An Update on Massive Binaries in Cygnus OB2

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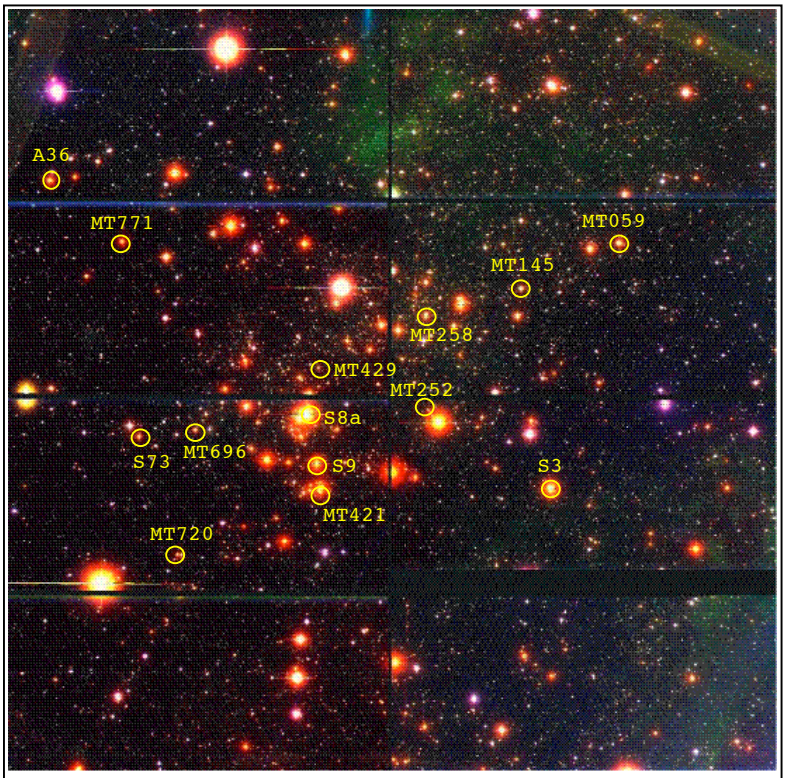

Fig. 1- Cygnus OB2 seen in B-band (blue), R-band (green), and I-band (red). Known OB binaries are labeled, and their parameters are listed in Table 1.

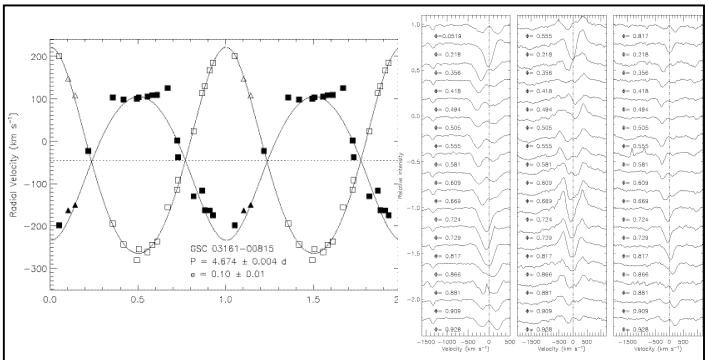

Fig. 2- A velocity curve (left) and time sequence (right) of He I 5876, Ha, and He I 6678 in the q=0.70 binary GSC03161-00813, a.k.a. A36 (Comeron et al. 2002). This system, curiously, has a V_{Hel}= -46 km/s, compared to $<V_{Hel}>$=-10 km/s for Cyg OB2 stars. [Kiminki et al. in prep]

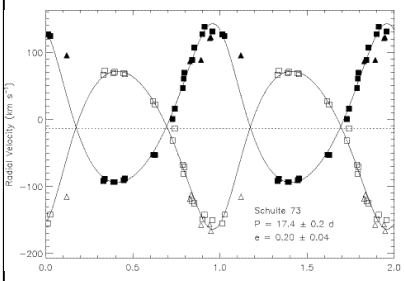

Fig.3 – Velocity curve for the "twin" system Schulte 73 consisting two O8 members. [Kiminki et al in prep]

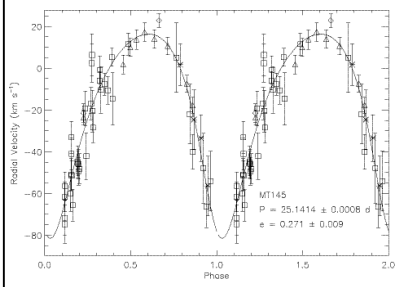

Fig.4 – Velocity curve for the 25 day O8V SB1 system MT145 (Massey & Thompson 1991). [Kiminki et al. in prep]

The Cygnus OB2 Association contains one of the largest collections of massive stars in the Galaxy. Since 1999 we have been conducting a radial velocity monitoring program on >140 Cyg OB2 stars in order to determine:

- The binary frequency among massive stars
- The distribution of mass ratios, $q=m_1/m_2$, where $p(q) \propto q^{\alpha}$
- The distribution of semi-major axes, $p(\log a) \propto (\log a)^{\beta}$
- The incidence of "runaway" stars

Or goal is to provide basic data to inform theories of the formation of massive stars and the formation of energetic events such as some classes of supernova and gamma ray bursts that arise from massive binary progenitors.

Figure 1 shows the Cyg OB2 association and the locations of presently known massive binaries. Preliminary results of the survey were presented in Kiminki, Kobulnicky, et al. (2007), Kobulnicky & Fryer (2007) and Kiminki, McSwain, & Kobulnicky (2008). These works suggested that

1) The binary frequency is high, in the range 70-100%.
2) The index, α, describing the distribution of mass ratios is near zero, i.e., a flat distribution of mass ratios.
3) The index, b, describing the distribution of separations is approximately flat in log space, i.e., the "Opik's Law" distribution
4) Among 17 massive binaries, we found only one "twin" system with q~1
5) We have found no "runaways"

Figures 2-5 illustrate some of our most recent discoveries. Table 1 summarizes the 17 massive binaries now known in Cygnus OB2—the most known in any cluster or association. The majority are short-period systems, and this is certainly a selection bias as they are the easiest to identify and measure. We are continuing to monitor ~60 systems that show evidence for radial velocity variability using the 2.3 m telescope and optical spectrograph at the Wyoming Infrared Observatory. We expect to identify many additional single-and some double-lined binaries over the next several years. These forthcoming data will allow us to constrain more tightly the initial binary parameters of young massive star systems.

Star	Type	S.C.	P (days)	q	Ref.
MT059	SB 1	O8V & B	4.8527 (0.0002)	0.24 (0.02)–0.64 (0.03)	1
MT145	SB 1	O9II & mid B	25.1399 (0.0008)	0.27 (0.01)–??	1
MT252	SB 2	B 2II & B 1V	18–19	0.8 (0.02)	1
MT258	SB 1	O8V & B	14.660 (0.002)	0.19 (0.01)–0.84 (0.05)	1
MT421	EA	O9.5V & B9V–A0 V	4.161	···	2
MT429	EA	B0 V & ??	2.9788	···	2
MT696	EW/K E	O 9.5V & early B	1.46	···	3
MT720	SB 2	early B & early B	< 5	···	1
MT771	SB 2	O7V & O 9V	1.5:	0.8 (0.1)	1
Schulte 3	SB2/EA:	O6V : & O9III	4.7464 (0.0002)	0.44 (0.06)	1,4
Schulte 5	EB	O7.5anf p & Ofpe/WN9 (& B0V?)	6.6	0.28 (0.02)	5,6,7,8,9,10
Schulte 8a	SB2	O5.5 I & O6?	21.908	0.86 (0.04)	11,12
Schulte 9	SB 2	O5? & O 6–7?	2.355 yr	···	12
Schulte 73	SB2	OBII & O 8?	17.4 (0.2)	1.00 (0.05)	1
A36	SB2/E A	B 0I? & early B	4.6742 (0.0004)	0.70 (0.06)	1
A45	SB2	B? & B ?	2–3	···	1
B17	SB2	OFI & OFI	···	···	14

Note. — Photometric types EW/KE, EA, and EB stand for Contact system of the W U Ma type (ellipsoidal ; P < 1 day), A lgol type (near spherical) , and β Ly r type (ellipsoidal ; P > 1 day) r espectively.

References . — (1) T his study ; (2) Pigulski & K olaczkowski (1998) ; (3) Rios & D eGi oia-East wood (2004) ; (4) Kine muchi et al. (2008, in prep); (5) W ilson (1948) ; (6) Wilson & A bt (1951) ; (7) Ma czaika (1953); (8) Wa lborn (1973); (9) Contreras et al. (1997) ; (10) Fa uw et al. (1999); (11) Romano (1969) ; (12) De Becker et al. (2004) ; (13) Naze et al. (2008) ; (14) Stroud et al. (2008)

Table 1 – A summary of massive binaries in Cyg OB2 with orbital solutions. The 17 systems represent the most of any single cluster or association. Ten of the systems are from our work, and we anticipate many more SB1 and perhaps more SB2 systems over the next few years.

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