Research Note

New Galactic Wolf-Rayet stars, and candidates

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 – stars: catalogue

1. Introduction

Wolf-Rayet (WR) stars represent the final phase in the evolution of massive stars (i.e., $M_i \geq 20 M_\odot$), 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 $\gamma$-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 $\gamma$-ray burst afterglow (e.g., Chevalier 2005, Dwardakas 2005, Zou et al. 2005, Eldridge et al. 2005, 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 (WR) 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 GCIRS13E (= WR101f in 7Cat, WN9-10), has been resolved by Maillard et al. (2005) into a cluster containing 7 stars, including two WR stars (GCIRS13 E2 and GCIRS13 E4) and three candidate WCLd stars (GCIRS13 E3A, GCIRS13 E3B, and GCIRS13 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. (2000). For example, GC IRS8, one of five GC stars suggested by Tanner et al. (2000) 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. (1995), as noted by Blum et al. (2001), Lang et al. (2001), and Figer et al. (2002). Those objects are now included in this Annex.

- Bartay et al. (1994) discovered (in the optical) one new WN4 star (WR 159) in the OB association Cas OB4, which has been re-discovered by Negueruela (2003).

- Figer et al. (1999) discovered (in the infrared) two WN9/Ofpe and five possible WCLd stars in the Quintuplet cluster. Tuthill et al. (2003) 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. (2003), Negueruela & Clark (2004), Negueruela (priv. comm.), and Crowther et al. (2005) 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. (2005) independently discovered (in the optical) three Wd1 WR stars discovered also by Crowther et al. (2005).

- 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 Hα 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 Hα 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 Hα Survey (Parker et al. 2005).

- Paunard et al. (2001, 2005), Eckart et al. (2001), Horrobin et al. (2004), Maillard et al. (2004), Moutlaka et al. (2004), and Tanner et al. (2002, 2004) 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 J. LaVine and S.S. 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 ~ 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.
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 | spectral type | ref. | m (mag) | RA(J2000) | Dec(J2000) | ref. | WR discovery designation |
|----|-------------------------|----------------------|------------------------|--------------|------|---------|-----------|------------|------|-------------------------|
| 75aa | HBD 1 | SHS J162620.2−455946 | WC9d | I = 14.18 | HB05 | 16 26 20.2 | −45 59 46 | HB05 | HB05 |
| 75ab | CPG 1 | | WN7h | K_0 = 8.91 | CP05 | 16 33 48.74 | −49 28 43.5 | CP05 | CP05 |
| 75c | HBD 2 | SHS J163403.6−434025 | WC9 | I = 13.12 | HB05 | 16 34 03.6 | −43 40 25 | HB05 | HB05 |
| 75d | HBD 3 | SHS J163417.5−460852 | WC9 | I = 12.30 | HB05 | 16 34 17.5 | −46 08 52 | HB05 | HB05 |

open cluster Westerlund 1

| 77aa | HBD 4, NC-T | SHS J164646.3−454758 | WC9d | J = 10.04 | 2MASS | 16 46 46.3 | −45 47 58 | HB05 | HB05 |
| 77a | NC-Q | | WN6-7 WN6 CH06 | J = 11.72 | CH06 | 16 46 55.55 | −45 51 35.0 | CH06 | NC05 |
| 77b | NC-N | | WC8 WC9d CH06 | J = 9.69 | 2MASS | 16 46 59.9 | −45 55 26 | 2MASS | NC05 |
| 77c | NC-I | | WN6-8 WN8 CH06 | J = 10.89 | CH06 | 16 47 00.88 | −45 51 20.8 | CH06 | NC02, NC03 |
| 77d | NC-P | Wd1-57c | WN8 WN7 CH06 | J = 11.06 | CH06 | 16 47 01.59 | −45 51 45.5 | CH06 | NC05 |
| 77e | NC-J | | WN1 WN5 CH06 | J = 11.7: | CH06 | 16 47 02.47 | −45 51 00.1 | CH06 | NC02, NC03 |
| 77f | NC-S | Wd1-5 | WNVL WN10-11: CH06 | J = 9.81 | CH06 | 16 47 03.25 | −45 50 43.8 | CH06 | NC03 |
| 77g | NC-K | | WC WC8 CH06 | J = 11.81 | CH06 | 16 47 03.81 | −45 50 38.8 | CH06 | Ne05 |
| 77h | NC-V | | WN8 | J = 10.47 | CH06 | 16 47 04.01 | −45 51 25.2 | CH06 | NC02, NC03 |
| 77i | NC-M | Wd1-66 | WC9 WC9d CH06 | J = 10.13 | CH06 | 16 47 04.36 | −45 51 37.8 | CH06 | NC05 |
| 77j | NC-G | | WN6-8 WN7 CH06 | J = 11.35 | CH06 | 16 47 04.01 | −45 51 25.2 | CH06 | NC02, NC03 |
| 77k | NC-L | Wd1-44 | WN9 WN9: CH06 | J = 9.08 | CH06 | 16 47 04.19 | −45 51 07.4 | CH06 | NC05 |
| 77l | NC-H | | WC9 WC9d CH06 | J = 10.3: | CH06 | 16 47 04.22 | −45 51 20.2 | CH06 | NC02, NC03 |
| 77m | NC-C | | WC8 WC9d NC05 | J = 11.26 | CH06 | 16 47 04.40 | −45 51 03.8 | CH06 | NC02, NC03 |
| 77n | NC-F | Wd1-239 | WC9 WC9d CH06 | J = 9.85 | CH06 | 16 47 05.22 | −45 52 50.0 | CH06 | NC02, NC03 |
| 77o | NC-B | | WN1 WN7 CH06 | J = 10.91 | CH06 | 16 47 05.36 | −45 51 05.0 | CH06 | NC02, NC03 |
| 77p | NC-E | Wd1-241 | WC9 | J = 10.12 | CH06 | 16 47 06.05 | −45 52 08.2 | CH06 | NC02, NC03 |
| 77q | NC-R | Wd1-14c | WN6-7 WN5 CH06 | J = 11.92 | CH06 | 16 47 06.07 | −45 50 22.6 | CH06 | NC05 |
| 77r | NC-D | | WN6-8 WN7 CH06 | J = 11.53 | CH06 | 16 47 06.24 | −45 51 25.6 | CH06 | NC02, NC03 |
| 77s | NC-U | GDTB 1 | WN4 WN6 CH06 | J = 10.76 | CH06 | 16 47 06.55 | −45 50 39.0 | CH06 | Ne05 |
| 77sa | NC-W | GDTB 3 | WN5-7 | K = 9.19 | GD06 | 16 47 06.6 | −45 50 38.6 | GD06 | GD06 |
| 77sb | NC-O | | WN5-6: WN6 CH06 | J = 12.11 | CH06 | 16 47 07.58 | −45 49 22.2 | CH06 | NC05 |
| 77sc | NC-A | Wd1-72 | WN4-5 WN7 CH06 | J = 11.00 | CH06 | 16 47 07.6 | −45 49 21.7 | CH06 | GD06 |
| 77sd | NC-X | GDTB 2 | WN4-5: WN5 CH06 | J = 12.36 | 2MASS | 16 47 14.1 | −45 48 32 | 2MASS | CH06 |
| 77t | HBD 5 | SHS J165057.6−434028 | WC9d | I = 13.00 | HB05 | 16 50 57.6 | −43 40 28 | HB05 | HB05 |
| 93b | DBU 1 | | WO3 | K = 10.17 | DB04 | 17 32 03.3 | −35 04 32.5 | DB04 | DB04 |
Table 1 (cont’d): New Galactic Wolf-Rayet stars. *Data quoted from 7Cat are listed in italics, revised and new data are listed in roman font.*

| WR discovery designation | other designation(s) | WR spectral designation | WR spectral type | m (mag) ref. | RA(J2000) | Dec(J2000) | WR discovery ref. |
|--------------------------|----------------------|------------------------|-----------------|-------------|-----------|-----------|-------------------|
| **Galactic Center cluster** |
| 100a | GC AF NW NW | E81 | WN7 | $K = 12.6$ | PG06 | 17 45 39.306 | -29 00 30.68 | a | PG06 |
| 101a | BSD 1 | MPE–8.3–5.7 | E82 | WC9 | WC8-9 | PG06 | 17 45 39.382 | -29 00 33.43 | a | BS95 |
| 101b | KGE1 | AF NW | E74 | WN9-11 | WN8 | PG06 | 17 45 39.458 | -29 00 31.67 | a | KG95 |
| 101c | KGE2 | AF | E79 | WN9-11 | Ofpe/WN9 | PG06 | 17 45 39.541 | -29 00 35.01 | a | KG95 |
| 101d | KGE3 | GC IRS6E | WC9 | $K = 9.55$ | OE99 | 17 45 39.643 | -29 00 27.33 | b | KG95 |
| 101da | PGM1 | | WN7? | $K = 12.4$ | PG06 | 17 45 39.708 | -29 00 29.75 | a | PG06 |
| 101db | PGM2 | GC IRS34W | E56 | Ofpe/WN9 | $K = 11.4$ | PG06 | 17 45 39.731 | -29 00 26.51 | a | PG06 |
| 101dc | MES-WR1 | GC IRS78W | E66 | WN8-9 | WN8 | PG06 | 17 45 39.739 | -29 00 23.17 | a | ME05 |
| 101dd | PGM3 | GC IRS34NW | E61 | WCld? | $K = 12.8$ | PG06 | 17 45 39.756 | -29 00 25.25 | a | PG06 |
| 101de | MPS1 | GC IRS13E5 | WCld? | $K = 11.90$ | MP04 | 17 45 39.780 | -29 00 29.65 | c | MP04 |
| 101df | MPS2 | GC IRS13E3B | WCld? | $K = 13.07$ | MP04 | 17 45 39.792 | -29 00 29.59 | c | MP04 |
| 101dg | TGM05-1 | GC IRS1 , BSD96-45 | WCld? | $K = 10.34$ | BS96 | 17 45 39.792 | -29 00 34.99 | i | TG05 |
| 101dh | MPS3 | GC IRS13E3A | E49 | WCld? | ? | PG06 | 17 45 39.796 | -29 00 29.63 | c | MP04 |
| 101di | MPS4 | GC IRS13E4 | E48 | WC8-9 | WC9 | PG06 | 17 45 39.797 | -29 00 29.52 | a | MP04 |
| 101e | KGE5 | GC IRS13E2 , MPS 5 | E51 | WN9-10 +? | WN8 | PG06 | 17 45 39.801 | -29 00 29.84 | a | KG95 |
| 101ea | EML1 | GC IRS13E3c | WCld? | $K = 12.49$ | MP04 | 17 45 39.808 | -29 00 29.48 | EM04 | EM04 |
| 101f | KGE4 | GC IRS7W , MES-WR2 | E68 | WN9-10 | WC9 | PG06 | 17 45 39.853 | -29 00 22.11 | a | KG95 |
| 101fa | HET1 | GC IRS3E | E58 | WC5-6d | WC5-6d? | PE05 | 17 45 39.868 | -29 00 24.30 | a | HE04 |
| 101g | KGE6 | GC IRS29N | E31 | WC9 | $K = 10.0$ | PG06 | 17 45 39.918 | -29 00 26.69 | a | KG95 |
| 101h | KGE8 | GC IRS15SW , MES-WR3 | E83 | WN9-11 | WN8-WC9 | PG06 | 17 45 39.920 | -29 00 18.08 | a | KG95 |
| 101i | KGE7 | GC IRS29NE1, MPE–1.0–3.5 | E35 | WC9 | WC8-9 | PG06 | 17 45 39.965 | -29 00 26.04 | a | KG95 |
| 101j | KGE9 | GC IRS16W | E19 | WN9-11 | Ofpe/WN9 | PG06 | 17 45 40.042 | -29 00 26.89 | a | KG95 |
| 101ja | PGM4 | GC IRS33E | E41 | Ofpe/WN9 | $K = 10.1$ | PG06 | 17 45 40.090 | -29 00 31.22 | a | PG06 |
| 101k | KGE10 | GC IRS16SW | E23 | WN9-11 +? | Ofpe/WN9 | PG06 | K = 9.61v | GP00 | 17 45 40.120 | -29 00 29.08 | a | KG95 |
| 101l | KGE11 | GC IRS16C | E20 | WN9-11 | Ofpe/WN9 | PG06 | K = 9.7 | PG06 | 17 45 40.126 | -29 00 27.62 | a | KG95 |
| 101m | KGE12 | GC IRS15NE | E88 | WN9-11 | WN8-9 | PG06 | 17 45 40.145 | -29 00 16.42 | a | KG95 |
| 101ma | PGM5 | GC IRS39E | E71 | WC8-9? | $K = 14.1$ | PG06 | 17 45 40.161 | -29 00 21.61 | a | PG06 |
| 101n | KGE13 | GC IRS16SE1, MPE+1.6–6.8 | E32 | WC9 | WC8-9 | PG06 | 17 45 40.181 | -29 00 29.25 | a | KG95 |
| 101na | TGM92-1 | GC IRS21 , BSD96-81 | WCLd? | $K = 10.55$ | CR01 | 17 45 40.221 | -29 00 30.84 | i | TG02 |
| 101nb | PGM6 | GC IRS7SE2 | WC7 | $K = 13.7$ | PG06 | 17 45 40.245 | -29 00 24.23 | k | PG06 |
| 101nc | PGM7 | GC IRS9W | E65 | WN8 | $K = 12.1$ | PG06 | 17 45 40.257 | -29 00 33.72 | a | PG06 |
| 101nd | PGM8 | GC IRS16NE | E39 | Ofpe/WN9 | $K = 8.9$ | PG06 | 17 45 40.259 | -29 00 27.07 | a | PG06 |
| 101o | KGE14 | GC IRS16SE2, MPE+2.7–6.9 | E40 | WC9 | WN5-6 | HE04 | 17 45 40.264 | -29 00 29.29 | a | KG95 |
Table 1 (cont’d): New Galactic Wolf-Rayet stars. Data quoted from 7Cat are listed in italics, revised and new data are listed in roman font.

| WR discovery designation | WR other designation(s) in PG06 | discovery spectral type | revised spectral type | ref. | $m$ (mag) | RA(J2000) | Dec(J2000) | WR discovery ref. |
|-------------------------|---------------------------------|-------------------------|----------------------|------|--------|-----------|-----------|------------------|

**Galactic Center cluster (cont’d)**

| 101oa PMM 1 | HeN3 | E59 | WR | WC9 | PG06 | $K = 13.0$ | 17 45 40.264 | −29 00 24.64 | a PM01 |
| 101ob PGM 9 | GC IRS 9SW | E76 | WC9 | $K = 13.1$ | 17 45 40.366 | −29 00 36.13 | a PG06 |
| 101oc PMM 2 | GC IRS 7E2 (ESE) | E70 | WR | Ofpe/WN9 | PG06 | $K = 12.9$ | 17 45 40.369 | −29 00 22.76 | b PM01 |
| 101od TGM05-3 | GC IRS 5 | WCLd? | $K = 14.4$ | 17 45 40.4 | −29 00 16 | d TG05 |
| 101oe MEV 1 | GC IRS 1W, BSD96-92 | WCLd? | $K = 8.72$ | 17 45 40.49 | −29 00 22.8 | OE99 |
| 101of PGM 11 | GC IRS 9SE | E80 | WC9? | $K = 11.7$ | 17 45 40.9 | −29 00 36.27 | a PG06 |
| 101oh PGM 10 | GC IRS 9SE | E80 | WC9? | $K = 13.6$ | 17 45 40.551 | −29 00 28.60 | a PG06 |
| 101oi PMM 3 | ID 180, HeI | E78 | WR | WC9 | PG06 | $K = 13.0$ | 17 45 40.760 | −29 00 27.79 | c PM01 |

| 101p HBP 1 | WC8-9 | $K_s = 11.20$ | 17 45 42.47 | −28 52 53.3 | HB03 |

**Arches cluster**

| 102a CSE 1 | “near G 0.10+0.20” | WN8 | $K'' = 10.22$ | 17 45 48.560 | −28 50 06.08 | f CS99 |
| 102ab NWS 3 | C13, AR6, B34, F2 | WN9 | WN9+OB? | LG01 | $K'' = 10.7$ | 17 45 49.76 | −28 49 26.0 | LJ05 |
| 102ac BSP 29 | B29, F17 | WN7 | $K'' = 11.46$ | 17 45 50.08 | −28 49 26.2 | g BS01 |
| 102ad NWS 5 | C9, AR3, B28, F1 | WN7 | $K'' = 12.15$ | 17 45 50.15 | −28 49 26.9 | g BS01 |
| 102ae NWS 5 | C1, B26, F9 | WN9 | $K'' = 10.6$ | 17 45 50.31 | −28 49 11.5 | g NW95 |
| 102af NWS 6 | C3, AR16, B25, F12 | WN9 | $K'' = 10.6$ | 17 45 50.31 | −28 49 17.0 | g NW95 |
| 102ag NWS 7 | C6, AR2, B24, F8 | WN9 | $K'' = 10.76$ | 17 45 50.39 | −28 49 21.3 | LJ05 |
| 102ah NWS 8 | C8, AR1, B23, F6 | WN9 | WN9+OB? | LG01 | $K'' = 10.1$ | 17 45 50.42 | −28 49 22.3 | LJ05 |
| 102ai NWS 9 | AR8, B22, F5 | WN9 | WN9+OB? | LG01 | $K'' = 10.86$ | 17 45 50.45 | −28 49 31.9 | LJ05 |
| 102aj NWS 10 | C5, AR4, B21, F7 | WN9 | WN9+OB? | LG01 | $K'' = 9.7$ | 17 45 50.47 | −28 49 19.5 | LJ05 |
| 102ak BSP 19 | B19, F16 | WN6-7 | $K'' = 11.40$ | 17 45 50.55 | −28 49 20.5 | g BS01 |
| 102al NWS 11 | C2, AR5, B17, F4 | WN9 | WN8 | La03 | $K'' = 10.2$ | 17 45 50.57 | −28 49 17.5 | LJ05 |
| 102b CSE 2 | “near Sgr A East region A” | WN6 | $K'' = 10.97$ | 17 45 50.626 | −28 59 19.61 | f CS99 |
| 102ba CEC 7 | B12, F14 | WN7 | $K'' = 11.22$ | 17 45 50.69 | −28 49 22.5 | g CE96 |
| 102bb NWS 14 | C11, AR7, B3, F3 | WN9 | WN9/Ofpe | La03 | $K'' = 10.3$ | 17 45 50.83 | −28 49 26.4 | LJ05 |
| 102bc CEC 10 | B1 | WN7 | $K'' = 11.3$ | 17 45 51.46 | −28 49 26.0 | g CE96 |
Table 1 (cont’d): 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 | $m$ (mag) | RA(J2000) | Dec(J2000) | WR discovery ref. |
|--------|--------------------------|----------------------|------------------------|-----------------------|-----------|-----------|-------------|------------------|
| 102bd  | HBP 2                    | WC8-9                |                        |                       |           | 17 45 57.78 | −28 54 46.1 | HB03             |
|        |                          |                      |                        |                       |           |           |             |                  |
| **Quintuplet cluster**                  |                        |                      |                        |                       |           |           |             |                  |
| 102c   | FMM96-1                  | qF353E               | WN6                    |                       | $K_s$ = 11.49 | HB03     | 17 46 11.2 | −28 49 05.6 | 7Cat, FM95       |
| 102ca  | HBP 3                    |                      |                        |                       | $K_s$ = 10.40 | HB03     | 17 46 13.04 | −28 49 25.4 | HB03             |
| 102d   | FMM95-1                  | qF320, QR8           | WN9                    |                       | $K_s$ = 10.50 | FM99     | 17 46 14.067 | −28 49 17.28 | h, FM95          |
| 102da  | FMM-d1                   | GCS 3-4, qF243, Q1   | WCLd?                  |                       | $K_s$ = 7.61 | GM99     | 17 46 14.151 | −28 49 37.42 | h, FM96          |
| 102db  | FMM-d2                   | GCS 3-3, qF258, Q9   | WCLd?                  |                       | $K_s$ = 8.98 | GM99     | 17 46 14.336 | −28 49 32.17 | h, FM96          |
| 102dc  | FMM-d3                   | GCS 3-2, qF231, Q2, QR7 | WCLd? WC7-8d+OB TM06  |                       | $K_s$ = 6.28v | GM99     | 17 46 14.721 | −28 49 41.46 | h, FM96          |
| 102dd  | FMM-d4                   | GCS 3-1, qF251, Q4   | WCLd?                  |                       | $K_s$ = 7.66 | GM99     | 17 46 14.810 | −28 49 35.02 | h, FM96          |
| 102e   | FMM96-2                  | qF151                | WC8                    |                       | $K_s$ = 10.44 | FM99     | 17 46 14.827 | −28 50 01.17 | h, FM96          |
| 102ea  | FMM96-7                  | qF241, Q10, QR5      | WN9/Ofpe               |                       | $K_s$ = 8.83 | GM99     | 17 46 15.129 | −28 49 37.82 | j, FM96          |
| 102f   | FMM96-3                  | qF235N               | WC<8 + ?               |                       |           | 17 46 15.168 | −28 49 40.25 | h, FM96          |
| 102g   | FMM99-1                  | qF235S               | WC<8                   |                       |           | 17 46 15.182 | −28 49 42.40 | h, FM99          |
| 102h   | FMM95-2                  | qF76                 | WC9                    |                       |           | 17 46 15.572 | −28 50 18.89 | h, FM95          |
| 102ha  | FMM-d5                   | GCS 4, qF211, Q3     | WCLd? WCLd+OB TM06    |                       | $K_s$ = 6.91v | GM99     | 17 46 15.884 | −28 49 46.27 | h, FM96          |
| 102hb  | FMM96-8                  | qF240, Q8            | WN9/Ofpe               |                       | $K_s$ = 9.01 | GM99     | 17 46 15.954 | −28 49 38.60 | j, FM96          |
| 102i   | FMM96-4                  | qF256                | WN9 + ?                |                       | $K_s$ = 11.38 | FM99     | 17 46 16.560 | −28 49 32.53 | h, FM96          |
| 102j   | FMM96-6                  | qF309                | WC<8                   |                       | $K_s$ = 11.52 | FM99     | 17 46 17.522 | −28 49 19.41 | h, FM96          |
| 102k   | FMM96-5                  | qF274                | WN9                    |                       | $K_s$ = 11.41 | FM99     | 17 46 17.548 | −28 49 29.52 | h, FM96          |
| 102k a | HBP 4                    |                      | WN10                   |                        | $K_s$ = 8.84 | HB03     | 17 46 18.12 | −29 01 36.5 | HB03             |
|        |                          |                      |                        |                        |           |           |             |                  |
| **“SGR 1806−20” cluster**              |                        |                      |                        |                        |           |           |             |                  |
| 111a   | FNG 1                    | FNG-1                | WC8                    |                        | $K_s$ = 11.76 | FN05     | 18 08 38.32 | −20 24 33.5 | FN05, FN05       |
| 111b   | EGH 1                    | FNG-B                | WC9d                   |                        | $K_s$ = 10.50 | FN05     | 18 08 39.24 | −20 24 42.50 | FN05, EGL04, FN05 |
| 111c   | FNG 2                    | FNG-2                | WN6                    |                        | $K_s$ = 12.16 | FN05     | 18 08 39.42 | −20 24 42.57 | FN05             |
| 111d   | FNG 3                    | FNG-3                | WN7?                   |                        | $K_s$ = 12.87 | FN05     | 18 08 39.50 | −20 24 35.88 | FN05             |
| 142a   | PCG 1                    | NGC 6910-MS 21       | WC8                    |                        | $K_s$ = 7.09 | PC02     | 20 24 06.2 | +41 25 33 | PC02             |
| 159    | BCC 1                    | BD+62°296B           | WN4                    |                        | $V_T$ = 11.20 | Ne03     | 23 47 20.4 | +63 13 14 | Ne03, BC94, Ne03 |
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 77o: formerly WR 77h in NC03.
8: WR 77p: formerly WR 77i in NC03.
9: WR 77q: formerly WR 77k in NC03.
10: WR 77r: formerly WR 77j in NC03.
11: WR 77s: 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 \( K'(\lambda_c = 2.11 \mu m) \). FN02 used \( m_{2002} \). HB03 used \( K_s \) (narrow continuum filter \( \lambda_c = 2.248 \mu m \)) 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. Moutlaka, 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. 2003
BC94 = BCC : Bartayya et al. 1994
BG95 = BSD : Blum et al. 1995
BS95 = 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
FM95 : Figer et al. 1995
FM96 : Figer et al. 1996
FM99a = FMM = FMM99 : Figer et al. 1999
FM99b = FMM99 : Figer et al. 1999
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 = HB : 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 : Moutlaka et al. 2004
ME05 = MES : Moutlaka et al. 2005
MP04 = MPS : Maillard et al. 2004
NO03 : Negueruela & Clark 2003
NO05 = NC : Negueruela & Clark 2005
Ne03 : Negueruela 2003
Ne05 : Negueruela, priv. comm.: VLT-FORS spectroscopy
NW95 = NWS : Nagata et al. 1995
OE09 : Ott et al. 2009
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 = PPM : 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
La03 : Lang 2003
Lang et al. 2005
TG02 = TGM02 : Tanner et al. 2002
TG05 = TGM05 : Tanner et al. 2005
TM06 : Tuthill et al. 2006

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).
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 = GDTB3 : 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 Lx, possibly colliding-wind binary.

**Galactic Center cluster :**

WR 101b = AF-NW : tentative association with X-ray source CXOJG/174539.4-2900310 (Baganoff et al. 2003).
WR 101db = GC IRS34W : irregular variable (ΔK=1.5 mag), possibly indicative for LBV phase (Trippe et al. 2006).
WR 101fa = GC IRS3 : 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 IRS3. See also Viehmann et al. 2006.
WR 101k = GC IRS16SW : periodic IR variable, K-band light curve, P = 9.725 d, M = 100 M⊙ (Ott et al. 1999, De Poy et al. 2001).
WR 101nd = GC IRS16NE : RV variable, may be SB (Tanner et al. 2006).

**Archae cluster :**

WR 102aa = NWS1 = AR6 : non-thermal radio source (Lang et al. 2001). X-ray detection (Wang et al. 2006). MaybeWN8+OB colliding wind binary.
WR 102ad = NWS4 = AR3 : moderately variable (29%) radio source, possibly indicative of a colliding wind binary (Lang et al. 2005).
WR 102ae = NWS5 : source A2 in X-ray detection by Law & Yusef-Zadeh 2003 and Wang et al. 2006.
WR 102ah = NWS8 = AR1 : source A1S in X-ray detection by Law & Yusef-Zadeh 2001 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 = NWS9 = AR8 : moderately variable (25%) radio source, possibly indicative of a colliding wind binary (Lang et al. 2006).
WR 102aj = NWS10 = AR4 : source A1B in X-ray detection by Law & Yusef-Zadeh 2001 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 102de = 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 2001) Wang et al. 2006. IR pinwheel discovered (Tuthill et al. 2006), proving a WCL+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 WC7-8+OB colliding wind binary with P = 850 ± 110 d.

5. Conclusion

The past five years have seen the number of known Galactic WR stars increase 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 quadrants 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 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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