Hydrogen-deficient central stars revisited

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Abstract. Previous spectral analyses of Wolf-Rayet type central stars resulted in different abundance patterns for late- and early [WC] subtypes, which could not be explained in the framework of post-AGB evolutionary scenarios with any form of a late thermal pulse. Presently we re-analyze systematically these stars, using the most recent version of our non-LTE models for expanding atmospheres which now account for line blanketing by the iron-group elements. So far we revisited the early subtypes. Although for some stars the carbon abundances are revised upwards, they are still only between 24 and 40% by mass and thus systematically lower than for late subtypes. This is inconsistent with an evolutionary sequence [WCL] → [WCE].

A considerable fraction of central stars shows Wolf-Rayet type spectra of the carbon sequence, characterized by bright and broad emission lines from He, C and O. Those stars have strong stellar winds, thus requiring adequate model atmospheres for their spectral analyses. Recent versions of such models, like the *Potsdam Wolf-Rayet (PoWR)* code (cf. Hamann & Gräfener 2004), account for iron-line blanketing and wind clumping.

We re-analyzed a sample of 12 [WCE]-type central stars (i.e. with WC spectra of *early* subtype) with the recent version of the *PoWR* models. Here we focus the discussion on the helium-to-carbon abundance ratio. Most useful for this purpose is the pair of neighboring lines He II 5412 and C IV 5470. The models reveal that the ratio between the strength of those lines is a sensitive function of the abundance ratio, but does not react much on the other fundamental parameters of the stellar atmosphere.

The present analyses confirm that central stars of late WC subtype, i.e. [WCL], have an atmospheric composition of He:C = 2:1 (by mass), typically. The empirical carbon mass fraction ranges from 0.24 to 0.40, as indicated by the shaded box in Fig. 1.

A couple of [WCL] stars have been re-analyzed with line-blanketed model atmospheres by the UCL group (e.g. Crowther et al. 2003). Those analyses, indicated in the upper part of Fig. 1, obtained rather high carbon abundances of 0.50, typically, for the [WCL].

Thus the He:C ratios seems to be different between the different classes, and inconsistent with an evolutionary sequence [WCL] → [WCE]. Moreover, evolutionary models (Herwig 2001) predict about equal mass fractions of He and C resulting from a "late", "very late" or "AGB final" thermal pulse (LTP, VLTP, AFTP).

Further research is needed to test all possible systematic errors in the spectroscopic abundance determinations. Due to the different ionization stages available, [WCL] and [WCE] analyses rely on different diagnostic lines. If the present discrepancy between [WCL] and [WCE] atmospheric compositions cannot be resolved, the evolutionary scenarios must be reconsidered.

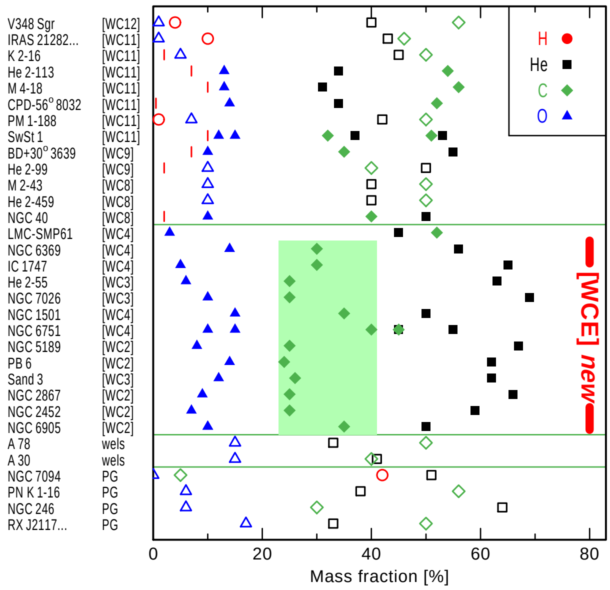

FIGURE 1. Atmospheric abundances in hydrogen-deficient central stars obtained from spectral analyses. Open symbols are based on studies with un-blanketed model atmospheres, while filled symbols represent values obtained more recently with line-blanketed models. Small vertical bars indicate upper limits of the hydrogen abundance.

REFERENCES

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