Particle-accelerating colliding-wind binaries: from the study of a few objects to a science case study

Michaël De Becker
Department of Astrophysics, Geophysics, and Oceanography
University of Liège
Belgium

Outline

A few facts...

The 'catalogue' of particle-accelerating colliding-wind binaries

The parameter space covered by these objects

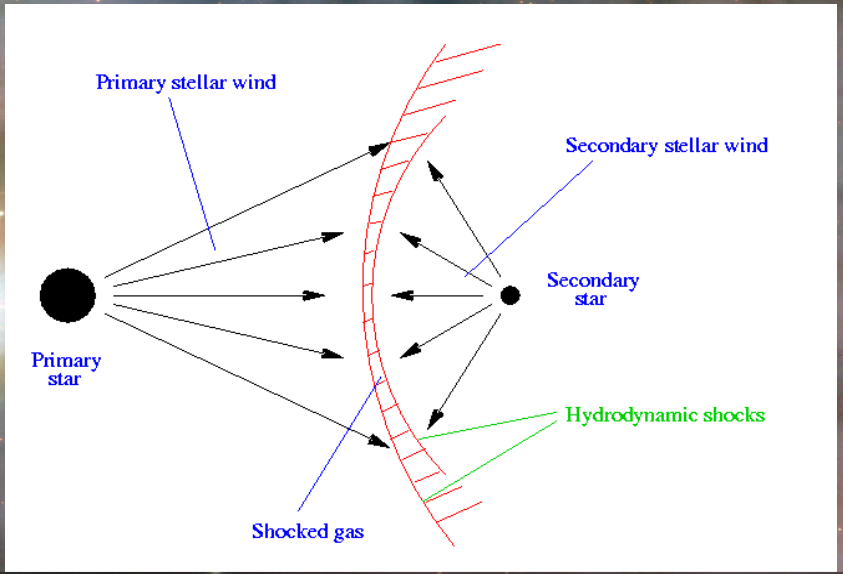
Concluding remarks

A few facts...

Connection with the VGGRS2010 talk...

- At least a few tens of colliding-wind binaries are able to accelerate particles up to relativistic energies

- Most of them are identified through synchrotron radiation in the radio domain (one exception : Eta Car)



- As we are dealing with (eccentric) binary systems, a significant variability is expected (time-scale = orbital period)

- The presence of high energy particles calls upon dedicated studies in the high energy domain

The catalogue

So far, about 40 systems identified to be particle accelerators among CWBs
- O-type stars
- Wolf-Rayet stars
- a few 'transitional' objects

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Previous censuses used to separate systems of different evolution stages, e.g. Dougherty & Williams 2000, De Becker 2007, Benaglia 2010...

→ strong need to unify these objects into a unique class, occupying a rather wide parameter space.

The catalogue

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Now unified in only one list!

Among these ~40 systems,
- 75 % considered to be 'certain'
- 25 % considered to be 'likely'

In addition, ~10 systems considered to be 'putative'

The catalogue

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among CWB
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- Wolf-Rayet
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ors

Among these
- 75 % could
- 25 % could

In addition, ~

#	usual ID	Status	Sp. type(s)	P
			List A	
1	HD 15558	B (T?)	O5.5III(f) + O7V	442 d
2	δOri A	T	(O9.5II + B0.5III) + B?	5.733 d/> 100 yr
3	σOri AB	M	O9.5V + B0.5V (+ OBs?)	?
4	15 Mon	B	O7V(f) + O9.5Vn	25.3 yr
5	WR 8	B	WN7 + WC(?)	38 d/115 d
6	WR 11	B	WC8 + O7.5	78.53 d
7	WR 14	B?	WC7	?
8	WR 21a	B	O3f*/WN6ha + O4	32.673 d
9	HD 93129A	B	O2If* + O3.5V?	?
10	HD 93250	B	O4III + O4III	> 100 d
11	η Car	B	? + ?	2022.7 d
12	WR 39	B?	WC7	?
13	WR 48	T	(WC5 + O6-7V) + OI?	19.138 d/?
14	HD 124314	B?	O6V(n)((f))	?
15	HD 150136	T	(O3-3.5V((f+)) + O5.5-6V((f))) + O6.5-7V((f))	2.675 d/8–10 yr
16	WR 79a	B	WN9ha + ?	many years
17	HD 152623	T	(O7V((f)) + OB?) + OB?	3.9 d/?
18	WR 89	B	WN8h + OB	?
19	WR 98	B	WN7/WC + O8-9	48.7 d
20	WR 98a	B	WC9 + OB?	565 d
21	WR 104	B	WC9 + B0.5V	220 d
22	9 Sgr	B	O3.5V((f+)) + O5V	~ 8.6 yr
23	WR 112	B?	WC9 + ?	?
24	HD 167971	T	(O6-7V + O6-7V) + O8I	3.321 d/~ 20 yr
25	HD 168112	B?	O5.5III(f+) (+ OB?)	> 1 yr
26	CEN 1a	B	O4 + ?	?
27	CEN 1b	B	O4 + ?	?
28	WR 125	B	WC7 + O9III	> 15 yr,~ 20-22 yr
29	WR 133	B	WN5 + O9I	112.4 d
30	WR 137	B	WC7 + OB	13.05 yr
31	WR 140	B	WC7 + O5	7.9 yr
32	Cyg OB2 #5	Q	(Ofpe/WN9 + O6–7Ia) + OB? + B0V	6.598 d/6.7 yr/> 9000 yr
33	Cyg OB2 #9	B	O5I + O6-7I	2.4 yr
34	Cyg OB2 #8A	B	O6If + O5.5III(f)	21.908 d
35	Cyg OB2-335	B	O7V + O9V	a few days(?)
36	WR 146	B (T?)	WC6 + O8?	many years ?
37	WR 147	B	WN8 + B0.5V	many years ?

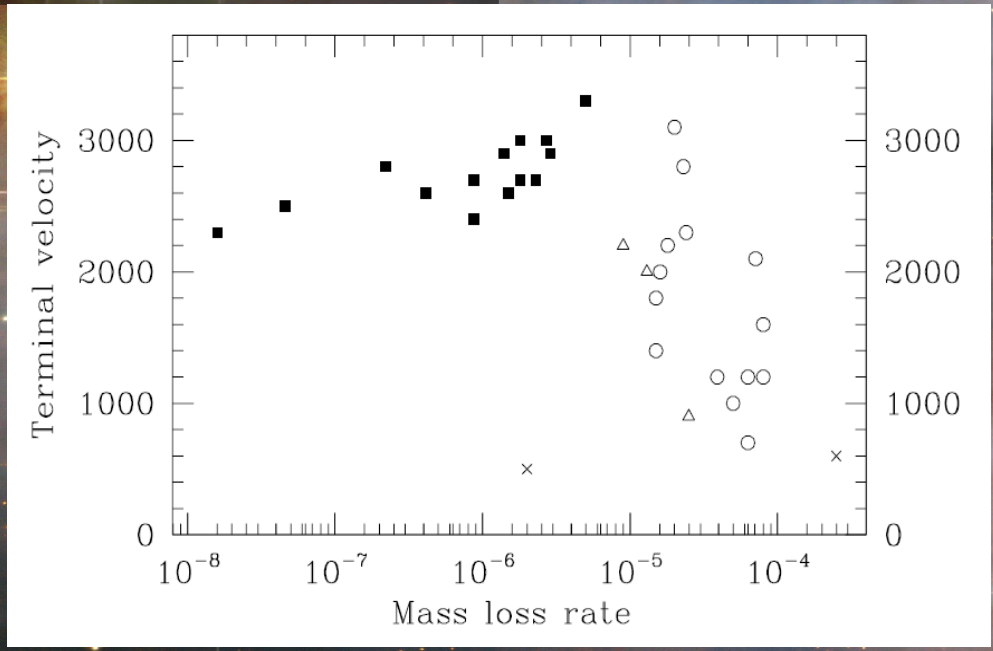
The parameter space

What do they have in common ?
Strong stellar winds & High wind velocities

Positions of the dominating star of each system, in the wind parameter space (mass loss rate in solar mass per year, and terminal velocity in km/s)

Accurate determination of the stellar parameters of the companions is still lacking in several systems

The distribution in the plot could be interpreted in terms of kinetic power!



(De Becker 201?, in preparation)

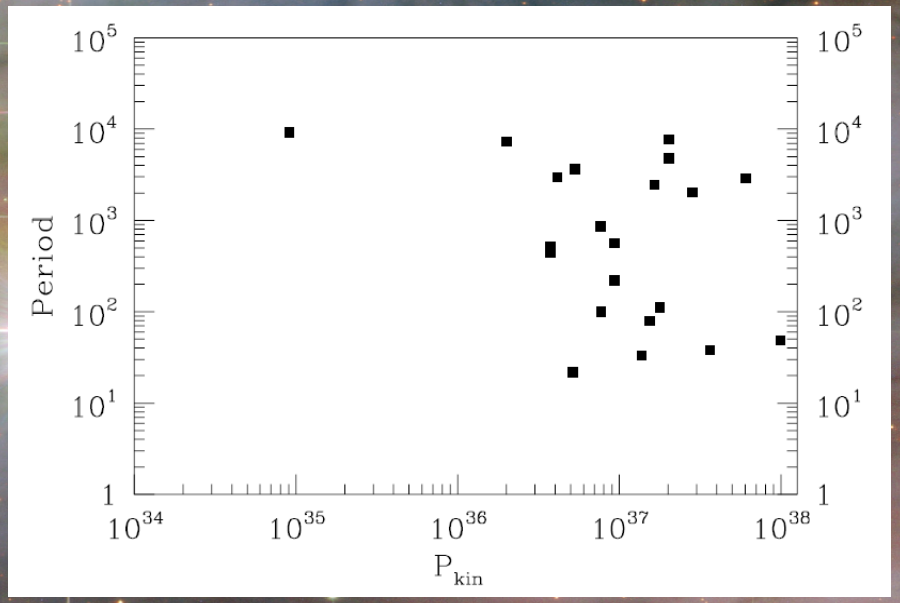
The parameter space

What about the orbital period ?

Plot of the period of the system expressed in days (when available!) as a function of the kinetic power in erg/s.

The lower limit on the period seems to be located at 'a few weeks'

The distribution in the plot could be interpreted in terms of kinetic power, and of the stellar separation !



(De Becker 201?, in preparation)

The multiplicity of these objects really deserves to be studied in detail in order to characterize properly the parameter space relevant to PACWBs

The parameter space

Question : are there systems occupying the 'adequate' volume of the parameter space and not yet identified as particle accelerators?

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→ Yes !

What is the reason for this lack of evidence for non-thermal processes ?
- an intrinsic lack of efficient particle acceleration process ?
- an observational bias?

Non-thermal radio emission (the main indicator of PA)! from colliding-wind massive binaries is like a thief ! You catch it when you see it!

Concluding remarks

The most important idea :

The study of PACWBs is now switching to a new regime. From a few individual studies of massive binaries, one can now consider the study of a real class of objects.

Significant advances in the characterization of the relevant parameter space have been made, but the investigation is still in progres :

- determination of the orbital parameters

- determination of the nature of the companion(s)

→ many observations using various techniques are needed

Concluding remarks

The census of information that has been synthesized so far should be viewed as a starting point for defining future observation strategies to
(i) improve our knowledge of identified PACWBs
(ii) to upgrade the catalogue

The global effort devoted to this class of object constitutes an important step to investigate their production of high energy photons, and their capability to accelerate particles (not only electrons, but also protons...)


Thank you !