value.

2. Observations and results

The 8 - 13 μm spectra were obtained April-July 1998, as part of a larger mid-infrared spectral survey of northern Galactic WR stars (Smith & Houck 2001) with SCORE, the *SIRTF* Cornell Echelle Spectrograph, on the Palomar 5m telescope. Two of the neon spectra are shown in Figure 1.

The fractional abundance γ_{Ne^+} by number was calculated from the measured line parameters, using a two-level approximation for the Ne^+ ground state, with chemical composition, distance, mass loss rate, and terminal velocity taken from the literature and analogy with survey stars of the same type. The resulting abundance values with respect to helium are listed in Table 1.

The WC9 star WR 121 shows neon abundance $\sim 7.5\times$ the cosmic value. (The higher ionization state Ne^{++} can be traced by [S IV] 10.5 μm, which is absent in all spectra except WR 105, indicating Ne^+ accounts for nearly all the neon in these stars' winds.) The three WN stars show near cosmic abundance levels, as expected for cores which have yet to undergo advanced nuclear processing. In WR 105, the $\mathrm{Ne}^+/\mathrm{S}^{3+}$ abundance ratio, which is immune to errors in mass

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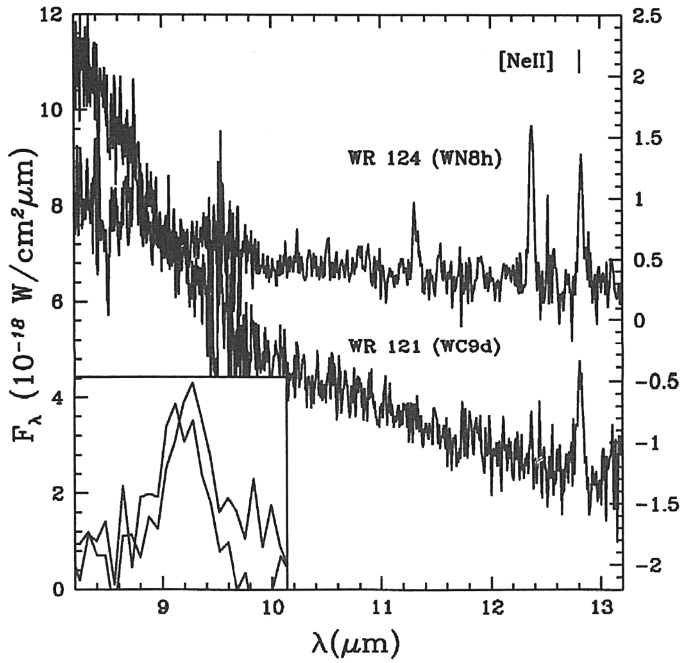

Figure 1. Two of the four stars with neon; [Ne II] line profiles inset.

Table 1. Neon abundances in WR stars

WR	type	Ne^+/He ($\times 10^{-4}$)
105	WN9h	8.8
116	WN8h	5.3
121	WC9d	41.
124	WN8h	4.2

loss rate, distance, *etc.*, is consistent with the solar Ne/S value, within the ionization distribution uncertainties.

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