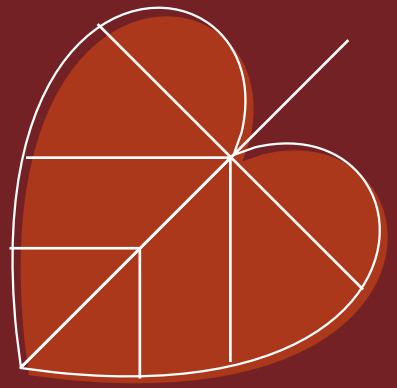
SYMBIOTIC BINARY STARS

Aki Ruokanen



BASICS

- Symbiotics are long-period interacting binary stars. In which an evolved giant(RG/Mira) transfers matter to a hot luminous companion(WD) that is surrounded by an ionized nebula
- Systems are divided into two types; S-type and D-type symbiots

S-type (Stellar, RG) : Which contains a normal red giant

D-type (Dusty, Mira) : Which contains a Mira variable that is surrounded by a dust shell

- A typical symbiotic binary is embedded in a circumstellar nebula which is mainly formed from material lost in the red giant, while the hot component is responsible for its ionization.

BASICS

- The nature of the giant determines the orbital separation at which the symbiotic interaction occurs
- -> The binary must have enough room for the red giant (and in the case of D-types also for its dust shell) and allow it to transfer sufficient mass to its companion
- -> Orbital periods for the S-types are of about 1–15 years, and more than 20 years for the D-types, which are the longest orbital periods among interacting binaries

WHY SYMBIOTIC?

- They show composite spectrum of nebular emission lines superimposed on molecular absorption bands.
- A typical spectrum contains TiO bands, neutral metals and associated red continuum for RGs
- Blue continuum with H balmer lines, highly ionized species of He1, He2 etc., usually found in planetary nebulae
- Simultaneous presence in a single object of low-temperature absorption features and emission lines that require high excitation conditions points to their binary nature

ACCRETION

- Systems may be detached or semi-detached
- Usually assumed that the symbiotic binary components do not fill their Roche lobes, and interact via stellar wind
- But it is possible that tidally distorted donors and Roche-lobe overflow are quite common in symbiotic binaries with P_orb below 1000 days
- Estimated wind accretion rates:

  S-types: 10^-8 – 10^-7 M_sun/year

  D-types: 10^-6 – 10^-5 M_sun/year

ORBITAL ELEMENTS OF SYMBIOTICS

- Orbital periods :

  100 -1400 days

  Separation :

  20 – 500 R_sun

  Mass ratio (q) :

  0.35 - 6.7

Table 1. Orbital elements for symbiotic binaries

Star	P [days]	K_g [km/s]	q M_g/M_h	γ_0 [km/s]	e	T_0 [JD[1]]	$a_g \sin i$ [$R_\odot$]	$f(M)$ [$M_\odot$]	
EG And	482.6	7.3		-95.0	0	50804[3]	70	0.020	[1]
AX Per	682.1	7.8	2.3	-117.4	0	50964	105	0.033	[2]
BD Cam	596.2	8.5		-22.3	0.09	42794[2]	99.7	0.037	[1]
V1261 Ori	642	7.5		79.7	0.07	46778[3]	95	0.028	[1]
BX Mon	1401	4.3	6.7	29.1	0.49	49530	104	0.0076	[1]
	1259	4.6		29.1	0.44	49680	103	0.0092	[1]
SY Mus	624.5	7.4		12.9	0	49082[3]	91	0.026	[1]
TX CVn	199	5.7		2.3	0.16	45195[2]	22	0.004	[1]
RW Hya	370.2	8.8		12.4	0	45072	65	0.026	[1]
	370.4	8.8		12.9	0	49512		0.026	[1]
BD-21 3873	281.6	10.6		203.9	0	49087[3]	59	0.035	[1]
T CrB	227.57	23.9	0.6	-27.8	0	47919[3]	107	0.322	[1]
AG Dra	549	5.9		-147.2	0	50775	64	0.0115	[2]
KX TrA	1350	6.8	2.3	-123.7	0.29	51703	175	0.039	[4]
AE Ara	812	5.4	4	-15.7	0	50217	87	0.0133	[5]
RS Oph	455.7	16.7	0.35	-40.2	0	50154[3]	150	0.221	[1]
V343 Ser	451.3	2.6		-5.63	0	50398[3]	23	0.0008	[3]
	450.5	2.7		-5.65	0.14	50575[2]	23.5	0.0009	[3]
FG Ser	633.5	6.9		73.3	0	51031	87	0.022	[2]
AR Pav	604.5	10.9	2.5	-68.3	0	48139	130	0.079	[6]
V443 Her	594	2.5		-55.5	0	50197	30	0.0010	[2]
FN Sgr	568.3	10.5	2.1	-53.7	0	50269	118	0.0689	[7]
BF Cyg	757.2	6.7	3.6	-3.75	0	51395	100	0.0239	[3]
CH Cyg	5700	4.9		-57.7	0.47	45086	478	0.045	[1]
	756.0	2.6		-60.6	0	46644	39	0.0014	[1]
	5292	4.8			0.06	45592[2]	500	0.060	[1]
CI Cyg	855.3	6.7	3	18.4	0	45242	114	0.027	[1]
	853.8	6.7		15.0	0.11	50426	112	0.026	[1]
V1329 Cyg	956.5	7.9	2.9	-23.1	0	51565	149	0.0481	[3]
CD-43 14304	1448	4.4		27.6	0	45929[3]	126	0.013	[1]
	1442	4.6		27.5	0.22	45560[2]	128	0.014	[1]
AG Peg	816.5	5.3	4	-15.9	0	31668	84	0.012	[1]
	818.2	5.4		-15.9	0.11	46812	87	0.0135	[1]
Z And	758.8	6.7		-1.8	0	50260	102	0.024	[2]
CD-27 8661	763.3	10.5		-5.5	0	49280[3]	158	0.092	[1]

MASS ESTIMATES OF SYMBIOTICS

Hot component (WD)

M ~ 0.5 M_sun (M_h)

Teff ~ 10^5 K

L ~ 100 –10000 L_sun

Evolving giant

M ~ 1.7 M_sun (M_g)

Table 2. Mass estimates for symbiotic binaries

Star	P [days]	Ecl.	i [deg]	M_g [$M_\odot$]	M_h [$M_\odot$]	Com.
EG And	481	Y	90	1.5 ± 0.6	0.4 ± 0.1	ET
AX Per	680.8	Y	90	0.9 ± 0.2	0.37 ± 0.06	BA
			$\gtrsim 70$	$\lesssim 1.1$	$\lesssim 0.44$	
BX Mon	1401	Y	90	3.0 ± 1.5	0.45 ± 0.21	BA
			$\gtrsim 62$	$\lesssim 3.7$	$\lesssim 0.6$	
SY Mus	625	Y	90	1.3 ± 0.25	0.43 ± 0.05	ET
RW Hya	370.2	Y	90	1.6 ± 0.3	0.48 ± 0.06	ET
T CrB	227.57	N	~ 60	0.7 ± 0.2	1.2 ± 0.2	BM
KX TrA	1350	?	90	1.0 ± 0.3	0.41 ± 0.04	He II W
			135	2.7	1.2	SP
AE Ara	812	N	60	2.0 ± 1.2	0.51 ± 0.2	He II W
RS Oph	455.7	N	≤ 45	≥ 0.40	≥ 1.1	BA.
FG Ser	650	Y	90	1.7 ± 0.7	0.60 ± 0.15	ET
AR Pav	604.5	Y	90	2.5 ± 0.6	1.0 ± 0.2	BA
			$\gtrsim 70$	$\lesssim 3$	$\lesssim 1.2$	
		Y	90	2.0 ± 0.5	0.87 ± 0.15	ET
FN Sgr	568.3	Y	90	1.4 ± 0.2	0.66 ± 0.08	BA.
			$\gtrsim 70$	$\lesssim 1.7$	$\lesssim 0.8$	
BF Cyg	757.2	Y	90	1.8 ± 0.6	0.51 ± 0.1	UVEL
			$\gtrsim 70$	$\lesssim 2.2$	$\lesssim 0.6$	
CI Cyg	855.3	Y	90	1.3 ± 0.3	0.43 ± 0.04	He II EL
			≥ 79	≤ 1.6	≤ 0.52	
V1329 Cyg	956.5	Y	86	2.1 ± 0.5	0.74 ± 0.08	H I W, SP
AG Peg	816.5	N	$\lesssim 60$	$\gtrsim 1.8$	$\gtrsim 0.46$	He II EL

ERUPTIONS

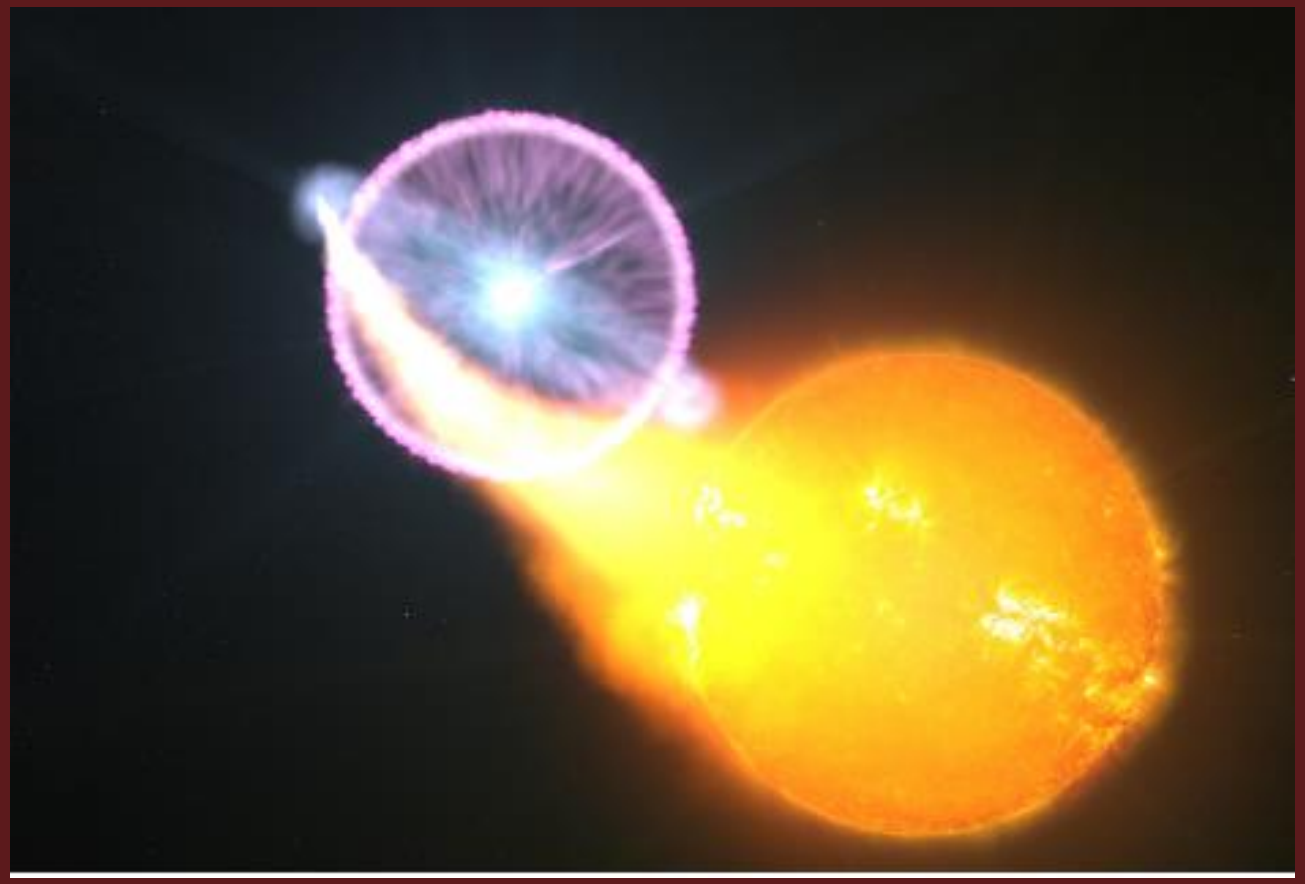
- Symbiotic Novae : Single outburst of several magnitudes lasting for dozen of years. -> Thermonuclear nova eruption. In some systems the outburst have developed very slowly: the rise to maximum takes months, and the decline to the pre-outburst stage lasts dozens of years. P_orb > 800 days

- Symbiotic Recurrent Novae: very fast recurrent novae with very short timescales of their outburst, lasting several days, and recurrence time of order of several years. P_orb ~ 600 days
- Difference in outburst behaviour seem to reflect in difference of WD masses

WHY TO STUDY THEM

- They are unique astrophysical labs for:
  - Nova-like thermonuclear outbursts
  - Colliding-wind processes
  - Progenitors of Supernovae Ia
  - Formation and collimation of jets

Etc.



SOURCES:

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- Etc...