Close Binary Stars in the Galactic Open Clusters

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The IMPACT of BINARIES on STELLAR EVOLUTION

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(Binary) stellar evolution

the equation of state

the nuclear reaction network

(from core to surface radiative/convective)

hydrostatic equilibrium

(pressure vs. gravity)

the radiative opacity

Convection with the mixing-length theory

semi-convective mixing

stellar wind mass-loss (dynamo action)

rotationally driven mixing and diffusive separation of abundances (Ap, Am and Fm stars)

convective core overshooting

tidal friction (circularize orbits)

Evolution Codes

Cambridge STARS Code

-Eggleton (1971-73)

-Pols, Tout, Eggleton, Zhanwen (1995)

-Hurley, Pols, Tout (2000)

-Eldridge+

EV Code

-Yakut & Eggleton (2005)

-Eggleton (2006)

-Eggleton & Yakut (2017)

Close binary stars (CBS)

“**close binary**”

- → **P** is short
- → tidal force & RLOF play important roles
- → AM, cMT,ncMT, ML, AML and NE
- → synchronously rotating
- → circular orbit

CBS types:

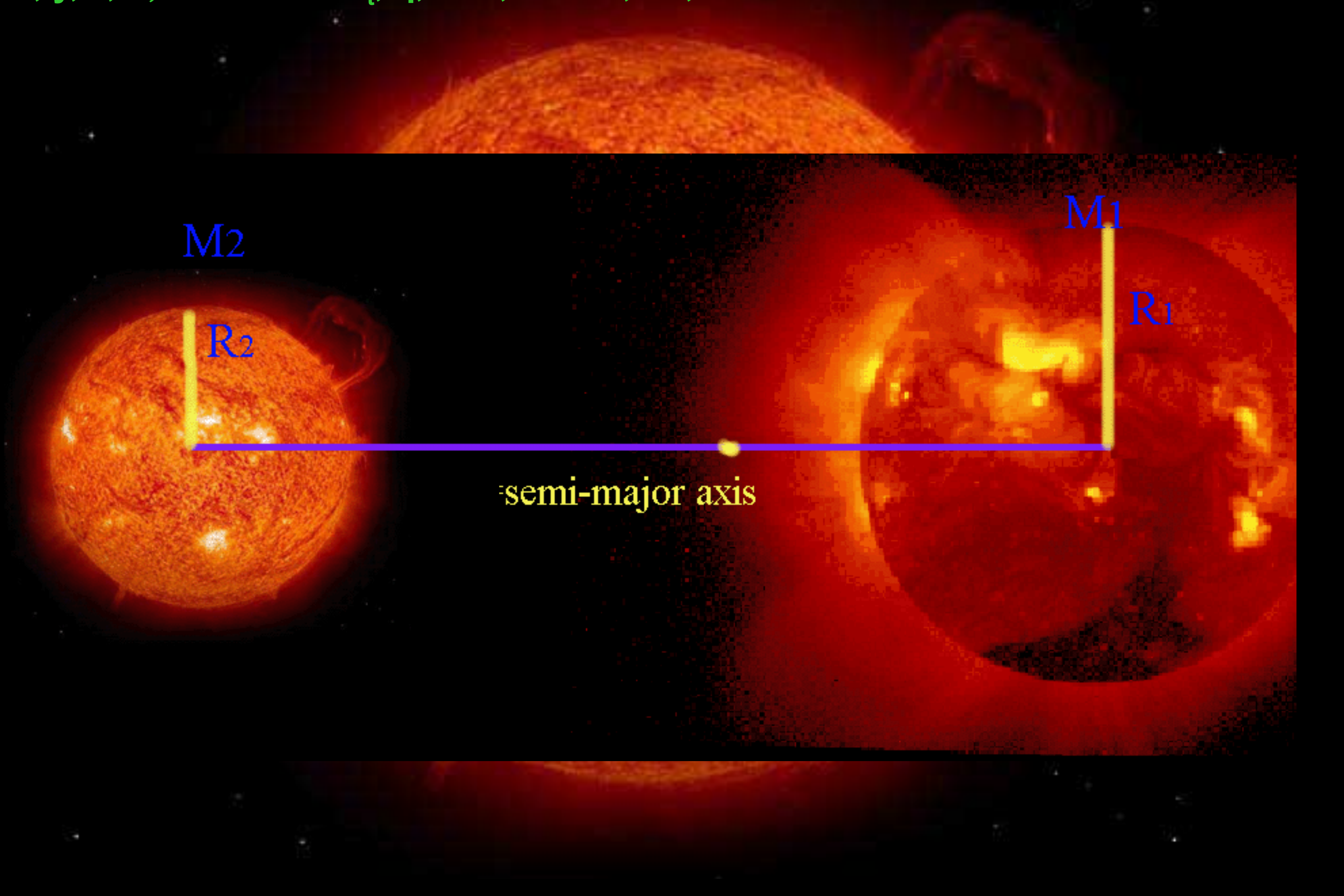
-Detached (D) [e.g, RS CVn, Giant+MS, Giant+Giant]

-Semi-detached (SD) [e.g. NCB, CV, X-ray binaries, AM CVn, ..]

-Contact (C) [e.g., LTCB=W UMa, ETCB]

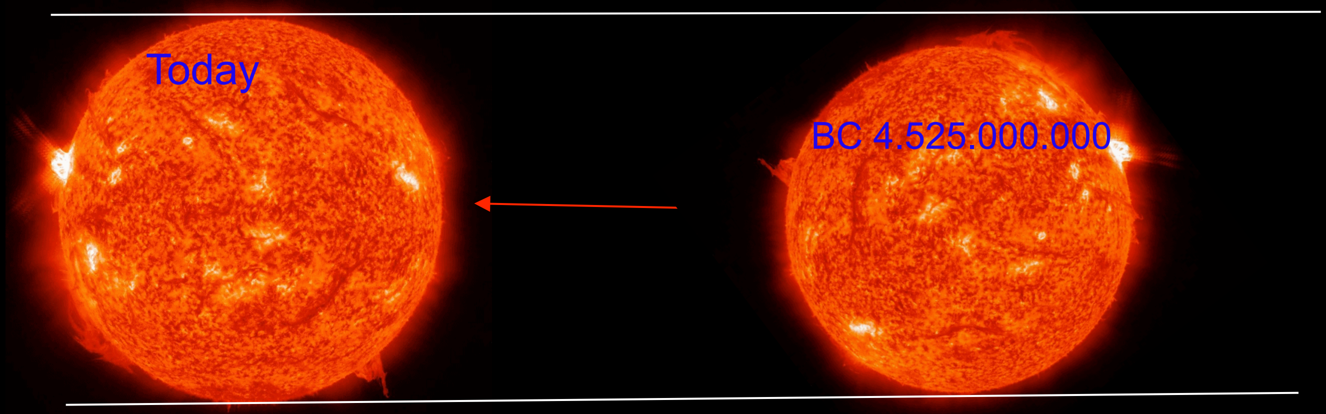
close binary stars (CBS)

M, y, z, α, dM/dt + M_t, q, P_{bin}, dMt/dt, P3, …



Single Star: Model of the Sun from its birth to its dead

Hypothetical mass-loss and dynamo activity during the Sun's evolution.

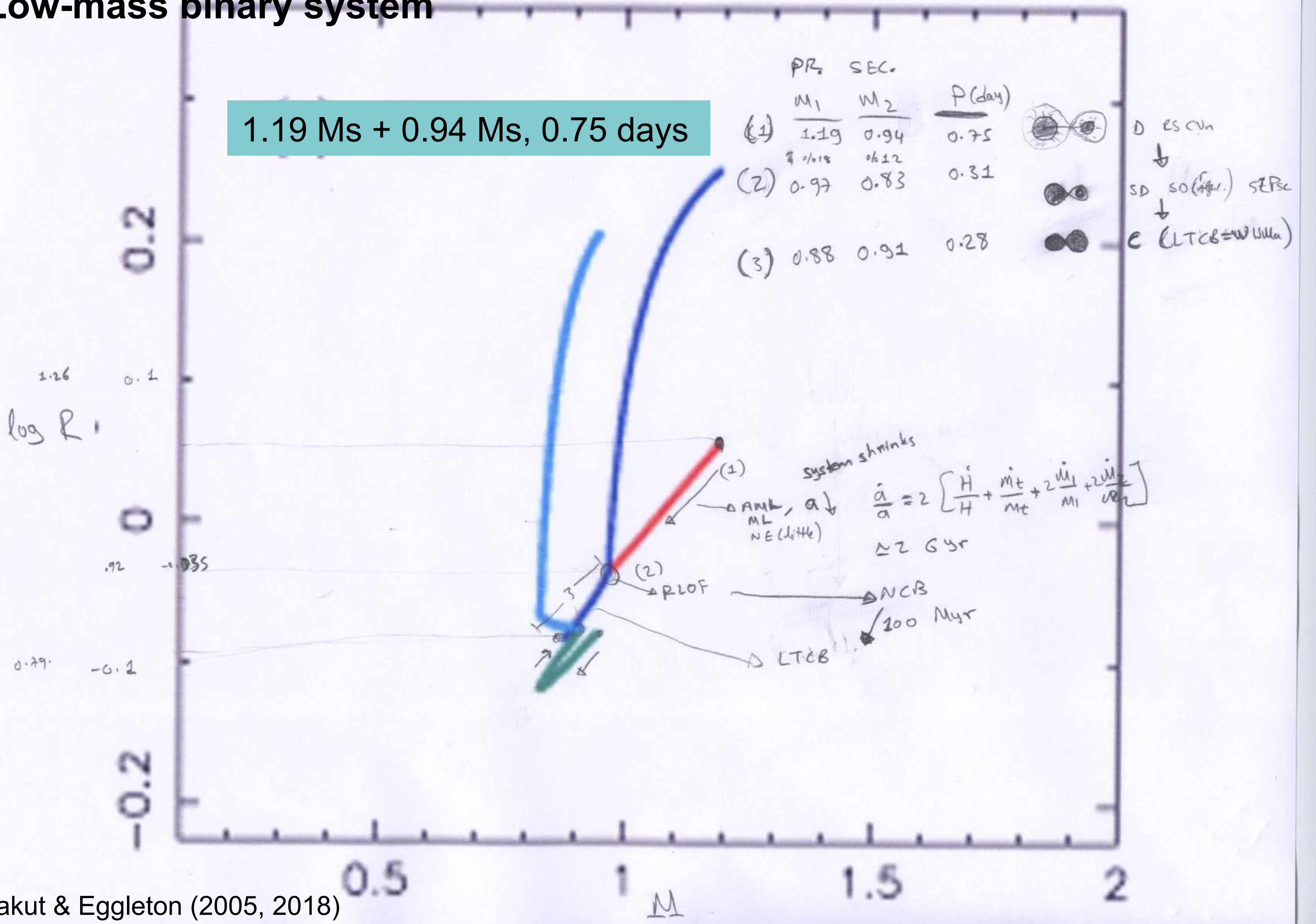


Eggleton & Yakut (2017) [MNRAS, 468, 3533]

n	Age (Gyr)	M ($M_\odot$)	P_{rot} (d)	log R ($R_\odot$)	log L ($L_\odot$)	$\dot{M}$ ($M_\odot$ yr^{-1})	B_P (G)	R_A/R	
3	0.000	1.0242	36.71	1.019	1.519	2.5×10^{-8}	15.1	1.70	Arbitrary starting point on the Hayashi track
1004	0.042	1.0129	2.991	−0.050	−0.137	5.3×10^{-11}	20.8	2.65	Minimum radius, at ZAMS
1110	0.278	1.0044	6.731	−0.045	−0.125	2.0×10^{-11}	14.5	3.21	Rotation slowed, mass-loss much down
1202	4.567	0.9999	24.89	0.000	0.005	3.1×10^{-14}	1.29	11.3	Present day
1400	10.30	0.9970	47.38	0.166	0.307	1.1×10^{-12}	0.35	0.35	Hertzsprung gap
2200	11.77	0.9861	2949	0.887	1.384	1.1×10^{-10}	0.0	0.0	Lower first giant branch
2360	11.87	0.9379	–	1.523	2.362	3.4×10^{-9}	–	–	Single red-giant wind becoming significant
2566	11.88	0.6224	–	2.367	3.405	1.1×10^{-7}	–	–	He flash
2567	11.88	0.6207	–	1.027	1.705	8.4×10^{-11}	–	–	'Zero-age' horizontal branch
2976	11.97	0.6146	–	0.924	1.634	5.9×10^{-11}	–	–	Local minimum radius
3809	12.04	0.5525	–	1.934	3.388	3.6×10^{-10}	–	–	Tip of AGB

1-Non-Conservative Evolution of Close/Interacting Binary Stars:

Low-mass binary system



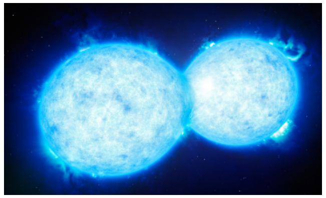
Yakut & Eggleton (2005, 2018)

TABLE 1

Physical Parameters of Well-determined LTCBs

Name (1)	B (2)	Sp1 (3)	Sp2 (4)	P (days) (5)	T_1 (K) (6)	T_2 (K) (7)	M_1 ($M_\odot$) (8)	M_2 ($M_\odot$) (9)	R_1 ($R_\odot$) (10)	R_2 ($R_\odot$) (11)	L_1 ($L_\odot$) (12)	L_2 ($L_\odot$) (13)	f (14)	X_1[a] (15)	X_2[a] (16)	References (17)
QX And	A	F4 V	F4+F5	0.4118	6500	6421	1.18	0.24	1.40	0.70	3.12	0.74	0.210	0.022	0.049	M95
AB And	W	G2 V	G8+G1	0.3319	5495	5888	1.01	0.49	1.05	0.77	0.91	0.63	0.130	0.024	0.036	H88d, D02
GZ And	W	F8 V	G4+F7	0.3050	5810	6200	1.12	0.59	1.01	0.76	1.05	0.77	0.080	0.016	0.023	B04a
OO Aql	A	G5 V	G6+G6	0.5068	5700	5680	1.05	0.88	1.40	1.30	1.85	1.57	0.220	0.058	0.064	H01
V417 Aql	W	F9 V	F9+F7	0.3703	6030	6256	1.40	0.50	1.31	0.84	2.02	0.96	0.190	0.029	0.050	S97, L99
SS Ari	W	G0 V	G2+F8	0.4060	5860	6123	1.31	0.40	1.37	0.82	1.99	0.84	0.160	0.022	0.041	K03a
AH Aur	A	F7 V	F7+F8	0.4941	6215	6141	1.68	0.28	1.89	0.91	4.75	1.06	0.670	0.060	0.143	V01
V402 Aur	W	F2 V	F2+F1	0.6035	6700	6775	1.64	0.33	1.98	0.96	7.05	1.75	0.030	0.003	0.007	Z04b
TY Boo	W	G5 V	G4+F7	0.3171	5800	6180	0.93	0.40	1.13	0.83	1.29	0.90	0.870	0.141	0.215	R90a
TZ Boo	A	G2 V	G1+G5	0.2976	5890	5754	0.72	0.11	0.97	0.43	1.02	0.18	0.130	0.011	0.029	H88c, A89
XY Boo	A	F0 V	A9+F0	0.3705	7200	7102	0.93	0.15	1.21	0.54	3.54	0.66	0.050	0.005	0.011	M83, A84
CK Boo	A:	F7	F7+F6	0.3551	6200	6291	1.42	0.15	1.48	0.59	2.89	0.48	0.650	0.044	0.126	K04a
EF Boo	W	F5 V	F6+F5	0.4295	6338	6450	1.61	0.82	1.50	1.13	3.24	1.97	0.280	0.053	0.076	O04
AO Cam	W	G5 V	G7+G1	0.3299	5590	5900	1.12	0.49	1.09	0.76	1.04	0.62	0.120	0.021	0.033	B04a
DN Cam	W	F2 V	F4+F2	0.4983	6530	6700	1.85	0.82	1.76	1.25	5.05	2.84	0.330	0.057	0.088	B04a
TX Cnc	W	F8 V	G1+F7	0.3830	5888	6165	0.91	0.50	1.13	0.87	1.37	0.98	0.210	0.042	0.059	H88c
BH Cas	W	K1	K3+K1	0.4059	4790	4980	0.74	0.35	1.11	0.80	0.58	0.35	0.220	0.040	0.060	M99, Z01
V523 Cas	W	K5 V*	K4+K3	0.2337	4410	4736	0.75	0.38	0.75	0.56	0.19	0.14	0.130	0.025	0.036	Z04a
RR Cen	A	F2 V	F0+F2	0.6060	6920	6760	2.09	0.45	2.24	1.07	10.31	2.14		0.052	0.007	H88c, K84b
V752 Cen	W	F8 V	G0+F7	0.3700	5955	6221	1.30	0.40	1.27	0.75	1.83	0.76	0.090	0.012	0.023	B93
V757 Cen	W	F9 V	G1+F9	0.3432	5900	6000	0.88	0.59	1.01	0.85	1.10	0.83	0.140	0.032	0.040	M84, K84a
VW Cep	W	K2 V	K1+K0	0.2783	5010	5250	0.93	0.40	0.93	0.64	0.49	0.28	0.180	0.031	0.049	H88c, K02a
TW Cet	W	G5 V*	G8+G6	0.3169	5450	5630	1.06	0.61	1.00	0.78	0.80	0.55	0.030	0.006	0.009	R82
RW Com	W	K0 V	K0+G8	0.2373	5120	5400	0.56	0.20	0.71	0.46	0.31	0.16	0.170	0.026	0.044	M87
RZ Com	W	F7 V	F7+F5	0.3385	6165	6450	1.23	0.55	1.12	0.78	1.62	0.94		−0.001	0.004	H88c
CC Com	W	K5	K6+K5	0.2210	4170	4365	0.79	0.43	0.75	0.58	0.15	0.11	0.240	0.048	0.067	H88c
ϵ CrA	A	F2 V	F0+F3	0.5914	7100	6640	1.72	0.22	2.12	0.88	10.27	1.34	0.300	0.023	0.063	G93
YY CrB	A:	F8 V	F8+F8	0.3766	6135	6142	1.43	0.35	1.45	0.82	2.66	0.86	0.630	0.073	0.146	P02b
SX Crv	A	F6 V	F6+F7	0.3166	6340	6160	1.25	0.10	1.31	0.44	2.50	0.25	0.270	0.015	0.051	Z04b
DK Cyg	A	A8	A8+F2	0.4707	7500	6700	1.74	0.53	1.70	1.02	8.16	1.89	0.300	0.041	0.075	B04a
V401 Cyg	A	F0 V*	F2+F3	0.5827	6700	6650	1.68	0.49	1.98	1.19	7.08	2.49	0.460	0.060	0.112	R02, W00
V1073 Cyg	A	F2 V	F2+F3	0.7859	6700	6590	1.60	0.51	2.51	1.64	11.37	4.53	0.920	0.123	0.216	A92
V2150 Cyg	A	A6 V	A6+A6	0.5919	8000	7920	2.35	1.89	2.02	1.84	14.94	11.91	0.190	0.049	0.056	K03c
RW Dor	W	K1 V	K3+K0	0.2855	4780	5200	0.64	0.43	0.80	0.67	0.30	0.30	0.130	0.030	0.038	H92
BV Dra	W	F7 V	F7+F6	0.3501	6245	6345	1.04	0.43	1.11	0.75	1.69	0.82	0.110	0.019	0.030	K86
BW Dra	W	F8 V	F9+F7	0.2922	5980	6164	0.92	0.26	0.98	0.56	1.11	0.41	0.140	0.018	0.035	K86
EF Dra	A:	F9 V	F9+F8	0.4240	6000	6054	1.81	0.29	1.72	0.80	3.43	0.77	0.460	0.041	0.099	P01b
FU Dra	W	F8 V	G4+F8	0.3067	5800	6133	1.17	0.29	1.13	0.62	1.29	0.48	0.240	0.029	0.058	V01
YY Eri	W	G5 V*	G9+G7	0.3210	5362	5600	1.54	0.62	1.20	0.80	1.06	0.56	0.100	0.017	0.027	N86, Y99, M94
QW Gem	W	F8 V	G1+F8	0.3581	5890	6100	1.31	0.44	1.26	0.79	1.72	0.77	0.230	0.033	0.059	K03c
V728 Her	W	F3 V	F3+F1	0.4713	6622	6787	1.65	0.30	1.81	0.92	5.65	1.59	0.710	0.067	0.153	N95
V829 Her	W:	G2 V	G1+G9	0.3581	5900	5380	0.86	0.37	1.07	0.74	1.25	0.42	0.200	0.034	0.054	Z04b
V842 Her	W	F9 V	F9+F6	0.4190	6000	6280	1.36	0.35	1.46	0.81	2.47	0.92	0.250	0.030	0.061	N96, R99
EZ Hya	W	F9 V	G6+F8	0.4497	5721	6100	1.37	0.35	1.55	0.87	2.30	0.94	0.340	0.041	0.082	Y04b
FG Hya	A:	G2 V	G1+F9	0.3278	5900	6012	1.44	0.16	1.42	0.59	2.20	0.41	0.860	0.059	0.165	Q05, L99
SW Lac	W	G3 V*	G9+G6	0.3207	5347	5630	0.98	0.78	1.03	0.94	0.78	0.80	0.310	0.078	0.089	A04
XY Leo A	W	K2 V	K4+K2	0.2841	4524	4850	0.82	0.50	0.86	0.69	0.28	0.23	0.060	0.013	0.017	Y03a
AP Leo	A:	F7	F8+F7	0.4304	6150	6250	1.46	0.43	1.46	0.85	2.75	0.98	0.060	0.008	0.015	K03c
VZ Lib	A	G0 V*	G1+G9	0.3583	5900	5380	1.48	0.38	1.33	0.73	1.92	0.40	0.130	0.016	0.032	Z04b
UV Lyn	W	F6 V*	F9+F7	0.4150	6045	6262	1.36	0.50	1.45	0.96	2.52	1.28	0.460	0.070	0.117	V01
TV Mus	A:	F8 V	F9+F8	0.4457	5980	6088	0.94	0.13	1.41	0.59	2.27	0.43	0.130	0.011	0.028	H89
V502 Oph	W	G2	G1+F7	0.4534	5880	6165	1.38	0.48	1.45	0.89	2.25	1.03		0.000	−0.008	H88c
V508 Oph	A	F9 V	F9+G3	0.3448	6000	5830	1.01	0.52	1.07	0.80	1.33	0.66	0.100	0.019	0.028	L90
V566 Oph	A	F1 V	F0+F1	0.4096	7000	6881	1.40	0.33	1.47	0.79	4.65	1.25		0.035	0.068	N03
V839 Oph	A	F7 V*	F3+F4	0.4090	6650	6554	1.64	0.50	1.50	0.90	3.94	1.33	0.230	0.031	0.058	P02a
V2388 Oph	A	F3 V	F1+F6	0.8023	6900	6349	1.80	0.34	2.64	1.35	14.12	2.63	0.650	0.063	0.142	Y04a
ER Ori	W	F8 V*	F7+F6	0.4234	6200	6314	1.53	0.98	1.40	1.15	2.60	1.90	0.150	0.034	0.043	G94
U Peg	W:	G2 V	G2+G3	0.3748	5860	5841	1.15	0.38	1.25	0.78	1.65	0.63	0.240	0.035	0.061	P02b
BX Peg	W	G9 V	G9+G7	0.2804	5300	5528	1.02	0.38	0.97	0.63	0.67	0.34	0.190	0.030	0.050	S91
AE Phe	W	G1	G1+F7	0.3624	5888	6166	1.38	0.63	1.26	0.90	1.72	1.05	0.210	0.037	0.057	H88c, B04b
OU Ser	W	G0 V	G0+F6	0.2968	5960	6380	1.02	0.18	1.09	0.52	1.36	0.40	0.310	0.029	0.069	P02b
Y Sex	A	F8	F7+F8	0.4198	6210	6093	1.21	0.22	1.50	0.75	3.01	0.70	0.640	0.061	0.139	Y03b
RZ Tau	A	F0 V*	A9+A9	0.4157	7300	7194	1.70	0.64	1.58	1.07	6.38	2.76	0.550	0.084	0.139	Y03c

2- Non-Conservative Binary Evolution:
High-mass binary system **V382 Cyg** (O6.5 V + O6 V)



New observations→ Ege University Observatory

Table 6
Observed and Model Parameters of the Components

	Star	M ($M_\odot$)	log R	log T	log L	P (days)	Age (yr)
Observed	A	20.8	0.9269	4.5367	4.954	1.8855	
	B	27.9	0.9868	4.5563	5.152		
Model No. 28	A	28.0	0.8687	4.5783	5.0039	1.6960	8.6×10^3
	B	23.5	0.8252	4.5532	4.8163		
Model No. 201	A	20.83	0.9224	4.5401	4.9581	1.8860	3.85×10^6
	B	27.65	0.9741	4.5606	5.1440		

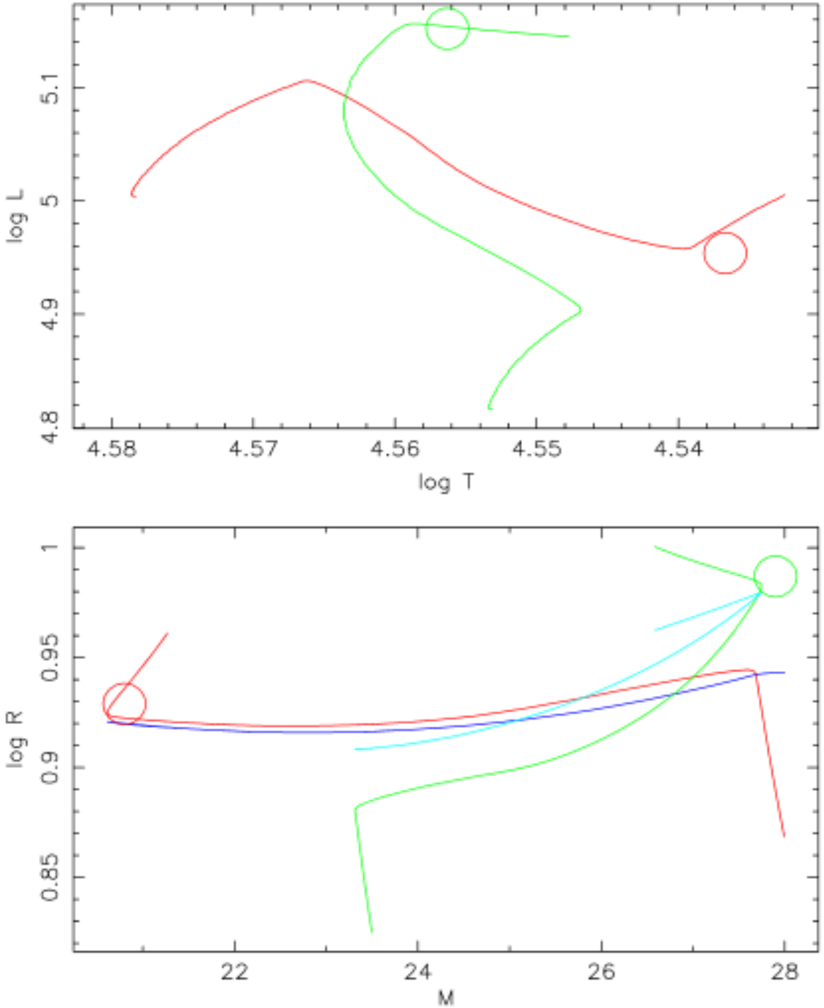


Figure 3. Non-conservative evolution of V382 Cyg in an H-R diagram (top panel) and the log R vs. M plane (bottom panel). More massive and less massive stars are shown respectively in red and green; their respective Roche lobe radii are dark blue and light blue. Initial parameters are 28.0 $M_\odot$, 23.5 $M_\odot$, and 1.72 days with an assumed solar composition. The original primary is now the secondary.

Yaşarsoy & Yakut (2013)
[AJ, 145, 9]

3-Binary system with giant components:

No.	Name spectra	P (d)	e	K_1 (km s^{-1})	K_2 (km s^{-1})	V_{12}	ΔV	A_V	T_1	T_2	plx (mas)	i	Type GoF Z
1	SMC-130	120.470	0.000	33.42	32.54	16.783	−0.72	0.24	4515	4912	0.0162	83.09	E
	G7III	0.001	0.000	0.12	0.11	0.010	0.10	0.02	150	150	0.0008	0.10	1.08
	+ K1III	120.470	0.000	33.42	32.54	16.783	−0.95	0.24	4365	4812	0.0180	83.09	.004
2	SMC-126	635.000	0.042	18.48	18.54	16.771	−0.192	0.24	4480	4510	0.0160	86.92	E
	K2III	0.009	0.002	0.110	0.10	0.01	0.020	0.02	150	150	0.0030	0.09	0.92
	+ K1III	635.000	0.042	18.48	18.54	16.771	−0.222	0.24	4250	4350	0.0165	86.92	.004
3	SMC-101	102.900	0.000	39.44	41.03	17.177	−0.203	0.20	5170	5580	0.0154	88.04	E
	K2III	0.000	0.000	0.20	0.12	0.010	0.020	0.02	95	90	0.0003	0.23	1.05
	+ K1II	102.900	0.000	39.44	41.03	17.177	−0.203	0.20	5170	5280	0.0154	88.04	.004
4	HD 4615	302.771	0.435	27.52	30.8	6.82	−1.10	0.25	4400	8700	2.48	71.4	N
	K2III	0.020	0.003	0.10	0.9	0.02	0.20	0.05	200	500	0.59	2.0	0.17
	+ A2V	302.771	0.435	27.52	30.8	6.82	−1.10	0.25	4400	8500	2.68	71.4	.02
5	η And	115.73	0.003	17.98	19.03	4.40	−0.54	0.05	5050	5000	13.3	30.5	A
	G8III	0.02	0.002	0.09	0.11	0.02	0.02	0.01	200	200	0.5	0.20	0.40
	+ G8III	115.73	0.003	18.04	18.92	4.40	−0.54	0.05	5000	5050	13.3	30.5	.02
6	SMC-108	185.220	0.000	37.85	37.96	15.205	0.081	0.28	4955	5675	0.015 62	78.87	E
	F9II + G7II	0.002	0.000	0.08	0.09	0.01	0.02	0.02	105	90	0.000 30	0.10	0.00
	+ G7III	185.220	0.000	37.85	37.96	15.205	0.081	0.28	4955	5675	0.015 62	78.87	.004

60 systems

	Name Ev. Type Quality	P_0	e_0	m_{10}	m_{20}	n	(Myr) Age GoF	P	e	m_1	m_2	$\log R_1$	$\log R_2$	$\log T_1$	$\log T_2$
1	SMC-130							120.5	0.000	1.806	1.855	1.673	1.409	3.655	3.691
	AGB + AGB	138.8	0.300	1.910	1.908	5066	1256.0	119.8	0.000	1.848	1.856	1.673	1.369	3.638	3.678
	BM−						1.08	120.5	0.000	1.807	1.856	1.696	1.361	3.640	3.682
2	SMC-126							635.0	0.042	1.675	1.669	1.652	1.603	3.651	3.654
	FGB + FGB	593.9	0.100	1.725	1.724	2293	1354.0	633.2	0.088	1.644	1.669	1.726	1.610	3.624	3.641
	A						0.92	635.0	0.042	1.675	1.669	1.727	1.644	3.628	3.638
3	SMC-101							102.9	0.000	2.838	2.728	1.380	1.249	3.713	3.747
	GKGC + GKGC	118.5	0.300	2.870	2.820	2920	397.1	104.6	0.000	2.836	2.795	1.362	1.293	3.721	3.722
	A						1.05	102.9	0.000	2.838	2.728	1.380	1.313	3.713	3.723
4	HD 4615							302.8	0.435	2.818	2.518	1.547	0.603	3.643	3.940
	AGB + MS	607.3	0.700	2.900	2.520	1773	525.0	303.7	0.422	2.797	2.520	1.513	0.580	3.651	3.930
	A						0.13	302.8	0.435	2.818	2.518	1.513	0.585	3.643	3.929
5	η And							115.7	0.003	2.391	2.259	1.028	0.933	3.703	3.699
	GKGC + FGB	133.0	0.300	2.368	2.268	1969	809.7	117.2	0.000	2.327	2.264	1.040	0.912	3.698	3.705
	A						0.40	115.7	0.003	2.371	2.260	1.041	0.920	3.699	3.703
6	SMC-108							185.2	0.000	4.435	4.423	1.813	1.664	3.695	3.754
	BL + BL	213.2	0.300	4.540	4.430	3555	133.6	188.1	0.000	4.478	4.385	1.813	1.629	3.699	3.761
	A+						0.00	185.2	0.000	4.435	4.423	1.813	1.664	3.695	3.754

Eggleton & Yakut (2017) [MNRAS, 468, 3533]

The model of Capella seems to fit the observations very well!!!

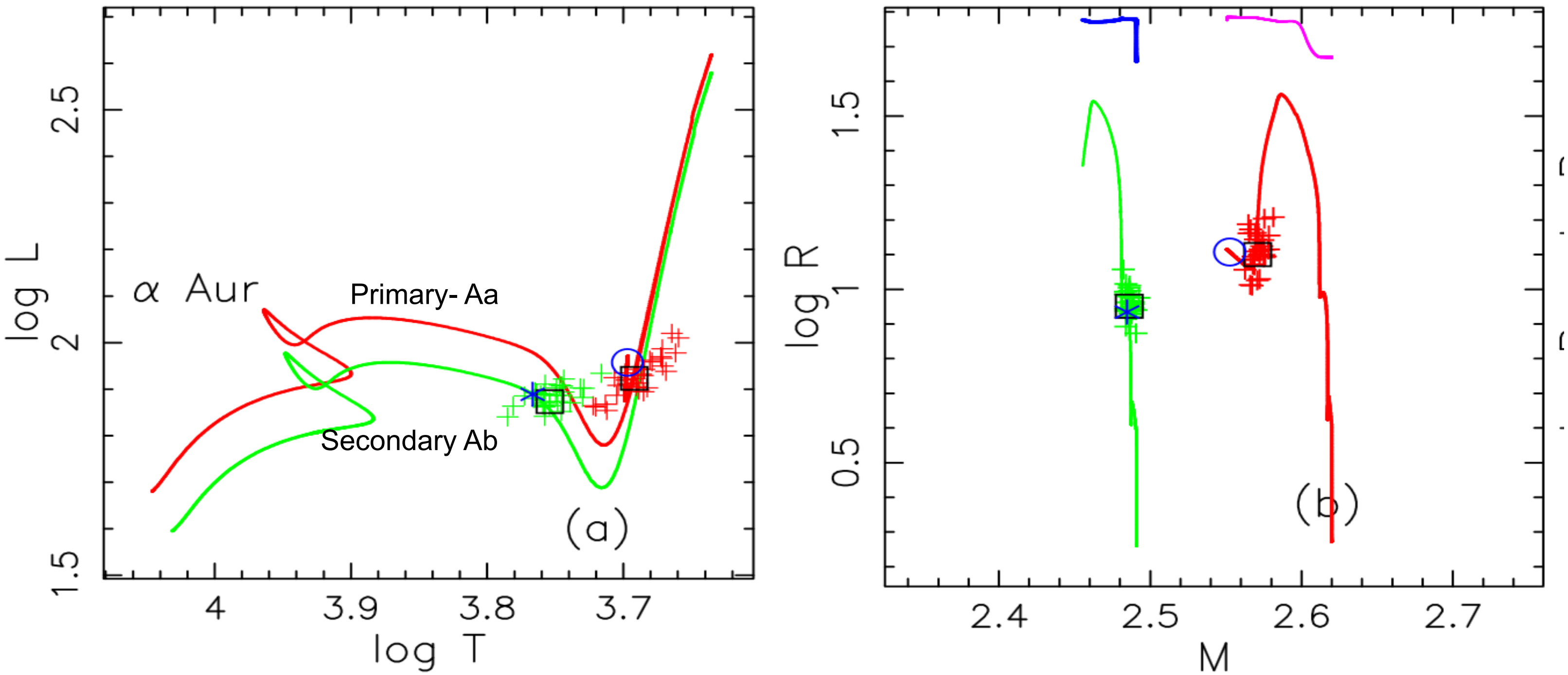


Figure 1. Evolutionary tracks for the components α Aur (Capela). Observed values are plotted as squares.

Table 4 – *continued*

	Name Ev. Type Quality	P_0	e_0	m_{10}	m_{20}	n	(Myr) Age GoF	P	e	m_1	m_2	$\log R_1$	$\log R_2$	$\log T_1$	$\log T_2$
22	OGLE-10567							117.9	0.000	3.347	3.184	1.405	1.558	3.705	3.672
	GKGC + HeIgn	135.8	0.300	3.400	3.350	2079	240.9	115.9	0.000	3.367	3.330	1.444	1.548	3.702	3.680
	BM+						0.0	117.9	0.000	3.347	3.184	1.405	1.558	3.705	3.672
23	OGLE-26122							771.8	0.419	3.591	3.408	1.505	1.352	3.698	3.699
	GKGC + GKGC	773.0	0.420	3.600	3.450	2650	252.9	765.4	0.402	3.538	3.426	1.489	1.352	3.699	3.701
	A+						0.0	771.8	0.419	3.591	3.408	1.505	1.352	3.698	3.699
24	α Aur							104.0	0.001	2.571	2.486	1.100	0.951	3.692	3.754
	GKGC + HG	117.7	0.300	2.620	2.491	1758	620.3	104.5	0.000	2.553	2.485	1.108	0.935	3.697	3.767
	A+						0.54	104.0	0.000	2.571	2.486	1.089	0.919	3.692	3.771
25	OGLE-15260							157.3	0.000	1.427	1.440	1.621	1.355	3.635	3.673
	FGB + FGB	181.2	0.300	1.497	1.495	2324	2043.0	161.5	0.000	1.424	1.458	1.621	1.376	3.631	3.663
	A						0.0	157.3	0.000	1.427	1.440	1.621	1.355	3.635	3.673

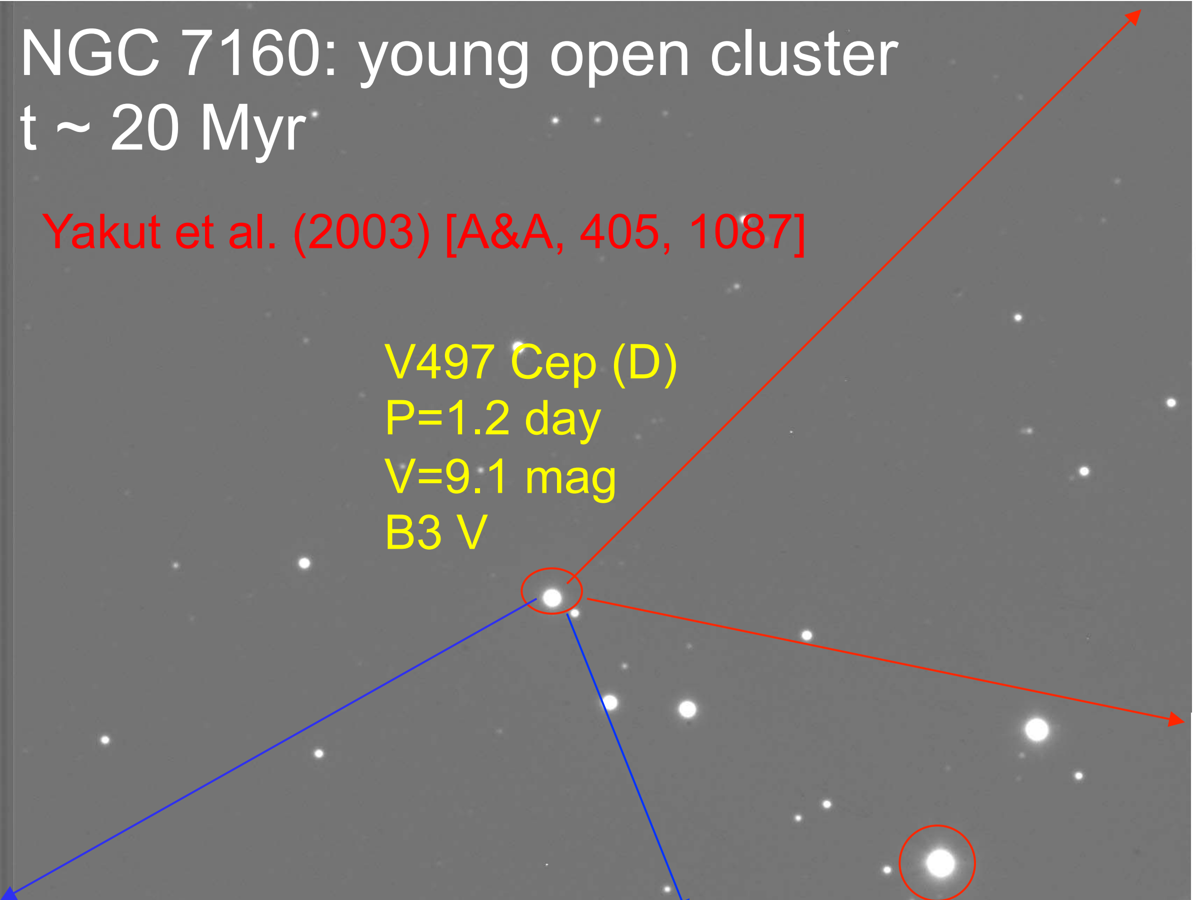
Eggleton & Yakut (2017) [MNRAS, 468, 3533]

Close binaries in open clusters

Cluster	Star	Type	Sp.T.	α_{2000}	δ_{2000}	m_V (mag)	Period (days)
NGC 6383	V701 Sco	C	B5V	17 34 25	-32 30 16	8.97	0.76187
NGC 7160	V497 Cep	D	B3V	21 53 26	+62 35 13	8.98	1.20283
	EM Cep	SD	B0.5V	21 53 48	+62 36 52	7.03	0.80618
M67	AH Cnc	C	F6.5V	08 51 38	+11 50 57	13.31	0.36046
	EV Cnc	SD	-	08 51 28	+11 49 28	12.89	0.44830
	ES Cnc	RS CVn	F4V	08 51 21	+11 53 26	11.22	1.06780
	EX Cnc	δ Scu	A7V	08 51 34	+11 51 11	10.97	-
	EW Cnc	δ Scu	-	08 51 33	+11 50 41	12.27	-
	EU Cnc	AM Her	-	08 51 27	+11 46 57	20.77	0.08710
	EY Cnc	BY Dra	-	08 51 35	+11 50 32	19.94	-
NGC 188	EQ Cep	C	K0V	00 47 34	+85 16 24	17.3	0.30690
	EP Cep	C	K0V	00 46 54	+85 21 44	17.5	0.28974
	ER Cep	C	G9V	00 50 28	+85 15 09	15.83	0.28574
	ES Cep	C	K0V	00 50 50	+85 16 12	15.76	0.34250
	V369 Cep	C	-	00 46 12	+85 14 03	16.9	0.32820
	V370 Cep	C	-	00 47 16	+85 15 35	17.1	0.33040
	V371 Cep	C	-	00 48 22	+85 15 55	15.87	0.5860o
NGC 6791	V568 Lyr						
	V523 Lyr						
	…….						

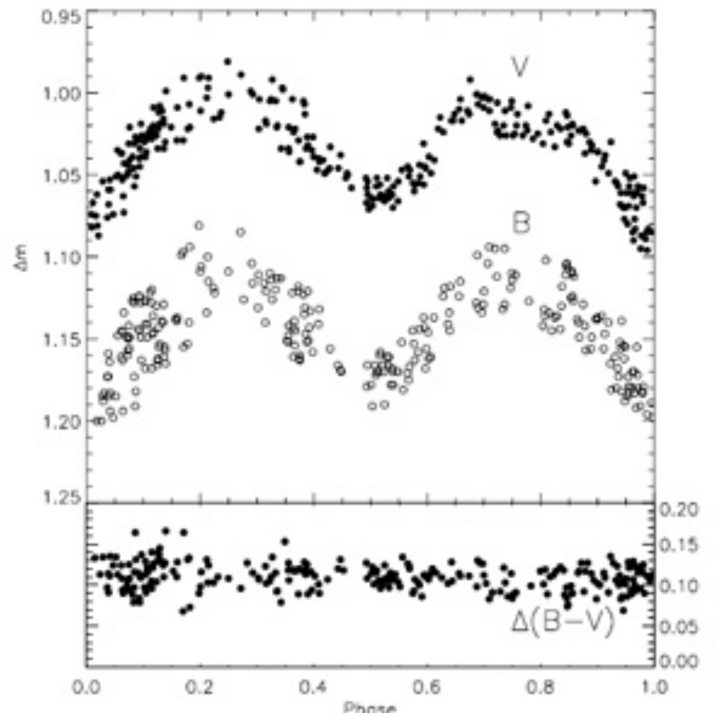
NGC 7160: young open cluster
t ~ 20 Myr

Yakut et al. (2003) [A&A, 405, 1087]

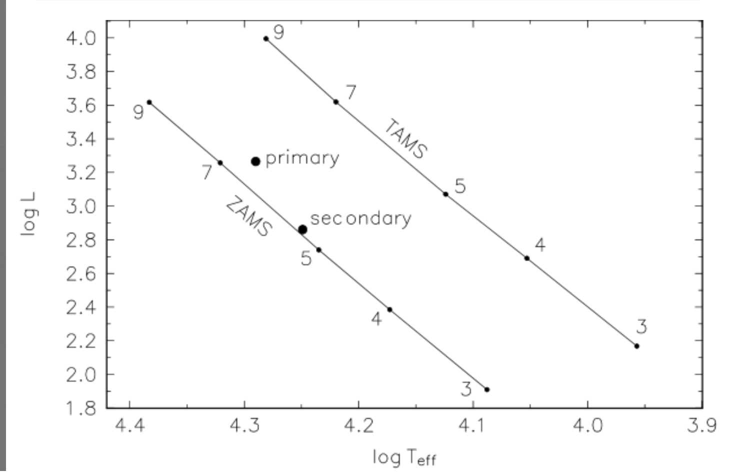


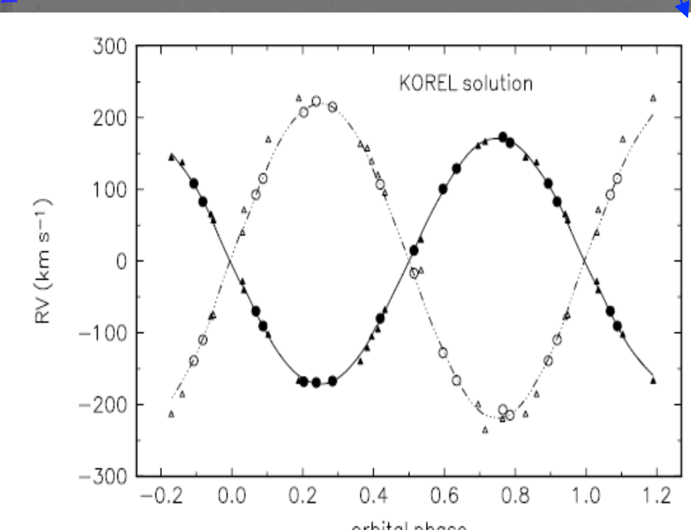
V497 Cep (D)
P=1.2 day
V=9.1 mag
B3 V

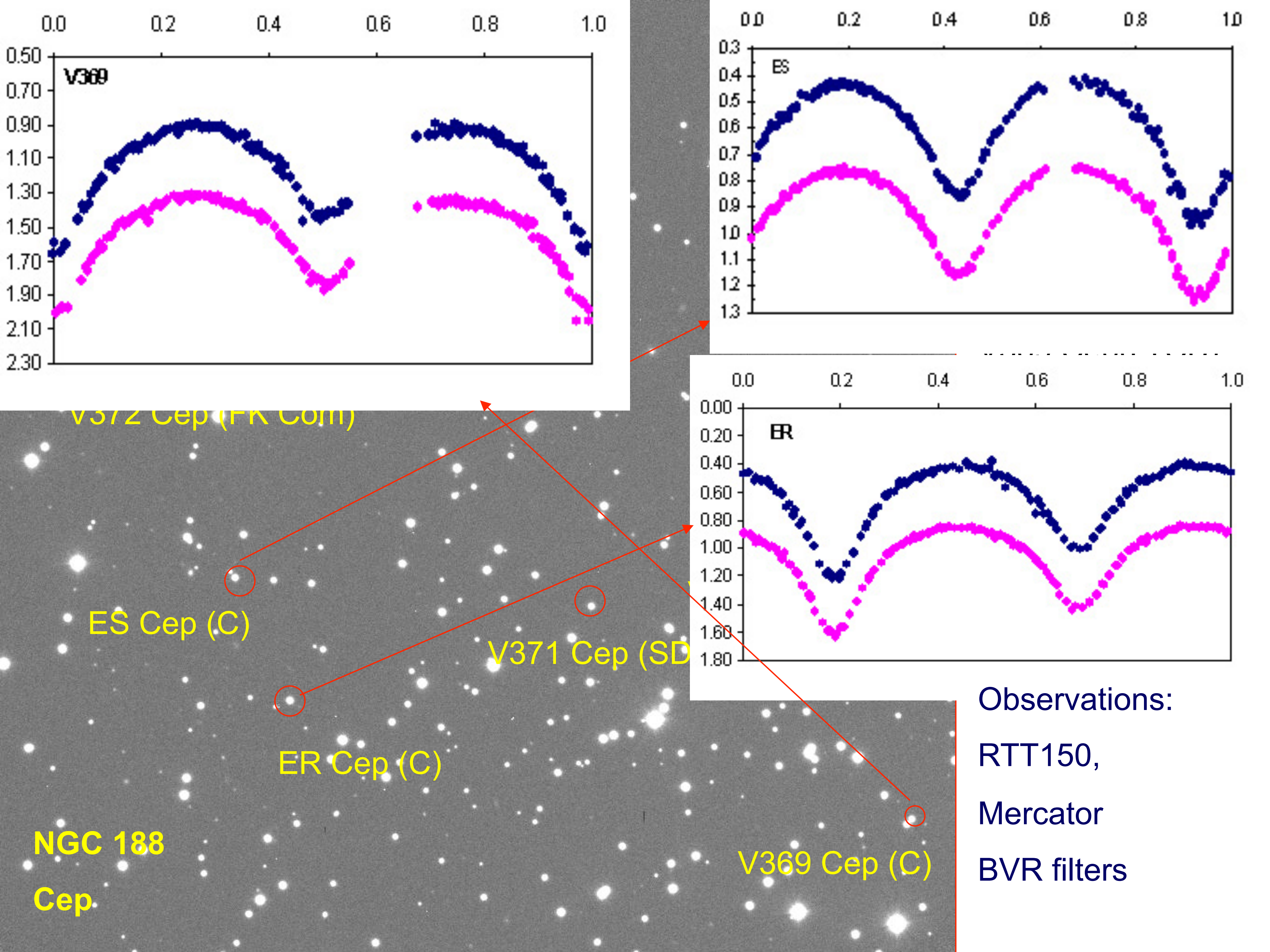
EM Cep (C,SD)
P=0.8 day
V=7.1 mag
B 0.5 V



Parameter		Primary	Secondary
M	$[M_\odot]$	6.89 (46)	5.39 (40)
R	$[R_\odot]$	3.69 (03)	2.92 (03)
T	[K]	19 500 (fixed)	17 756 (405)
L	$[L_\odot]$	1842^{+512}_{-426}	725^{+226}_{-185}







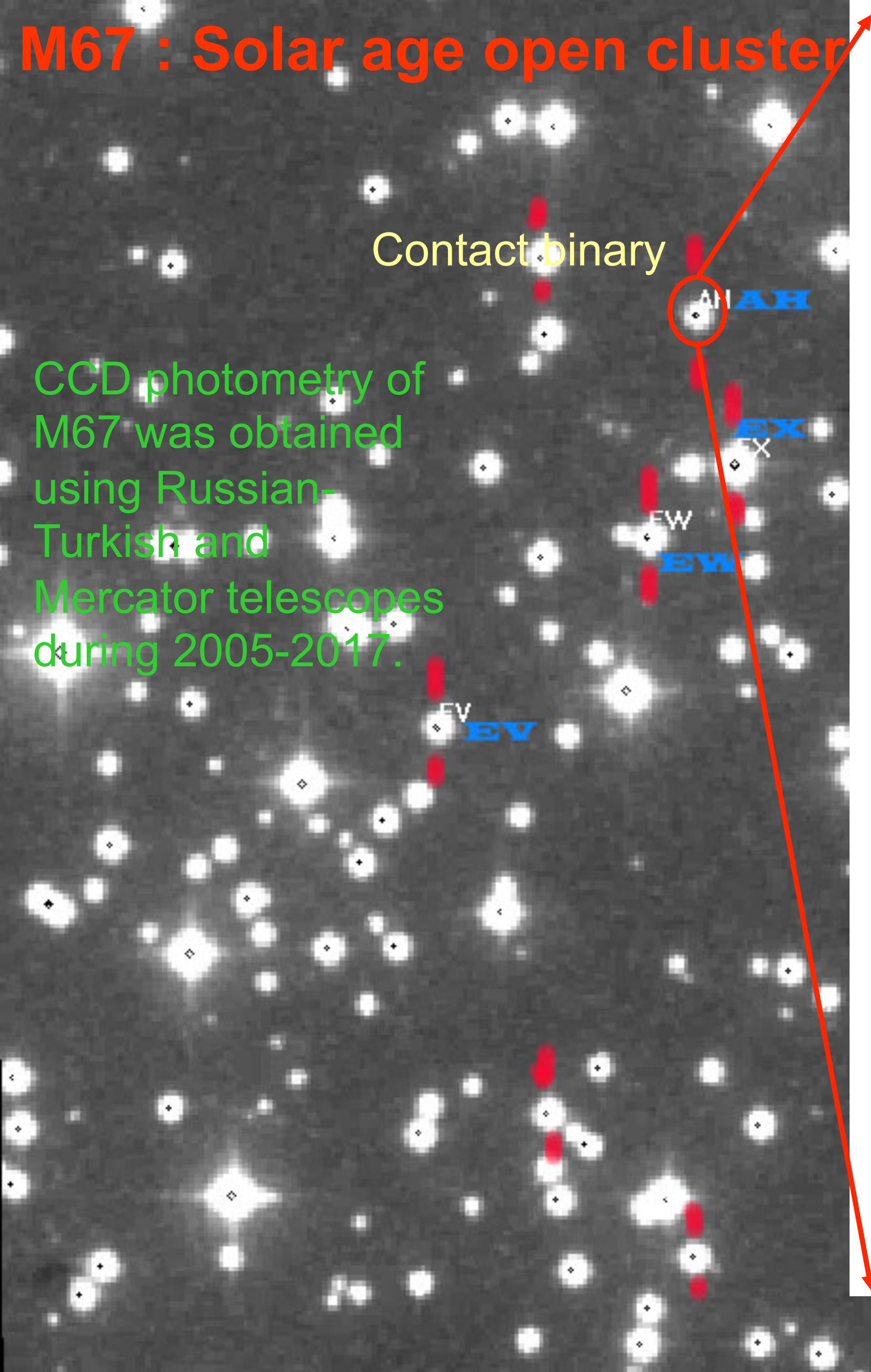
Observations:

RTT150,

Mercator

BVR filters

M67 : Solar age open cluster



CCD photometry of M67 was obtained using Russian-Turkish and Mercator telescopes during 2005-2017.

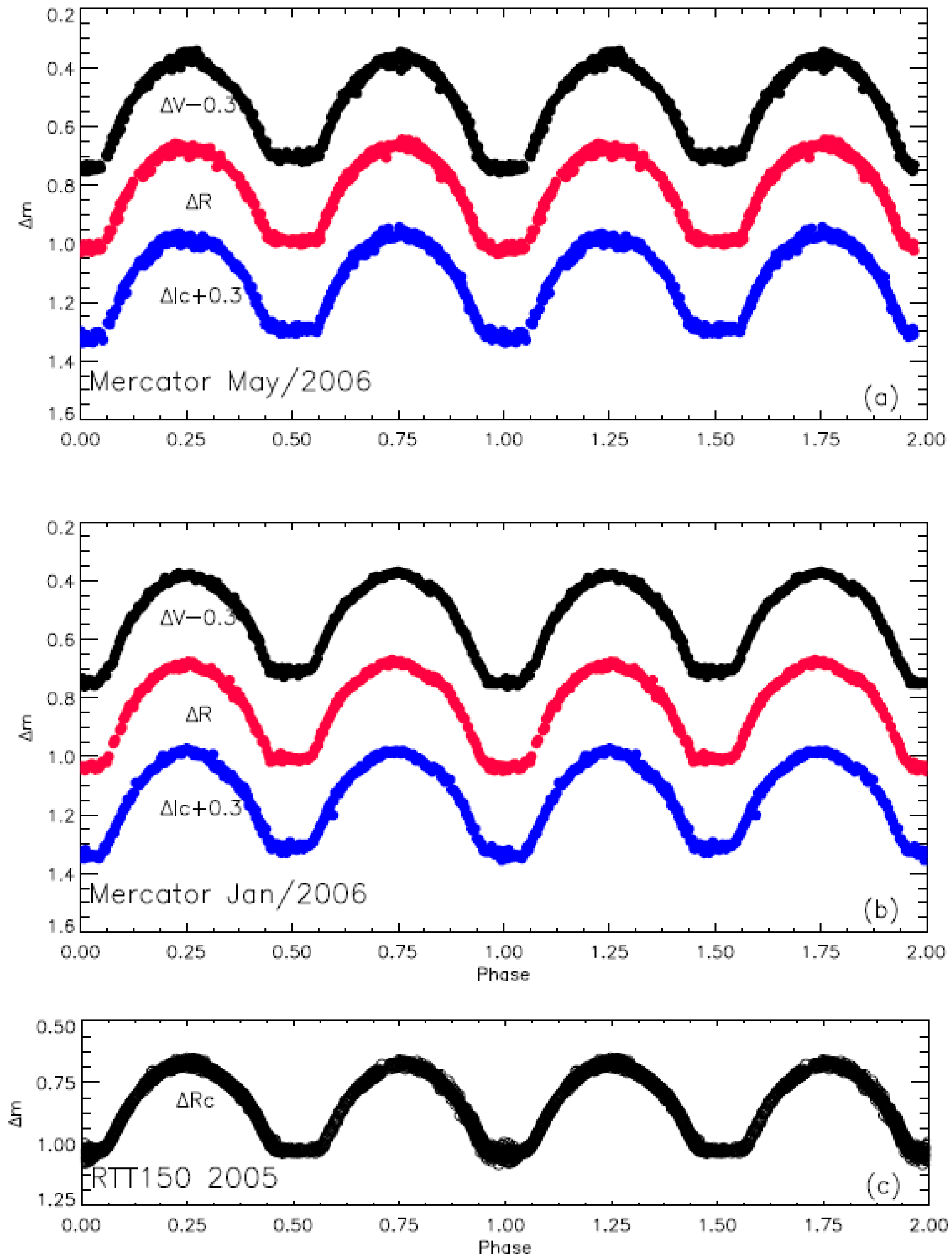
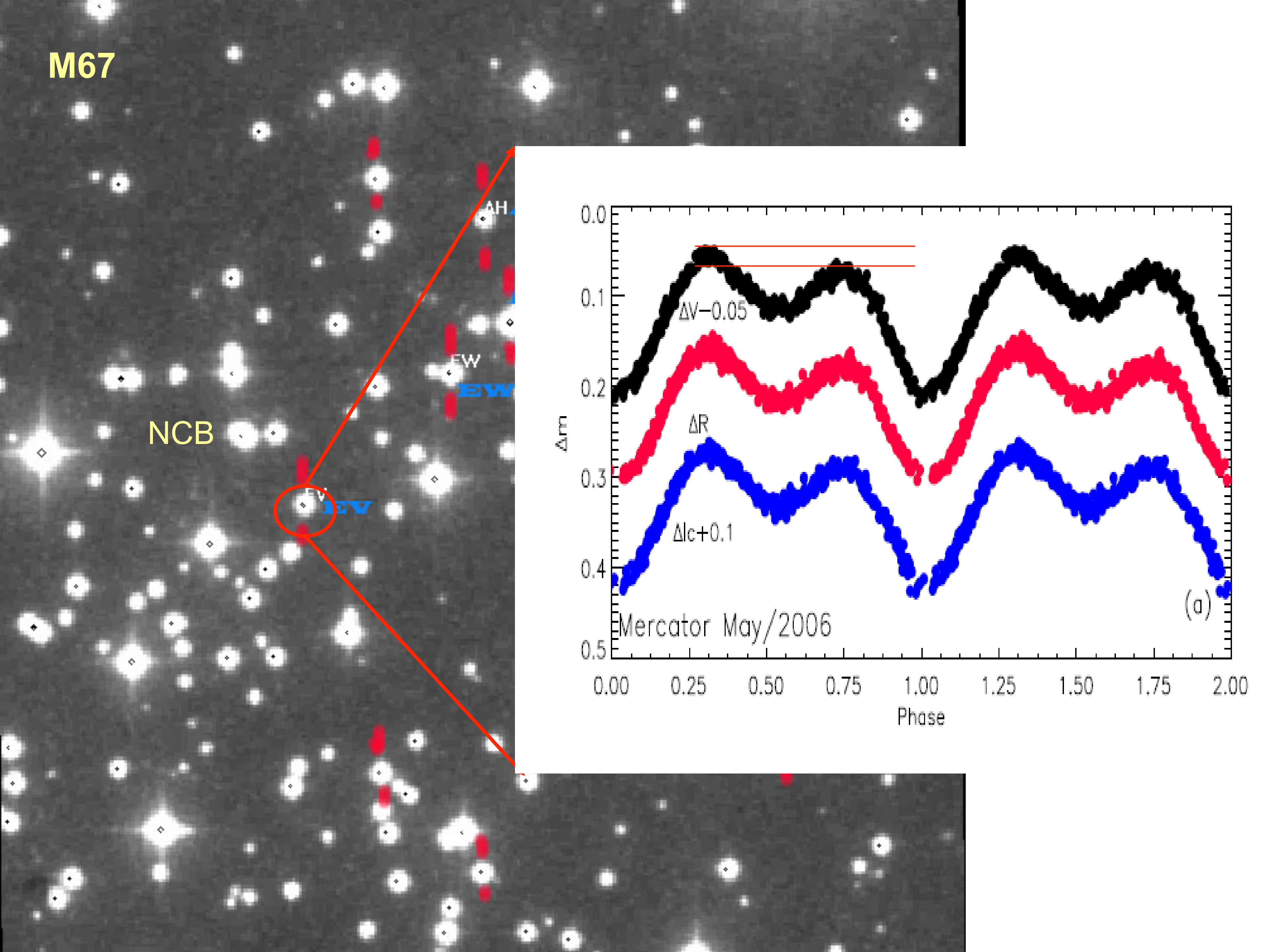
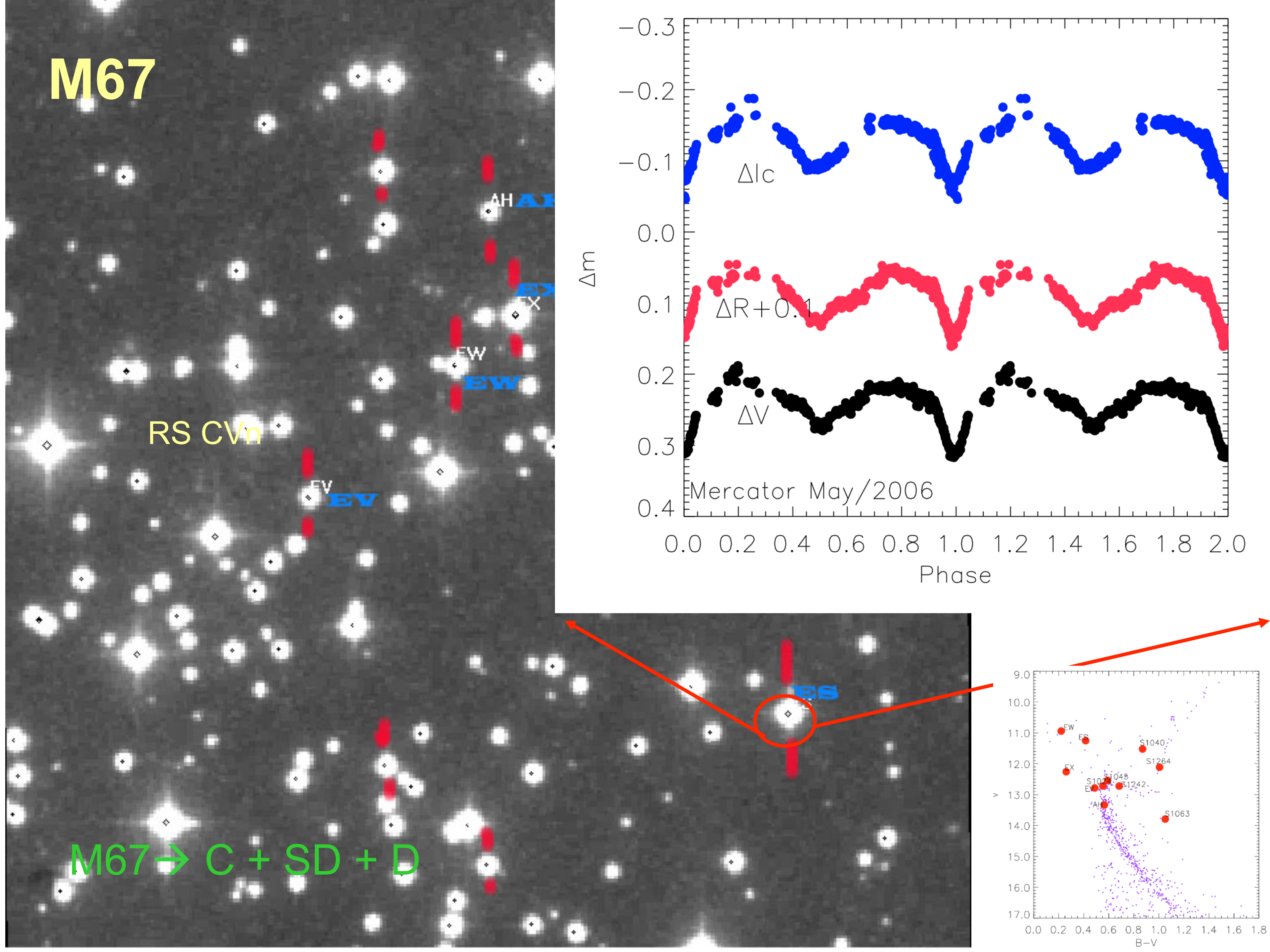


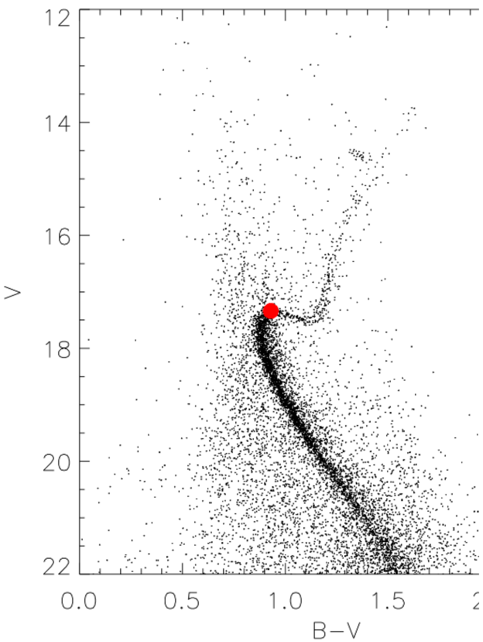
Figure 2. The light curves of AH Cnc using the Mercator and RTT150 telescopes

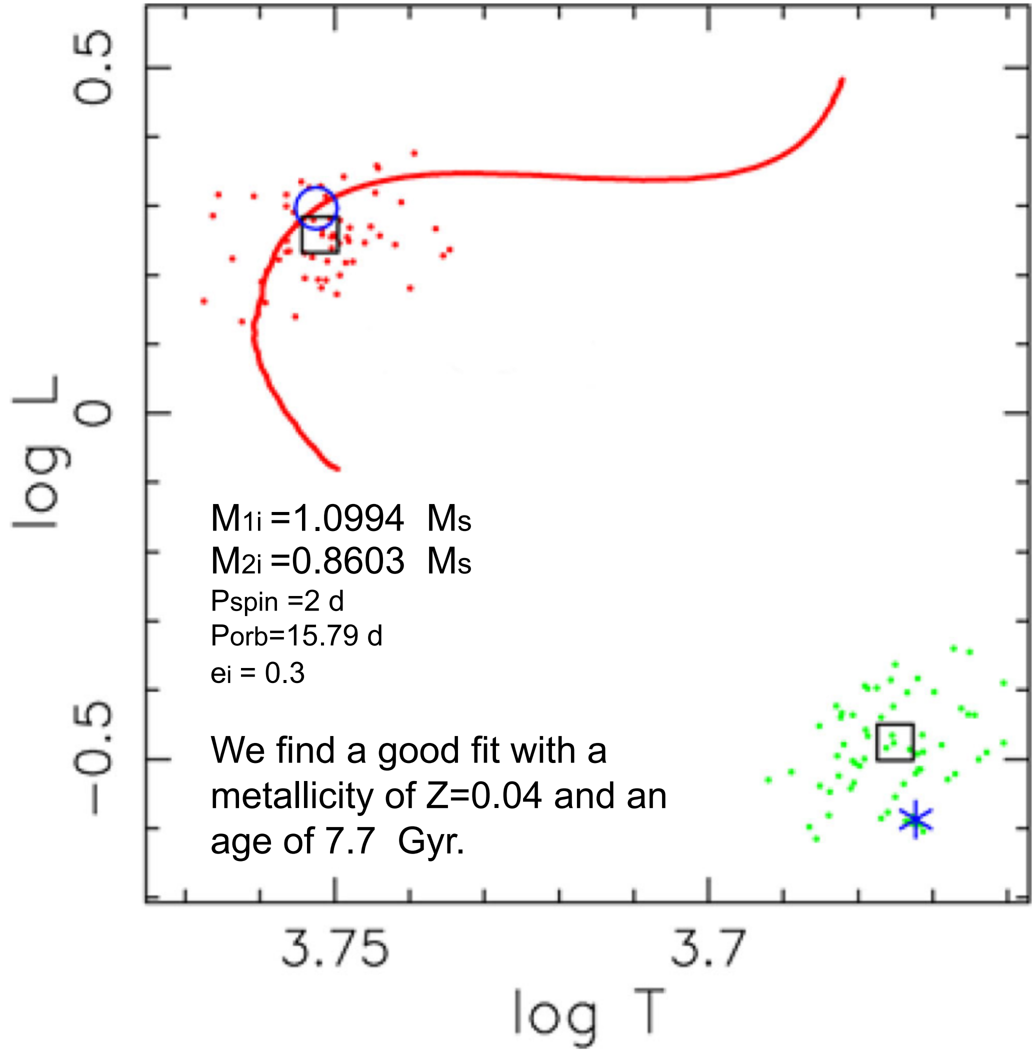

M67
NCB
EW
EW
AH
ΔV−0.05
ΔR
ΔIc+0.1
Δm
Phase
Mercator May/2006
(a)
0.0
0.1
0.2
0.3
0.4
0.5
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

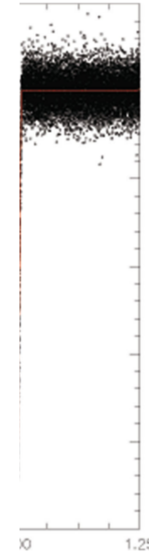


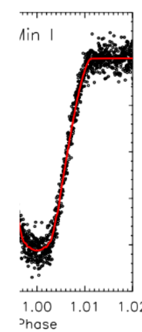
M67
RS CVn
M67→ C + SD + D
AH
EX
EW
EV
ES
ΔIc
ΔR+0.1
ΔV
Mercator May/2006
Δm
Phase
S1040
S1264
S1063
S1242
B−V
V

A turn-off detached bi… …est
open cluster (NGC 679…

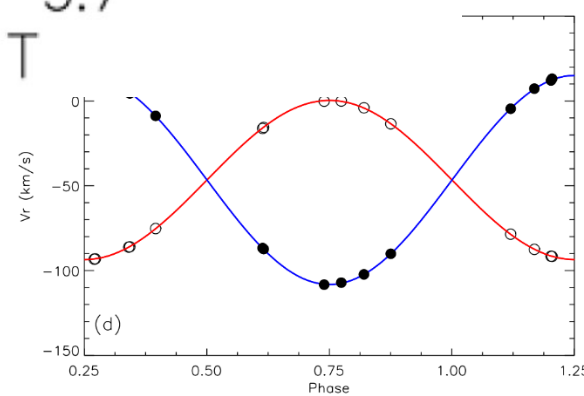








Masses $M/M_\odot$		
Radii $R/R_\odot$		
Effective temperatures $T_{\rm eff}/K$		
Luminosities $L/L_\odot$	1.85(15)	0.292(18)
Surface gravity $\log_{10}(g/\mathrm{cm\,s^{-2}})$	4.170(44)	4.551(33)
Absolute bolometric magnitude M_B	4.09(7) mag	6.09(7) mag
Absolute visual magnitude M_V	4.19(8) mag	6.53(8) mag
Separation between stars $a/R_\odot$	31.06(3)	
Distance d/pc	4260(290)	



Yakut; Eggleton; Kalomeni; Tout; Eldridge, (2015) [MNRAS, 453, 293]