

# Wavelength calibration with WR lines

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## Abstract

**Key words:** stars: evolution — stars: supergiants — stars: massive

## 1 Introduction

Wolf–Rayet stars exhibit strong emission lines in their spectra. They can be identified even at the low resolution of the Gaia BP/RP spectra. An example of line identification is provided in Marin et al. (2024).

A catalog of Wolf-Rayet stars in the Milky Way is maintained by Prof. Crowther and is available on Crowther's webpage.

## 2 A set of reference spectra

The database compiled by Crowther comprises about 700 Wolf–Rayet (WR) stars, all of which are already identified with Gaia DR3 sources. For the present study, I have used a subset of 397 stars, assembled from the lists of van der Hucht (2001), Mauerhan et al. (2011), Shara et al. (2012), and Kanarek et al. (2015).

These 397 stars were cross-correlated with the 2MASS database and subsequently with the Gaia DR3 catalog using the 2MASS identifiers, yielding 204 secure sources with available BP/RP spectra. The Gaia sources were verified against the SIMBAD database.

Known binary stars were excluded, as well as stars with poor BP/RP spectra or spectra with ambiguous classifications (reported as WN or WC but showing mixed features indicative of binarity). Only Gaia point sources with RUWE values smaller than 1.4 were retained.

In the end, a list of 82 WN stars and 31 WC stars was obtained.

As noted above, additional stars can be incorporated from Crowther's comprehensive compilation (but, this will require a

new round of visual inspection, cannot be done automatically).

## 3 High-resolution spectra

I have quickly found 16 nice spectra.

UVES\_POP library contains the spectra of 8 WR stars.

Aadland et al. (2022) analyzed high-quality UV, optical, and near-IR (NIR) data on six WC-type stars and two WO. The spectra are on VIZIER.

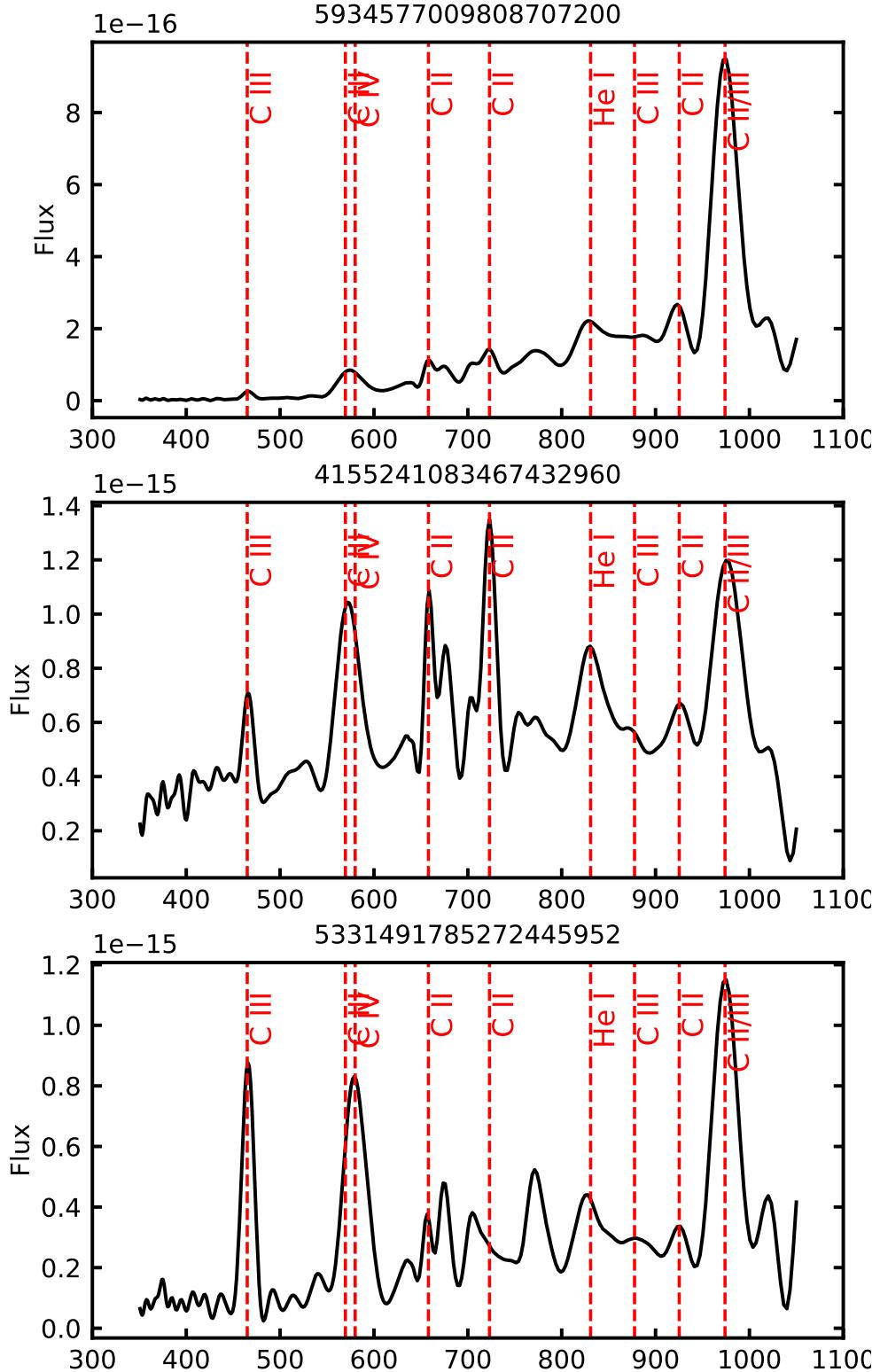
A direct comparison of BPRP spectra and high-resolution is therefore possible.

## 4 News of PNs

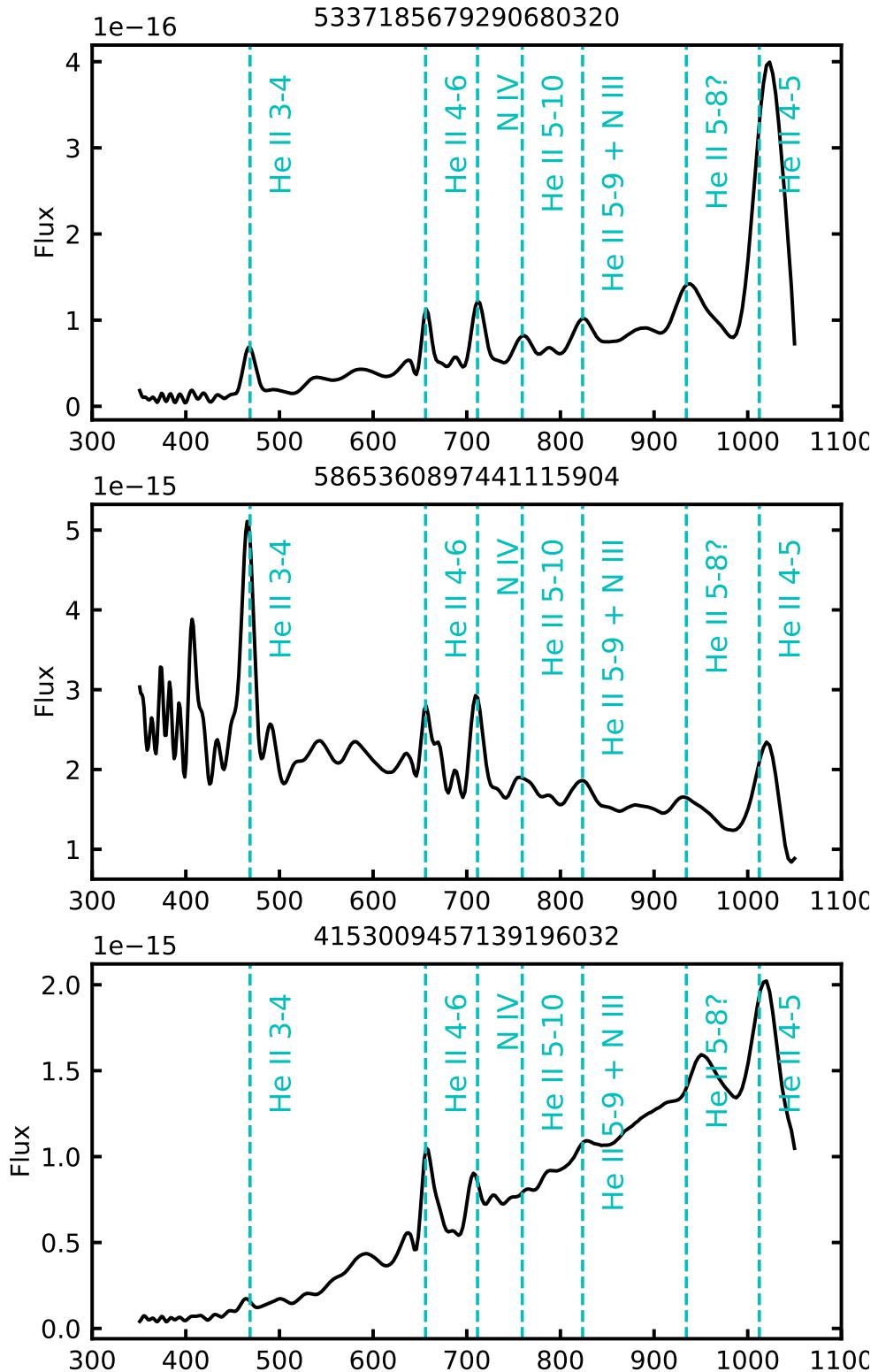
In preparation for the calibration of Euclid data, several planetary nebulae (PNs) were observed with VLT/X-shooter (Euclid Collaboration et al. 2023). The corresponding FITS files are available at VizieR (Fits at VIZIER).

## References

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**Fig. 1.** Example of a WC spectrum: a WC9 at the top, a WC9d in the middle, and a WC6 in the lower panel. Lines prominent in WC spectra are plotted in red, while those characteristic of WN stars are shown in green. Note that the lines around 550nm vary with spectral type; therefore, precise knowledge of the spectral type is required, as indicated in the table.



**Fig. 2.** Example of WN spectra: a WN4-s at the top, a WN7 in the middle, and a WN8h in the bottom panel. Lines prominent in WC spectra are plotted in red, while those characteristic of WN stars are shown in green.

**Table 1.** Prominent lines in WC stars (red lines)

Line Å	Element	Reference	Type
4650	CIII	Marin et al. (2024)	all WC
5696	CIII	Marin et al. (2024)	WC8/WC9
5800	CIV	Crowther (2007)	WC5,WC6,WC7
6580	CII	Marin et al. (2024)	
7231.36	CII	Marin et al. (2024)	
8308	He I	He I 2 <sup>1</sup> S – 2 <sup>1</sup> P (singlet)	WC8/WC9
8772-8780	CIII	Marin et al. (2024)	
9238-9267	CII	Marin et al. (2024)	WC8/WC9
9733-9747	CII/III blend	Marin et al. (2024)	all WC

- Lines are taken from Marin et al. (2024), Aadland et al. (2022), and Crowther (2007).

**Table 2.** Prominent lines in WR stars (green lines)

Line (air) Å	Element	Reference	Type
4686	He II (3-4)	Marin et al. (2024)	
6560	He II (4-6)	Marin et al. (2024)	
7115	NIV	Marin et al. (2024)	
7592	He II (5-10)	Hamann et al. (1995),Hamann et al. (2006)	
8237	He II (5-9) +N III	Hamann et al. (1995),Nugis et al. (2008)	
934.49	He II (5-8)?	Peter van Hoof, Atomic line list	WN3, WN4, WN5, WN6
10124	He II (4-5)	Howarth & Schmutz (1992),Vreux et al. (1990)	
10830	He I	Groh et al. (2007),Howarth & Schmutz (1992),Vreux et al. (1990)	

- Lines are taken from Marin et al. (2024), Hamann et al. (1995), Groh et al. (2007), and Howarth & Schmutz (line atlas from 0.92 to 1.12  $\mu$ m, 1992).
- transitions are read from Peter van Hoof, The Atomic line list.

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