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Spectrophotometric study of southern symbiotic stars

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Abstract. We have analyzed the optical spectra of 67 symbiotic stars and objects suspected of being symbiotic, and found 18 new symbiotic systems. This is the largest homogeneous set of optical spectrophotometric data for symbiotic binaries ever studied. We have derived the reddenings and distances for all systems, estimated the IR classes (S and D) for the new systems, and determined the location of the hot components in the Hertzsprung-Russell diagram.

Key words: Binaries: symbiotic – stars: fundamental parameters – Hertzsprung-Russell diagram – circumstellar matter

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Table 1. Emission line fluxes in units of 10^{-13}ergcm^{-2}s-1

Star	JD	H I				[O III]			He I			He II		O VI	[Fe VII]	
	244...	6563	4860	4340	4100	4363	4960	5007	5876	6678	7065	4686	5412	6825	5721	6086
He2–38	5821	518.8	17.3	5.00	2.43	9.36	12.8	44.9	7.54	3.55	8.93	5.71	1.04	13.8	1.31	2.67
He2-87	5817	3.56	0.05						0.09	0.05	0.14			0.06		
St2–22	8067	11.6	0.63	0.15			0.08	0.20	0.35	0.38	0.50	0.31				
V704 Cen	5818	7.20	0.58			0.25	0.29	0.88	0.31	0.16	0.43					
V852 Cen	5457	173.4	10.3				11.2	36.7	4.77	1.20		1.54	0.31			
	6263	330.2	33.5	12.0	6.72	12.3	32.3	97.3	9.57	2.83	10.3	5.95	1.52			
	6280	142.7	13.3	5.08	2.83	5.57	13.6	38.7	4.33	1.37	4.53	2.34	0.45			
V835 Cen	5817	411.4	13.5	3.81	1.52	6.20	20.0	66.3	4.47	2.88	7.41	3.98	1.06	26.6	1.30	2.72
He2–127	5817	88.8	4.70	1.34		0.60	1.24	4.72	1.07	0.70	1.46	2.41	0.29	5.46	0.46	0.86
Hen 1092	5817	31.1	4.00	1.63	0.67	0.45			0.95	0.50	1.13	3.70	0.35	2.53	0.43	0.78
HD 330036	5818	110.7	18.2	7.90		26.2	73.8	216.0	9.16	1.82	7.64	2.25				
He2–147	5458	2.48	0.34	0.14:		0.25	1.32	4.25	0.11	0.05:	0.08	0.03:				
	8066	3.39	0.43			0.23	1.77	5.62	0.14	0.06:	0.10	0.03:				
He2–156	5817	60.4	4.95	1.50					1.09	0.59	0.66					
He2–171	5819	47.6	3.59	0.94	0.37	1.12	3.52	12.6	0.69	0.36	0.85	2.14	0.31	0.95	1.22	2.49
He2–173	5817	65.2	3.14	0.82		0.77	0.80	3.13	2.29	2.36	2.86	0.96	0.12			
He2–176	5457	42.8	0.38				0.07	0.18	0.57	0.93	2.20	0.19	0.06	1.02		
KX TrA	5819	454.1	37.9	11.1	6.01	4.27	4.96	15.0	6.66	7.61	8.46	29.3	3.18	21.0	4.95	9.03
MaC 1–3	7675	8.05	0.28						0.12	0.08	0.16	0.09		0.28	0.05	0.12
V455 Sco	5820	172.9	7.17	1.66	0.99	0.57	0.84	2.63	3.25	1.57	4.21	6.99	1.04	6.69	2.26	4.13
AS 221	5817	18.2	0.74	0.22		0.16	0.07	0.37	0.51	0.49	0.97	0.67	0.10	0.21	0.24	0.49
H2–5	5820	6.80	0.38						0.17	0.07	0.16	0.23	0.03	0.66		0.08
Th3–7	6622	8.52	0.59						0.25	0.33				0.31	0.31	0.36
Th3–17	6265	4.96	0.16					0.08	0.12	0.24	0.20					
Th3–18	5820	20.3	0.67	0.13					0.22	0.36	0.37	0.29	0.04	1.42		
Th3–20	5821	7.43	0.28	0.05		0.06	0.22	0.19	0.15	0.37	0.20	0.09	0.26	0.10	0.15	
Th3–29	6262	8.34	0.18					0.08	0.18	0.24	0.24			0.06		
Th3–30	6262	8.62	0.21						0.14	0.25	0.22	0.09	0.01	0.37		
Th3–31	5821	4.17	0.14					0.09	0.13	0.25	0.28					
M1–21	5818	153.0	16.4	4.86	2.53			1.26	4.02	2.68	4.14	7.53	0.75	5.63	0.60	0.87
He2–251	5821	10.9	0.19					0.12	0.10	0.05	0.18			0.42		
W16–296	8066	14.4	0.46					0.09	0.50	0.55	0.81					
WR 99	8066	49.3	0.97	0.14			0.18	0.63	1.13	1.34	2.87	0.18	0.06	0.64	0.06	0.15
AE Ara	5821	182.1	27.4	10.0	7.14	3.02	6.43	19.1	4.99	3.43	5.50	2.49				
UU Ser	5819	43.7	4.48	1.21	0.54	0.09		0.43	1.06	1.27	1.35	4.26	0.40	3.26	0.19	0.30
AS 241	6266	3.63	0.30						0.05	0.08	0.09					
He2–275	6281	7.85	0.71	0.27:					0.24	0.32	0.33	0.24		0.71		
HD 316285	6281	1462	146.2	31.4	10.6	10.7			77.3	70.6	158.2					
V4141 Sqr	5821	12.1	0.93	0.29			0.15	0.55	0.38	0.16	0.54					
ALS 2	5817	19.6	1.95	0.77	0.25				0.76	0.78	1.10	1.05	0.14	1.38:		
AS 245	5818	10.5	0.26				0.11	0.42	0.20	0.20	0.54	0.18	0.04	0.78	0.16	0.32
He2–294	5821	11.5	0.39						0.27	0.20	0.33	0.23		1.13		
Bl3–6	6266	2.82	0.11						0.05	0.09	0.10	0.08		0.35		
MaC 1–9	7676	10.6	0.82	0.27		0.07		0.18	0.44	0.77	0.70	0.05				
V2416 Sgr	5821	93.9	2.12	0.32					1.11	1.04	1.94	1.13	0.20	2.54	0.48	0.93
AS 269	6278	107.6	3.23						0.56	0.45:	0.49					
Ap1–8	5458	20.2	1.27	0.54		0.09		0.46	0.72	0.53	0.86	1.02		0.51:	0.18	0.34
SS 122	7676	126.1	11.0	2.77	1.38	0.94	1.91	8.04	5.24	3.00	7.13	3.14	0.63	1.12	2.50	4.70
H2–38	5458	179.7	9.20	2.50	0.94	5.18	10.4	33.7	2.37	0.94	3.14	4.78	0.65	14.2	1.03	2.17
SS 129	8067	6.11	0.39						0.86	0.33	0.82	0.61		0.90		
V615 Sgr	6278	140.1	25.7	9.63	5.30	1.58		2.66	4.93	6.86	5.22	0.44				
AS 280	6278	33.5	10.0	5.55	2.64			0.65	3.03	1.80	1.52	6.89				
Ap1–9	6278	58.7	5.24	1.33				0.67	2.20	2.12	2.27	0.17				
AS 281	6278	134.0	11.0	4.00	1.77				1.94	1.43	2.33	7.00	0.85	5.76	0.60	0.89
V2506 Sgr	5816	55.9	5.86	1.94					0.92	0.85	1.03	2.83	0.30	2.87	0.14	0.45
V2756 Sgr	6280	37.3	5.30	2.14		0.76	1.48	4.45	2.17	1.32	1.75	4.00	0.25:			
HD 319167	6280	115.9	13.8	4.17		3.01	1.42	5.30	5.60	3.71	6.29	1.36				
He2–374	6280	48.6	2.28	0.53		0.44	0.33	1.22	1.82	1.56	3.29	0.57				
He2–376	6267	18.7	1.91					0.84	1.00	0.72	0.91					
AS 299	8067	107.6	15.1	4.15	1.89			1.49	5.48	4.83	5.91	0.74				
V2601 Sgr	5816	3.66	0.35	0.15:		0.15:		0.10:	0.03:	0.09:	0.09:	0.03:				
K 3–9	6265	12.3	0.24				0.12	0.59	0.21	0.11	0.34	0.13		0.24	0.25	0.60
AS 316	6274	105.0	7.18	1.75	0.57				0.78	0.90	1.03	4.73	0.56	8.68		
AS 323	6280	19.8	1.49	0.65					0.41	0.53	0.56	1.51	0.19	0.90	0.12	0.20
AS 327	8067	96.6	9.90	2.91	1.27				2.99	3.18	3.87	4.65	0.74	6.53		
Pe2–16	5819	15.1	0.54				0.06	0.14	0.53	0.50	1.08	0.30		0.06	0.06	0.13
V1413 Aql	7677	58.3	7.78	2.55	1.20	0.26	0.53	1.89	3.90	1.92	2.27					
MaC 1–17	8067	8.00	0.78	0.21		0.09			0.34	0.73	0.42	0.17	0.02			
V352 Aql	7679	5.53	0.41	0.12					0.08	0.10	0.11	0.29	0.04	0.56	0.02:	0.08
ALS 1	5819	14.3	1.93	0.66					0.64	0.77	0.78	0.21	0.02:	0.15:		

Table 3. Reddening estimates

Star	Type	E(B–V)						
		H I (case B)	H I ($\tau_{\mathrm{H}\alpha}$)	He I	He II	[Fe VII]	IR	Adopted
He2–38	D		1.6 (∼ 10)	1.6	1.5	1.5	2.5:	1.5
He2–87	S	3.0	1.8 ÷ 2.5	1.0:			2.0	2.0
St2–22	S		1.4 (∼ 10)	1.0				1.0
V704 Cen	D	1.3		1.8				1.5
V852 Cen	D		0.8 (∼ 10)	0.5	1.7		5.0	1.0
V835 Cen	D		1.6 (∼ 10)	2.4	2.1	1.7	3.3	2.0
He2–127	S		1.4 (∼ 10)	0.9	0.8	1.1		0.9
Hen 1092	S		0.6 (∼ 10)	0.6	0.4	0.9		0.6
HD 330036	D'		0.4 (∼ 10)	0.0				0.4
He2–147	D	1.0		1.4:			2.0	1.0
He2–156	S		1.1 (∼ 5)					1.1
He2–171	D	1.4		1.8	1.1	1.5	3.3	1.4
He2–173	S		0.9 (∼ 10)	0.7	0.8			0.8
He2–176	S	3.6	2.3 ÷ 3.0	2.8	2.4			2.8
KX TrA	S		1.0 (∼ 10)	0.8	0.6	0.9		0.8
MaC 1–3	D	2.2		2.5		2.4		2.3
V455 Sco	S		1.0 (∼ 50)	0.8	1.1	0.7	0.9	0.9
AS 221	S		1.3 (∼ 5)	1.5	1.1	1.5		1.3
H2–5	D	1.8		1.1	0.9			1.0
Th3–7	S	1.6	1.0 (∼ 10)					1.0
Th3–17	S	2.3	1.1 ÷ 1.7	1.2				1.2
Th3–18	S	2.1	1.3 (∼ 100)	1.2	1.0			1.2
Th3–20	S	2.2	0.9 ÷ 1.6	1.6	2.9:	0.1:		1.6
Th3–29	S	2.7	1.4 (∼ 10)	0.8				1.4
Th3–30	S	2.6	1.4 ÷ 2.0	1.1	0.8			1.1
Th3–31	S	2.3		1.7				1.7
M1–21	S	1.0		0.4	0.5	0.0	1.2	0.5
He2–251	D	2.9		1.7				1.7
W16–296	S	2.3	1.1 ÷ 1.8	1.2				1.2
WR 99	S	2.7	2.4 (∼ 10)	2.0	2.6	2.8		2.4
AE Ara	S		0.5 (∼ 10)	0.5			0.6	0.5
UU Ser	S	1.2	0 ÷ 0.6	0.7	0.4	0.2		0.5
AS 241	S	1.4		1.3				1.3
He2–275	S		0.8 (∼ 10)	0.9				0.9
HD 316285	S	1.5		1.6				1.5
V4141 Sgr	D	1.2		1.3			1.1	1.2
ALS 2	S		0.9 (∼ 10)	1.0	0.9			0.9
AS 245	S	2.6		2.1	1.8	1.4		1.8
He2–294	S	2.3	1.1 ÷ 1.7	0.7				1.0
Bl3–6	S	2.1		1.6				1.6
MaC 1–9	S		1.1 (∼ 5)	1.2				1.2
V2416 Sgr	S	2.5	1.4 ÷ 2.0	1.2	1.4	1.2	1.7	1.4
AS 269	?	2.4		3.0:				2.4
Ap1–8	S		0.8 (∼ 10)	0.6		1.0		0.7
SS 122	S	1.3		0.9	1.6	1.1		1.3
H2–38	D		1.4 (∼ 10)	1.1	1.2	1.7:	1.1	1.1
SS 129	S	1.6	0.4 ÷ 1.1	0.3				1.0
V615 Sgr	S	0.5		0.4				0.4
AS 280	S	0.0						0.0
Ap1–9	S	1.3		0.4				0.4
AS 281	S		0.9 (∼ 10)	0.7	0.8	0.0	0.5	0.7
V2506 Sgr	S		0.7 (∼ 10)	0.5	0.5			0.5
V2756 Sgr	S		0.5 (∼ 10	0.0				0.5
HD 319167	S	1.0	0.6 (∼ 10)	0.5				0.5
He2–374	S		1.5 (∼ 5)	1.4				1.4
He2-376	S	1.2	0 ÷ 0.6	0.2				0.6
AS 299	S	1.0	0 ÷ 0.3	0.4				0.4
V2601 Sgr	S		0.7 (∼ 10)					0.7
K 3–9	D	2.8		2.0		2.4	2.9	2.4
AS 316	S	1.5	0.4 ÷ 1.0	0.8	0.7			0.7
AS 323	S		0.7 (5 ÷ 10)	0.9	0.8	0.4		0.9
AS 327	S	1.1		0.8	1.2		1.0	1.0
Pe2–16	S	2.2		1.6		1.9		1.7
V1413 Aql	S	0.9	0.6 (5 ÷ 10)	0.0			0.5	0.4
MaC 1–17	S	1.2		0.7	0.7			0.7
V352 Aql	S		1.0 (∼ 10)	0.9	1.0			1.0
ALS 1	S		0.6 (5 ÷ 10)	0.6	0.4			0.6

Table 4. Physical parameters

Star	Type	Sp This study	Sp Other	d[kpc]	Ion	$T_h[10^3$ K]	$L_h[L_\odot]$
He2–38	D	M0	≥M5	2.2	O^{+5}	114	13000
He2–87	S		M7	3.5	O^{+5}	114	700
St2–22	S	M2	M	5	He^{+2}	54 ÷ 100	600
V704 Cen	D			16	O^{+2}	35 ÷ 55	6000
V852 Cen	D		M	4.3	He^{+2}	54 ÷ 90	10000
V835 Cen	D		M5	1.9	O^{+5}	114	28000
He2–127	S		M7+D	10	O^{+5}	114	11000
Hen 1092	S	M5	K5	5.7	O^{+5}	114	1700
HD 330036	D'		G+D	4	He^{+2}	54 ÷ 80	1600
He2–147	D	M7	M8.5+D	3	He^{+2}	54 ÷ 80	100
He2–156	S	K5	M1	3.4	O^{+2}	35	3900
He2–171	D		M+D	5	O^{+5}	114	12000
He2–173	S	M3	M	2.8	He^{+2}	54 ÷ 100	700
He2–176	S		M7	2.6	O^{+5}	114	4300
KX TrA	S	M3	M6	3	O^{+5}	114	7500
MaC 1–3	D	M2		(3)	O^{+5}	114	≥ 3000
V455 Sco	S	M1	M6	2.8	O^{+5}	114	2000
AS 221	S	M1	M4	4	O^{+5}	114	1800
H2–5	D	M6	M	4.8	O^{+5}	114	300
Th3–7	S	M3	M5	6	O^{+5}	114	820
Th3–17	S	M3	M3:	5	O^{+2}	35 ÷ 55	100
Th3–18	S	M2	M2:	4.2	O^{+5}	114	750
Th3–20	S	M3	M	5.2	O^{+5}	114	2600
Th3–29	S	M3		3	O^{+5}	114	240
Th3–30	S	M1	K5	3.8	O^{+5}	114	100
Th3–31	S		M5	4.3	O^{+2}	35 ÷ 55	290
M1–21	S	M1	M2	3	O^{+5}	114	700
He2–251	D			8.5	O^{+5}	114	5700
W16–296	S	K5		(2)	He^{+}	24 ÷ 54	≥ 100
WR 99	S			(1)	O^{+5}	114	≥ 3000
AE Ara	S	M3	M2	2.3	He^{+2}	54 ÷ 80	1000
UU Ser	S	M4	M	6	O^{+5}	114	1500
AS 241	S	M1	M6	6.3	He^{+}	24 ÷ 35	940
He2–275	S	M3		≥8.5	O^{+5}	114	≥ 960
HD 316285	S				O^{+2}	35 ÷ 55	
V4141 Sgr	D			7	O^{+2}	35 ÷ 55	1400
ALS 2	S	M2		(3)	O^{+5}	114	500
AS 245	S	M2	M6	4.5	O^{+5}	114	3500
He2–294	S	M3	M3	5.5	O^{+5}	114	430
Bl3–6	S	M3		(4)	O^{+5}	114	≥ 600
MaC 1–9	S	M2		(3)	He^{+2}	54 ÷ 75	≥ 500
V2416 Sgr	S	M2	M5.5	1.3	O^{+5}	114	460
AS 269	?			0.6	He^{+}	24	
Ap1–8	S	M4	M0	5.3	O^{+5}	114	570
SS 122	S		M7.5	4.8	O^{+5}	114	12000
H2–38	D		M8.5	7.2	O^{+5}	114	20000
SS 129	S	K5	K	1.7	O^{+5}	115 ÷ 130	100
V615 Sgr	S	M2	M	3.6	He^{+2}	54 ÷ 65	800
AS 280	S				He^{+2}	54 ÷ 110	
Ap1–9	S	K5	K4	2.5	He^{+2}	54 ÷ 70	200
AS 281	S	M3	M5.5	4.5	O^{+5}	114	2800
V2506 Sgr	S	M2	M	5	O^{+5}	114	700
V2756 Sgr	S	K5	M2:	4	Ca^{+4}	67 ÷ 110	900
HD 319167	S	M3	M3	4	He^{+2}	54 ÷ 80	1000
He2–374	S	M4	M	2.5	Fe^{+5}	75 ÷ 100	1300
He2-376	S	M2		(4)	O^{+2}	35 ÷ 55	≥ 200
AS 299	S	M0		2.4	He^{+2}	54 ÷ 70	430
V2601 Sgr	S	M5	M	6.1	He^{+2}	54 ÷ 80	90
K 3–9	D	M3		3.6	O^{+5}	114	14000
AS 316	S	M3	M4	4.5	O^{+5}	114	2000
AS 323	S	M3		4.5	O^{+5}	114	1200
AS 327	S	M0	M2	3	O^{+5}	114	2700
Pe2–16	S	K5	M5	5.5	O^{+5}	114	6200
V1413 Aql	S	M0	M5	5	O^{+2}	35 ÷ 55	400
MaC 1–17	S	M1		(7)	He^{+2}	54 ÷ 90	≥ 740
V352 Aql	S	M3		≥9.6	O^{+5}	114	≥ 1600
ALS 1	S	M3		(6)	He^{+2}	54 ÷ 80	≥ 500