

New Galactic Wolf-Rayet stars, and candidates (Research Note)

An annex to The VIIth Catalogue of Galactic Wolf-Rayet Stars

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ABSTRACT

This paper gathers, from the literature and private communication, 72 new Galactic Population I Wolf-Rayet stars and 17 candidate WCLd stars, recognized and/or discovered after the publication of *The VIIth Catalogue of Galactic Wolf-Rayet Stars*. This brings the total number of known Galactic Wolf-Rayet stars to 298, of which 24 (8%) are in open cluster Westerlund 1, and 60 (20%) are in open clusters near the Galactic Center.

Key words. stars: Wolf-Rayet

1. Introduction

Wolf-Rayet (WR) stars represent the final phase in the evolution of massive stars (i.e., $M_i \gtrsim 20 M_\odot$), before becoming a supernova and/or stellar remnant. They are the chemically evolved descendants of OB stars (e.g., Meynet & Maeder 2005) and contribute to chemical and kinetic enrichment of their environment through their dense stellar winds and Lyman continuum photons. Some of them could be the possible progenitors of core-collapse supernovae and γ -ray bursts, especially in a low metallicity environment (e.g., Hirschi et al. 2005; Petrovic et al. 2005; Yoon & Langer 2005; Langer & Norman 2006; Woosley & Heger 2006; Fruchter et al. 2006). Where $\sim 35\%$ of the Galactic WR stars have wind blown bubbles, visible as ring nebulae (Marston 1997), they provide the ideal environment for a γ -ray burst afterglow (e.g., Chevalier 2005; Dwardakas 2005; Zou et al. 2005; Eldridge et al. 2006; Eldridge & Vink 2006; Hammer et al. 2006). For all practical purposes, it is important to know as many WR stars as possible. Assembling a complete catalogue of WR stars, their spectral types (and hence chemical make-up) and relative numbers is important in order to understand their impact on the Galactic environment as well as to investigate their suitability as precursors to very energetic processes in extragalactic systems.

Since the publication of *The VIIth Catalogue of Galactic Wolf-Rayet Stars* (van der Hucht 2001, henceforth 7Cat), numerous new Galactic Population I Wolf-Rayet stars have been discovered, notably near the Galactic Center (in the infrared) and in open clusters (e.g., in Westerlund 1, optically), but also as individual field stars, thanks to the advancements in sensitivity and spatial resolution. In order to list these new WR stars properly in the 7Cat numbering system, and because of the crowding and the occasional resolution of apparently single objects into multiple objects, it became necessary to have the RA/Dec(J2000) coordinates of the 26 7Cat WR stars near the Galactic Center re-determined with higher accuracy. For

example, with improving spatial resolution and sensitivity, it appears that what Krabbe et al. (1995) saw as the single object GC IRS 13E (=WR 101f in 7Cat, WN9-10), has been resolved by Maillard et al. (2004) into a cluster containing 7 stars, including two WR stars (GC IRS13 E2 and GC IRS13 E4) and three candidate WCLd stars (GC IRS13 E3A, GC IRS13 E3B, and GC IRS13 E5). A critical analysis of IRS 13E has been presented recently by Paumard et al. (2006).

This paper, rather than providing a completely revised WR catalogue, presents as an annex to the 7Cat a list of new WR stars and candidate WR stars discovered in recent years, together with updated coordinates for some objects.

All of the new discoveries quoted here require confirmation by additional multi-frequency high-spectral resolution and high-angular resolution observations, which may throw new light on earlier results, e.g., Tanner et al. (2006). For example, GC IRS8, one of five GC stars suggested by Tanner et al. (2005) to be WR stars, turned out to be an O5-O6 giant or supergiant when observed by Geballe et al. (2006).

2. New data

The new Galactic WR stars listed in this annex have been discovered by the following authors:

- Some 15 possible WR stars in the Arches cluster had been recognized (in the infrared) before 2001 by Nagata et al. (1995) and Cotera et al. (1996), as noted by Blum et al. (2001), Lang et al. (2001), and Figer et al. (2002). Those objects are now included in this annex.
- Bartaya et al. (1994) discovered (in the optical) one new WN4 star (WR 159) in the OB association Cas OB 4, which has been re-discovered by Negueruela (2003).
- Figer et al. (1996) discovered (in the infrared) two WN9/Ofpe and five possible WCLd stars in the Quintuplet cluster. Tuthill et al. (2006) showed that at least two of those

WCLd stars, Q2 and Q3, have infrared pinwheels, indicative of dust formation originating in the colliding winds of long period WCL+OB binaries.

- Clark & Negueruela (2002), Negueruela & Clark (2003), Clark et al. (2005), Negueruela & Clark (2005), Negueruela (priv. comm.), and Crowther et al. (2006), discovered (in the optical) 24 new WR stars in the open cluster Westerlund 1, extremely rich in O stars, WR stars and LBVs. Groh et al. (2006) independently discovered (in the optical) three Wd1 WR stars discovered also by Crowther et al. (2006).
- Pasquali et al. (2002) discovered (in the infrared) one new WC8 star (WR 142a), in Cygnus.
- Homeier et al. (2003) discovered (in the infrared) three WC8-9 stars and one WN10 star, in the inner Galaxy.
- Drew et al. (2004) discovered (in the optical) one new WO3 star (WR 93b), located most likely in the Scutum-Crux arm of the inner Milky Way, from follow-up observations of candidate emission-line stars in the AAO/UKST Southern Galactic Plane H α Survey (Parker et al. 2005).
- Cohen et al. (2005) discovered (in the optical and infrared) one new WN7 star (WR 75ab), from follow-up observations of candidate emission-line stars in the AAO/UKST Southern Galactic Plane H α Survey (Parker et al. 2005).
- Hopewell et al. (2005) discovered (in the optical) five new WC9 stars in a programme of follow-up optical spectroscopy of candidate emission-line stars in the AAO/UKST Southern Galactic Plane H α Survey (Parker et al. 2005).
- Paumard et al. (2001, 2006), Eckart et al. (2004), Horrobin et al. (2004), Maillard et al. (2004), Moultaqa et al. (2005), and Tanner et al. (2002, 2005) together discovered (in the infrared) 14 new WR stars and 14 candidate WCLd stars in the Galactic Center cluster.
- Eikenberry et al. (2001, 2004) discovered (in the infrared) one new WC9 star (WR 111b) in the cluster apparently near the soft γ -ray repeater SGR 1806–20.
- Figer et al. (2005) discovered (in the optical and infrared) three new WR stars in the cluster around the soft γ -ray repeater SGR 1806–20, two of which (WR 111a and WR 111c) had been discovered independently (in the infrared) by LaVine and Eikenberry (2004, private communication).

3. The census of Population I WR stars and candidate WR stars in the Galaxy

The new Galactic WR stars and candidates are listed in Table 1, together with those WR stars from the 7Cat for which the coordinates have been re-determined. Table 1 lists:

- Galactic WR running number in the 7Cat system;
- WR discovery designation, acknowledging the authors of the discovery paper;
- additional designation(s) from the literature;
- discovery spectral type;
- revised spectral type;
- magnitude (*V*, or *R*, or *K*);
- RA/Dec(J2000) coordinates;
- discovery reference.

There are 72 new Galactic WR stars listed in this annex, plus 17 candidate WR stars, some possibly of the WCLd type. Of the 72 new Galactic WR stars we find: 45 WN stars, 26 WC stars, and one WO star.

Of the 72 new Galactic WR stars, in most cases the number of observations is still too small to establish which are binaries.

We would expect a binary frequency of $\sim 40\%$ (van der Hucht 2001, Table 20). Only a few new WR stars have shown some indication of binarity (see Table 1).

There are now 60 known WR stars in the open clusters near the Galactic Center, i.e., the Galactic Center cluster (29, plus 13 candidate WR stars), the Arches Cluster (17, all WN) and the Quintuplet cluster (14, plus 3 candidate WR stars), plus 16 candidate WR stars, mostly candidate WCLd.

Together with the 226 WR stars in the 7Cat, this annex brings the total number of presently known Galactic Population I WR stars to 298, excluding the 17 candidate WR stars. The spectral subtype distribution is: 171 WN stars, 10 WN/WC stars, 113 WC stars, and 4 WO stars.

The 7Cat has 53 of its 226 WR stars in open clusters and OB associations, i.e. 23%. Together with this annex we count 137 out of the 298 known Galactic WR stars in open clusters and OB associations, i.e. 46%, of which 8% are in open cluster Westerlund 1 and 20% are in open clusters near the Galactic Center.

4. Notes on individual stars

Westerlund 1:

- 77b** = NC-N: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77g** = NC-K: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77j** = NC-G: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77k** = NC-L = Wd1-44: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77n** = NC-F = Wd1-239: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77o** = NC-B: X-ray detection by *Chandra* (Skinner et al. 2006). Relatively high L_x , possibly colliding wind binary.
- 77p** = NC-E = Wd1-241: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77q** = NC-R = WD1-14c: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77r** = NC-D: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77sa** = NC-W = GDTB 3: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77sb** = NC-O: X-ray detection by *Chandra* (Skinner et al. 2006).
- 77sc** = NC-A: X-ray detection by *Chandra* (Skinner et al. 2006). Relatively high L_x , possibly colliding-wind binary.

Galactic Center cluster:

- WR 101b** = AF-NW: tentative association with X-ray source CXOGC/J174539.4–2900310 (Baganoff et al. 2003).
- WR 101db** = GC IRS 34W: irregular variable ($\Delta K = 1.5$ mag), possibly indicative for LBV phase (Trippe et al. 2006).
- WR 101fa** = GC IRS 3: an ESO VLTI-MIDI observation by Pott et al. (2005) shows a *N*-band (8–12 μm) size of ≤ 40 mas, i.e., ≤ 300 AU, compatible with the typical dust envelope size of WCd stars (Williams et al. 1987). However, Pott et al. argue that the WC5-6 spectrum may be associated with a faint star ~ 120 mas east of IRS 3. See also Viehmann et al. (2006).
- WR 101k** = GC IRS 16SW: periodic IR variable, *K*-band light curve, $P = 9.725$ d, $M \approx 100 M_\odot$ (Ott et al. 1999; De Poy et al. 2004).
- WR 101nd** = GC IRS 16NE: RV variable, may be SB (Tanner et al. 2006).

Table 1. New Galactic Wolf-Rayet stars. *Data quoted from 7Cat are listed in italics*, revised and new data are listed in roman font.

| WR | WR discovery designation | Other designation(s) | Discovery spectral type | Revised spectral type | <i>m</i> (mag) | RA(J2000) | Dec(J2000) | WR discovery ref. | |
|----------------------------------|--------------------------------|----------------------|-------------------------------|-----------------------------|-------------------------------------|---------------------------|----------------------------|-------------------------|--|
| 75aa | HBD 1 | SHS J162620.2–455946 | WC9d | | <i>I</i> = 14.18 | 16 26 20.2 | –45 59 46 | HB05 | |
| 75ab | CPG 1 | | WN7h | | <i>K_s</i> = 8.91 | 16 33 48.74 | –49 28 43.5 | CP05 | |
| 75c | HBD 2 | SHS J163403.6–434025 | WC9 | | <i>I</i> = 13.12 | 16 34 03.6 | –43 40 25 | HB05 | |
| 75d | HBD 3 | SHS J163417.5–460852 | WC9 | | <i>I</i> = 12.30 | 16 34 17.5 | –46 08 52 | HB05 | |
| <i>open cluster Westerlund 1</i> | | | | | | | | | |
| 77aa | HBD 4, NC-T | SHS J164646.3–454758 | WC9d | | <i>J</i> = 10.04 | 16 46 46.3 | –45 47 58 | HB05 | |
| 77a | NC-Q | | WN6-7 | WN6 | <i>J</i> = 11.72 | 16 46 55.55 | –45 51 35.0 | CH06 | |
| 77b | NC-N | | WC8 | WC9d | <i>J</i> = 9.69 | 16 46 59.9 | –45 55 26 | 2MASS | |
| 77c ¹ | NC-I | | WN6-8 | WN8 | <i>J</i> = 10.89 | 16 47 00.88 | –45 51 20.8 | CH06 | |
| 77d | NC-P | Wd1-57c | WN8 | WN7 | <i>J</i> = 11.06 | 16 47 01.59 | –45 51 45.5 | CH06 | |
| 77e ² | NC-J | | WNL | WN5 | <i>J</i> = 11.7: | 16 47 02.47 | –45 51 00.1 | CH06 | |
| 77f | NC-S | Wd1-5 | WNVL | WN10-11: | <i>J</i> = 9.81 | 16 47 02.98 | –45 50 20.0 | CH06 | |
| 77g ³ | NC-K | | WC | WC8 | <i>J</i> = 11.81 | 16 47 03.25 | –45 50 43.8 | CH06 | |
| 77h | NC-V | | WN8 | | <i>J</i> = 10.47 | 16 47 03.81 | –45 50 38.8 | CH06 | |
| 77i | NC-M | Wd1-66 | WC9 | WC9d | <i>J</i> = 10.13 | 16 47 03.96 | –45 51 37.8 | CH06 | |
| 77j ⁴ | NC-G | | WN6-8 | WN7 | <i>J</i> = 11.35 | 16 47 04.01 | –45 51 25.2 | CH06 | |
| 77k | NC-L | Wd1-44 | WN9 | WN9: | <i>J</i> = 9.08 | 16 47 04.19 | –45 51 07.4 | CH06 | |
| 77l ⁵ | NC-H | | WC9 | WC9d | <i>J</i> = 10.3: | 16 47 04.22 | –45 51 20.2 | CH06 | |
| 77m ⁶ | NC-C | | WC8 | WC9d | <i>J</i> = 11.26 | 16 47 04.40 | –45 51 03.8 | CH06 | |
| 77n ⁷ | NC-F | Wd1-239 | WC9 | WC9d | <i>J</i> = 9.85 | 16 47 05.22 | –45 52 25.0 | CH06 | |
| 77o ⁸ | NC-B | | WNL | WN7 | <i>J</i> = 10.91 | 16 47 05.36 | –45 51 05.0 | CH06 | |
| 77p ⁹ | NC-E | Wd1-241 | WC9 | | <i>J</i> = 10.12 | 16 47 06.05 | –45 52 08.2 | CH06 | |
| 77q | NC-R | Wd1-14c | WN6-7 | WN5 | <i>J</i> = 11.92 | 16 47 06.07 | –45 50 22.6 | CH06 | |
| 77r ¹⁰ | NC-D | | WN6-8 | WN7 | <i>J</i> = 11.63 | 16 47 06.24 | –45 51 26.5 | CH06 | |
| 77s | { NC-U GDTB 1 | | WN4 WN5-7 | WN6 | <i>J</i> = 10.76 <i>K</i> = 9.19 | 16 47 06.55 16 47 06.6 | –45 50 39.0 –45 50 38.6 | CH06 GD06 | |
| 77sa | { NC-W GDTB 3 | | WN5-6: WN7 | WN6 | <i>J</i> = 12.11 <i>K</i> = 9.70 | 16 47 07.58 16 47 07.6 | –45 49 22.2 –45 49 21.7 | CH06 GD06 | |
| 77sb | NC-O | | WN6 | | <i>J</i> = 11.00 | 16 47 07.66 | –45 52 35.9 | CH06 | |
| 77sc ¹¹ | NC-A | Wd1-72 | WN4-5 | WN7 | <i>J</i> = 10.34 | 16 47 08.32 | –45 50 45.5 | CH06 | |
| 77sd | { NC-X GDTB 2 | | WN4-5: WN4-5 | WN5 | <i>J</i> = 12.36 <i>K</i> = 9.99 | 16 47 14.1 16 47 14.2 | –45 48 32 –45 48 31.4 | 2MASS GD06 | |
| 77t | HBD 5 | SHS J165057.6–434028 | WC9d | | <i>I</i> = 13.00 | 16 50 57.6 | –43 40 28 | HB05 | |
| 93b | DBU 1 | | WO3 | | <i>K</i> = 10.17 | 17 32 03.30 | –35 04 32.5 | DB04 | |

Arches cluster:

WR 102aa = NWS 1 = AR6: non-thermal radio source (Lang et al. 2001). X-ray detection (Wang et al. 2006). Maybe WN8+OB colliding wind binary.

WR 102ad = NWS 4 = AR3: moderately variable (29%) radio source, possibly indicative of a colliding wind binary (Lang et al. 2005).

WR 102ae = NWS 5: source A2 in X-ray detection by Law & Yusef-Zadeh (2004) and Wang et al. (2006).

WR 102ah = NWS 8 = AR1: source A1S in X-ray detection by Law & Yusef-Zadeh (2004) and Wang et al. (2006). Non-thermal and moderately variable (12%) radio source, possibly indicative of a colliding wind binary (Lang et al. 2005).

WR 102ai = NWS 9 = AR8: moderately variable (25%) radio source, possibly indicative of a colliding wind binary (Lang et al. 2005).

WR 102aj = NWS 10 = AR4: source A1N in X-ray detection by Law & Yusef-Zadeh (2004) and Wang et al. (2006). Moderately variable (30%) radio source, possibly indicative of a colliding wind binary (Lang et al. 2005).

WR 102b = Sgr A-A: X-ray detection (Muno et al. 2006).

Quintuplet cluster:

WR 102dc = Q2 = GCS3-2 = qF231 = QR7: variable at *K* (Glass et al. 1999, 2001), indicative of WCLd+OB colliding wind binary. Detection in X-rays (Law & Yusef-Zadeh 2004; Wang et al. (2006). IR pinwheel discovered (Tuthill et al. 2006), proving a WCLd+OB colliding wind binary.

WR 102ha = Q3 = GCS4 = qF211: variable at *K* (Glass et al. 1999, 2001), indicative of WCLd+OB colliding wind binary. X-ray detection (Wang et al. (2006). Rotating IR pinwheel discovered (Tuthill et al. 2006), proving WC7-8d+OB colliding wind binary with $P = 850 \pm 110$ d.

Notes to Table 1

Revised WR numbers of stars in 7Cat:

¹ : WR 77c: formerly WR 77b in NC03.

² : WR 77e: formerly WR 77a in NC03.

³ : WR 77g: formerly WR 77c in NC03.

⁴ : WR 77j: formerly WR 77e in NC03.

⁵ : WR 77l: formerly WR 77d in NC03.

⁶ : WR 77m: formerly WR 77f in NC03.

⁷ : WR 77n: formerly WR 77g in NC03.

Table 1. continued.

| WR | WR discovery designation | Other designation(s) | Discovery in spectral PG06 type | Revised spectral type | <i>m</i> (mag) | RA(J2000) | Dec(J2000) | WR discovery ref. |
|--------------------------------|--------------------------|--|---------------------------------|-----------------------|-----------------------------------|-------------------|--------------|----------------------|
| <i>Galactic Center cluster</i> | | | | | | | | |
| 100a | | GC AFWNW | E81 WN7 | | <i>K</i> = 12.6 | PG06 17 45 39.306 | -29 00 30.68 | <i>a</i> PG06 |
| 101a | <i>BSD 1</i> | <i>MPE-8.3-5.7</i> | E82 WC9 | WC8-9 | PG06 <i>K</i> = 13.0 | PG06 17 45 39.382 | -29 00 33.43 | <i>a</i> <i>BS95</i> |
| 101b | <i>KGE 1</i> | <i>AFNW</i> | E74 WN9-11 | WN8 | PG06 <i>K</i> = 11.7 | PG06 17 45 39.458 | -29 00 31.67 | <i>a</i> <i>KG95</i> |
| 101c | <i>KGE 2</i> | <i>AF</i> | E79 WN9-11 | Ofpe/WN9 | PG06 <i>K</i> = 10.8 | PG06 17 45 39.541 | -29 00 35.01 | <i>a</i> <i>KG95</i> |
| 101d | <i>KGE 3</i> | <i>GC IRS 6E</i> | WC9 | | <i>K</i> = 9.55 | OE99 17 45 39.643 | -29 00 27.33 | <i>b</i> <i>KG95</i> |
| 101da | PGM 1 | | E60 WN7? | | <i>K</i> = 12.4 | PG06 17 45 39.708 | -29 00 29.75 | <i>a</i> PG06 |
| 101db | PGM 2 | GC IRS 34W | E56 Ofpe/WN9 | | <i>K</i> = 11.4 | PG06 17 45 39.731 | -29 00 26.51 | <i>a</i> PG06 |
| 101dc | MES-WR 1 | GC IRS 7SW | E66 WN8-9 | WN8 | PG06 <i>K</i> = 12.0 | PG06 17 45 39.739 | -29 00 23.17 | <i>a</i> ME05 |
| 101dd | PGM 3 | GC IRS 34NW | E61 WN7 | | <i>K</i> = 12.8 | PG06 17 45 39.756 | -29 00 25.25 | <i>a</i> PG06 |
| 101de | MPS 1 | GC IRS 13E5 | WCLd? | | <i>K</i> = 11.90 | MP04 17 45 39.780 | -29 00 29.65 | <i>c</i> MP04 |
| 101df | MPS 2 | GC IRS 13E3B | WCLd? | | <i>K</i> = 13.07 | MP04 17 45 39.792 | -29 00 29.59 | <i>c</i> MP04 |
| 101dg | TGM05-1 | GC IRS 2 , <i>BSD96-45</i> | WCLd? | | <i>K</i> = 10.34 | BS96 17 45 39.792 | -29 00 34.99 | <i>i</i> TG05 |
| 101dh | MPS 3 | GC IRS 13E3A | E49 WCLd? | ? | PG06 <i>K</i> = 13.0 | PG06 17 45 39.796 | -29 00 29.63 | <i>c</i> MP04 |
| 101di | MPS 4 | GC IRS 13E4 | E48 WC8-9 | WC9 | PG06 <i>K</i> = 11.7 | PG06 17 45 39.797 | -29 00 29.52 | <i>a</i> MP04 |
| 101e ¹² | <i>KGE 5</i> | <i>GC IRS 13E2</i> , MPS 5 | E51 WN9-10 +? | WN8 | PG06 <i>K</i> = 10.8 | PG06 17 45 39.801 | -29 00 29.84 | <i>a</i> <i>KG95</i> |
| 101ea | EML 1 | GC IRS 13E3c | WCLd? | | <i>K</i> = 12.49 | MP04 17 45 39.808 | -29 00 29.48 | EM04 EM04 |
| 101f ¹³ | <i>KGE 4</i> | <i>GC IRS 7W</i> , MES-WR2 | E68 WN9-10 | WC9 | PG06 <i>K</i> = 13.1 | PG06 17 45 39.853 | -29 00 22.11 | <i>a</i> <i>KG95</i> |
| 101fa | HET 1 | GC IRS 3E | E58 WC5-6d | WC5-6d? | PE05 <i>K</i> = 15.0 | PG06 17 45 39.868 | -29 00 24.30 | <i>a</i> HE04 |
| 101g | <i>KGE 6</i> | <i>GC IRS 29N</i> | E31 WC9 | | <i>K</i> = 10.0 | PG06 17 45 39.918 | -29 00 26.69 | <i>a</i> <i>KG95</i> |
| 101h ¹⁴ | <i>KGE 8</i> | <i>GC IRS 15SW</i> , MES-WR3 | E83 WN9-11 | WN8-WC9 | PG06 <i>K</i> = 12.0 | PG06 17 45 39.920 | -29 00 18.08 | <i>a</i> <i>KG95</i> |
| 101i ¹⁵ | <i>KGE 7</i> | <i>GC IRS 29NE1</i> , <i>MPE-1.0-3.5</i> | E35 WC9 | WC8-9 | PG06 <i>K</i> = 11.7 | PG06 17 45 39.965 | -29 00 26.04 | <i>a</i> <i>KG95</i> |
| 101j | <i>KGE 9</i> | <i>GC IRS 16NW</i> | E19 WN9-11 | Ofpe/WN9 | PG06 <i>K</i> = 10.0 | PG06 17 45 40.042 | -29 00 26.89 | <i>a</i> <i>KG95</i> |
| 101ja | PGM 4 | GC IRS 33E | E41 Ofpe/WN9 | | <i>K</i> = 10.1 | PG06 17 45 40.090 | -29 00 31.22 | <i>a</i> PG06 |
| 101k | <i>KGE 10</i> | <i>GC IRS 16SW</i> | E23 WN9-11 +? | Ofpe/WN9 | PG06 <i>K</i> = 9.61 ^v | GP00 17 45 40.120 | -29 00 29.08 | <i>a</i> <i>KG95</i> |
| 101l | <i>KGE 11</i> | <i>GC IRS 16C</i> | E20 WN9-11 | Ofpe/WN9 | PG06 <i>K</i> = 9.7 | PG06 17 45 40.126 | -29 00 27.62 | <i>a</i> <i>KG95</i> |
| 101m | <i>KGE 12</i> | <i>GC IRS 15NE</i> | E88 WN9-11 | WN8-9 | PG06 <i>K</i> = 11.8 | PG06 17 45 40.145 | -29 00 16.42 | <i>a</i> <i>KG95</i> |
| 101ma | PGM 5 | | E71 WC8-9? | | <i>K</i> = 14.1 | PG06 17 45 40.161 | -29 00 21.61 | <i>a</i> PG06 |
| 101n | <i>KGE 13</i> | <i>GC IRS 16SE1</i> , <i>MPE+1.6-6.8</i> | E32 WC9 | WC8-9 | PG06 <i>K</i> = 10.9 | PG06 17 45 40.181 | -29 00 29.25 | <i>a</i> <i>KG95</i> |
| 101na | TGM02-1 | GC IRS 21 , <i>BSD96-81</i> | WCLd? | | <i>K</i> = 10.55 | CR01 17 45 40.221 | -29 00 30.84 | <i>i</i> TG02 |
| 101nb | PGM 6 | GC IRS 7SE2 | WC? | | <i>K</i> = 13.7 | PG06 17 45 40.245 | -29 00 24.23 | <i>k</i> PG06 |
| 101nc | PGM 7 | GC IRS 9W | E65 WN8 | | <i>K</i> = 12.1 | PG06 17 45 40.257 | -29 00 33.72 | <i>a</i> PG06 |
| 101nd | PGM 8 | GC IRS 16NE | E39 Ofpe/WN9 | | <i>K</i> = 8.9 | PG06 17 45 40.259 | -29 00 27.07 | <i>a</i> PG06 |
| 101o | <i>KGE 14</i> | <i>GC IRS 16SE2</i> , <i>MPE+2.7-6.9</i> | E40 WC9 | WN5-6 | HE04 <i>K</i> = 12.0 | PG06 17 45 40.264 | -29 00 29.29 | <i>a</i> <i>KG95</i> |

⁸ : WR 77o: formerly WR 77h in NC03.

⁹ : WR 77p: formerly WR 77i in NC03.

¹⁰: WR 77r: formerly WR 77j in NC03.

¹¹: WR 77sc: formerly WR 77k in NC03.

¹²: WR 101e: formerly WR 101f in 7Cat.

Erratum: for GC IRS 13E1 in 7Cat, read GC IRS 13E2.

¹³: WR 101f: formerly WR 101e in 7Cat.

¹⁴: WR 101h: formerly WR 101i in 7Cat.

¹⁵: WR 101i: formerly WR 101h in 7Cat.

¹⁶: WR 102bd: formerly WR 101q in HB03.

¹⁷: WR 102j: formerly WR 102k in 7Cat.

¹⁸: WR 102k: formerly WR 101j in 7Cat.

Magnitudes:

For each object the most recently published magnitude has been quoted, unless the new observation only confirms the earlier observation. CS99 used $K'(\lambda_c = 2.11 \mu\text{m})$. FN02 used m_{F205W} . HB03 used K_s (narrow continuum filter $\lambda_c = 2.248 \mu\text{m}$) from 2MASS.

Coordinates:

Coordinates from reference in last column, unless indicated otherwise (p.c. = private communication):

a: coordinates from F. Martins, 11 August 2005, p.c.; also PG05.

b: revised coordinates from T. Paumard, October 2004, p.c.

c: coordinates from T. Paumard, August 2004, p.c.

d: coordinates from CDS-Simbad.

e: coordinates from J. Moulta, August 2005, p.c.

f: coordinates from A. S. Cotera, July 2005, p.c.

g: coordinates from R. D. Blum, August 2004, p.c.

h: coordinates from D. F. Figer, August 2004, p.c.

i: coordinates from F. Martins, 30 August 2005, p.c.; also PG05.

j: coordinates from D. F. Figer, April 2006, p.c.

k: coordinates from F. Martins, May 2006, p.c.

Reference abbreviations:

AR: Lang et al. (2001); Lang (2003), Lang et al. (2005).

BC94 = BCC: Bartaya et al. (1994).

BS01 = B = BSP: Blum et al. (2001).

BS95 = BSD: Blum et al. (1995).

BS96 = BSD96: Blum et al. (1996).

CE96 = C = CEC: Cotera et al. (1996).

CH06: Crowther et al. (2006).

CN02: Clark & Negueruela (2002).

CP05 = CPG: Cohen et al. (2005).

CR01: Clénet et al. (2001).

CS99: Cotera et al. (1999).

DB04 = DBU: Drew et al. (2004).

E: running number in Paumard et al. (2006), Table 2.

EG01: Eikenberry et al. (2001).

EM04: Eckart et al. (2004).

EML = EML04: Eikenberry et al. (2004).

F: Figer et al. (2002).

Table 1. continued.

| WR | WR discovery designation | Other designation(s) | Discovery in spectral PG06 type | Revised spectral type | <i>m</i> (mag) | RA(J2000) | Dec(J2000) | WR discovery ref. |
|--|--------------------------|----------------------------|---------------------------------|-----------------------|-----------------|-------------------|--------------|-------------------|
| <i>Galactic Center cluster (continued)</i> | | | | | | | | |
| 101oa | PMM 1 | HeI N3 | E59 WR | WC9 | PG06 $K = 13.0$ | PG06 17 45 40.264 | -29 00 24.64 | <i>a</i> PM01 |
| 101ob | PGM 9 | GC IRS 9SW | E76 WC9 | | $K = 13.1$ | PG06 17 45 40.366 | -29 00 36.13 | <i>a</i> PG06 |
| 101oc | PMM 2 | GC IRS 7E2 (ESE) | E70 WR | Ofpe/WN9 | PG06 $K = 12.9$ | PG06 17 45 40.369 | -29 00 22.76 | <i>b</i> PM01 |
| 101od | TGM05-3 | GC IRS 5 | | WCLd? | | 17 45 40.4 | -29 00 16 | <i>d</i> TG05 |
| 101oe | MEV 1 | GC IRS 1W, BSD96-92 | | WCLd? | $K = 8.72$ | CR01 17 45 40.442 | -29 00 27.53 | <i>i</i> ME04 |
| 101of | PGM 10 | GC IRS 9SE | E80 WC9 | | $K = 11.7$ | PG06 17 45 40.471 | -29 00 36.27 | <i>a</i> PG06 |
| 101og | TGM05-4 | GC IRS 10W, BSD96-94 | | WCLd? | $K = 10.25$ | BS96 17 45 40.49 | -29 00 22.8 | OE99 TG05 |
| 101oh | PGM 11 | | E72 WC9? | | $K = 13.6$ | PG06 17 45 40.551 | -29 00 28.60 | <i>a</i> PG06 |
| 101oi | PMM 3 | ID 180, HeI N1 | E78 WR | WC9 | PG06 $K = 13.0$ | PG06 17 45 40.760 | -29 00 27.79 | <i>c</i> PM01 |
| 101p | HBP 1 | | | WC8-9 | $K_s = 11.20$ | HB03 17 45 42.47 | -28 52 53.3 | HB03 HB03 |
| <i>Arches cluster</i> | | | | | | | | |
| 102a | CSE 1 | “near G 0.10+0.20” | | WN8 | $K' = 10.22$ | CS99 17 45 48.560 | -28 50 06.08 | <i>f</i> CS99 |
| 102aa | NWS 1 | C13, AR6, B34, F2 | | WN9 | $K' = 10.7$ | CE96 17 45 49.76 | -28 49 26.0 | LJ05 NW95 |
| 102ab | BSP 30 | B30, F10 | | WN7 | $K' = 11.46$ | FN02 17 45 50.08 | -28 49 26.2 | <i>g</i> BS01 |
| 102ac | BSP 29 | B29, F17 | | WN7 | $K' = 12.15$ | FN02 17 45 50.15 | -28 49 26.9 | <i>g</i> BS01 |
| 102ad | NWS 4 | C9, AR3, B28, F1 | | WN9 | $K' = 10.2$ | CE96 17 45 50.20 | -28 49 22.3 | LJ05 NW95 |
| 102ae | NWS 5 | C1, B26, F9 | | WN9 | $K' = 10.6$ | CE96 17 45 50.31 | -28 49 11.5 | <i>g</i> NW95 |
| 102af | NWS 6 | C3, AR16, B25, F12 | | WN9 | $K' = 10.6$ | CE96 17 45 50.31 | -28 49 17.0 | <i>g</i> NW95 |
| 102ag | NWS 7 | C6, AR2, B24, F8 | | WN9 | $K' = 10.76$ | FN02 17 45 50.39 | -28 49 21.3 | LJ05 NW95 |
| 102ah | NWS 8 | C8, AR1, B23, F6 | | WN9 | $K' = 10.1$ | CE96 17 45 50.42 | -28 49 22.3 | LJ05 NW95 |
| 102ai | NWS 9 | AR8, B22, F5 | | WN9 | $K' = 10.86$ | FN02 17 45 50.45 | -28 49 31.9 | LJ05 NW95 |
| 102aj | NWS 10 | C5, AR4, B21, F7 | | WN9 | $K' = 9.7$ | CE96 17 45 50.47 | -28 49 19.5 | LJ05 NW95 |
| 102ak | BSP 19 | B19, F16 | | WN6-7 | $K' = 11.40$ | FN02 17 45 50.55 | -28 49 20.5 | <i>g</i> BS01 |
| 102al | NWS 11 | C2, AR5, B17, F4 | | WN9 | $K' = 10.2$ | CE96 17 45 50.57 | -28 49 17.5 | LJ05 NW95 |
| 102b | CSE 2 | “near Sgr A East region A” | | WN6 | $K' = 10.97$ | CS99 17 45 50.626 | -28 59 19.61 | <i>f</i> CS99 |
| 102ba | CEC 7 | B12, F14 | | WN7 | $K' = 11.22$ | FN02 17 45 50.69 | -28 49 22.5 | <i>g</i> CE96 |
| 102bb | NWS 14 | C11, AR7, B3, F3 | | WN9 | $K' = 10.3$ | CE96 17 45 50.83 | -28 49 26.4 | LJ05 NW95 |
| 102bc | CEC 10 | B1 | | WN7 | $K' = 11.3$ | CE96 17 45 51.46 | -28 49 26.0 | <i>g</i> CE96 |

FM95: Figer et al. (1995).

FM96: Figer et al. (1996).

FM99a = FMM = FMM99: Figer et al. (1999a).

FM99b = FMG99: Figer et al. (1999b).

FN05 = FNG: Figer et al. (2005).

GCS: Nagata et al. (1995).

GD06 = GDTB: Groh et al. (2006).

GM99: Glass et al. (1999).

GP00 = GPE: Genzel et al. (2000).

HB03 = HBP: Homeier et al. (2003).

HB05 = HBD: Hopewell et al. (2005).

HE04 = HET: Horrobin et al. (2004).

KG95 = KGE: Krabbe et al. (1995).

La03: Lang (2003).

LG01: Lang et al. (2001).

LJ05: Lang et al. (2005).

ME04 = MEV: Moulataka et al. (2004).

ME05 = MES: Moulataka et al. (2005).

MP04 = MPS: Maillard et al. (2004).

NC03: Negueruela & Clark (2003).

NC05 = NC: Negueruela & Clark (2005).

Ne03: Negueruela (2003).

Ne05: Negueruela, priv. comm.: VLT-FORS spectroscopy.

NW95 = NWS: Nagata et al. (1995).

OE99: Ott et al. (1999).

Pa04: Paumard (2004, private communication).

PC02 = PCG: Pasquali et al. (2002).

PE05: Pott et al. (2005).

PG04: Paumard et al. (2004).

PG05: Paumard et al. (2005).

PG06 = PGM: Paumard et al. (2006).

PM01 = PMM: Paumard et al. (2001).

PM03: Paumard et al. (2003).

Q = GMM = GM90: Glass et al. (1990) (see also Moneti et al. 2001).

QR: Lang et al. (1999); Lang (2003); Lang et al. (2005).

TG02 = TGM02: Tanner et al. (2002).

TG05 = TGM05: Tanner et al. (2005).

TM06: Tuthill et al. (2006).

5. Conclusion

The past five years have seen the number of known Galactic WR stars increasing by ~30% to close to 300 objects. It is to be expected that, with the advance of observing capabilities, that number will continue to increase. Whether the expected number of ~1600 WR stars in our observable quadrant of the Galaxy (van der Hucht 2001) will be reached remains to be seen.

Discovering and monitoring WR star in the Galaxy and in the Local Group is important for the study of Galactic structure and chemical evolution, and it is likely that some WR

Table 1. continued.

| WR | WR discovery designation | Other designation(s) | Discovery spectral type | Revised spectral type | <i>m</i> (mag) ref. | RA(J2000) ref. | Dec(J2000) | WR discovery ref. | WR ref. |
|------------------------------|--------------------------------|-------------------------|-------------------------------|-----------------------------|---------------------------|-------------------|--------------|-------------------------|-------------|
| 102bd | ¹⁶ HBP 2 | | WC8-9 | | $K_s = 11.49$ | HB03 17 45 57.78 | -28 54 46.1 | HB03 | HB03 |
| <i>Quintuplet cluster</i> | | | | | | | | | |
| 102c | FMM96-1 | qF353E | WN6 | | $K = 11.53$ | FM99 17 46 11.2 | -28 49 05.6 | 7Cat | FM95 |
| 102ca | HBP 3 | | WC8-9 | | $K_s = 10.40$ | HB03 17 46 13.04 | -28 49 25.4 | HB03 | HB03 |
| 102d | FMM95-1 | qF320, QR8 | WN9 | | $K = 10.50$ | FM99 17 46 14.067 | -28 49 17.28 | <i>h</i> | FM95 |
| 102da | FMM-d1 | GCS 3-4, qF243, Q1 | WCLd? | | $K = 7.61$ | GM99 17 46 14.151 | -28 49 37.42 | <i>h</i> | FM96 |
| 102db | FMM-d2 | GCS 3-3, qF258, Q9 | WCLd? | | $K = 8.98$ | GM99 17 46 14.336 | -28 49 32.17 | <i>h</i> | FM96 |
| 102dc | FMM-d3 | GCS 3-2, qF231, Q2, QR7 | WCLd? | WC7-8d+OB | $K = 6.28_v$ | GM99 17 46 14.721 | -28 49 41.46 | <i>h</i> | FM96 |
| 102dd | FMM-d4 | GCS 3-1, qF251, Q4 | WCLd? | | $K = 7.66$ | GM99 17 46 14.810 | -28 49 35.02 | <i>h</i> | FM96 |
| 102e | FMM96-2 | qF151 | WC8 | | $K = 10.44$ | FM99 17 46 14.827 | -28 50 01.17 | <i>h</i> | FM96 |
| 102ea | FMM96-7 | qF241, Q10, QR5 | WN9/Ofpe | | $K = 8.83$ | GM99 17 46 15.129 | -28 49 37.82 | <i>j</i> | FM96 |
| 102f | FMM96-3 | qF235N | WC < 8 + ? | | | 17 46 15.168 | -28 49 40.25 | <i>h</i> | FM96 |
| 102g | FMM99-1 | qF235S | WC<8 | | | 17 46 15.182 | -28 49 42.40 | <i>h</i> | FM99 |
| 102h | FMM95-2 | qF76 | WC9 | | $K = 11.44$ | FM99 17 46 15.572 | -28 50 18.89 | <i>h</i> | FM95 |
| 102ha | FMM-d5 | GCS 4, qF211, Q3 | WCLd? | WCLd+OB | $K = 6.91_v$ | GM99 17 46 15.884 | -28 49 46.27 | <i>h</i> | FM96 |
| 102hb | FMM96-8 | qF240, Q8 | WN9/Ofpe | | $K = 9.01$ | GM99 17 46 15.954 | -28 49 38.60 | <i>j</i> | FM96 |
| 102i | FMM96-4 | qF256 | WN9 + ? | | $K = 11.38$ | FM99 17 46 16.560 | -28 49 32.53 | <i>h</i> | FM96 |
| 102j | ¹⁷ FMM96-6 | qF309 | WC<8 | | $K = 11.52$ | FM99 17 46 17.522 | -28 49 19.41 | <i>h</i> | FM96 |
| 102k | ¹⁸ FMM96-5 | qF274 | WN9 | | $K = 11.41$ | FM99 17 46 17.548 | -28 49 29.52 | <i>h</i> | FM96 |
| 102ka | HBP 4 | | WN10 | | $K_s = 8.84$ | HB03 17 46 18.12 | -29 01 36.5 | HB03 | HB03 |
| <i>“SGR 1806–20” cluster</i> | | | | | | | | | |
| 111a | FNG 1 | FNG-1 | WC8 | | $K = 11.76$ | FN05 18 08 38.32 | -20 24 33.5 | FN05 | FN05 |
| 111b | EGH 1 | FNG-B | WC9d | | $K = 10.50$ | FN05 18 08 39.24 | -20 24 42.50 | FN05 | EG01, EML04 |
| 111c | FNG 2 | FNG-2 | WN6 | | $K = 12.16$ | FN05 18 08 39.42 | -20 24 42.57 | FN05 | FN05 |
| 111d | FNG 3 | FNG-3 | WN7? | | $K = 12.87$ | FN05 18 08 39.50 | -20 24 35.88 | FN05 | FN05 |
| 142a | PCG 1 | NGC 6910-MS 21 | WC8 | | $K_s = 7.09$ | PC02 20 24 06.2 | +41 25 33 | PC02 | PC02 |
| 159 | BCC 1 | BD+62°2296B | WN4 | | $V_T = 11.20$ | Ne03 23 47 20.4 | +63 13 14 | Ne03 | BC94, Ne03 |

stars are Type Ib/c supernova progenitors and/or GRB progenitors. Identifying even one such object before it explodes could contribute greatly to our understanding of these energetic phenomena.

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