Полуразделенные системы: параметры компонентов и редкие наблюдательные классы

О.Ю.Малков (ИНАСАН; физфак МГУ)

Абстракт

- Скомпилирован самый полный список полуразделенных затменных систем с линиями обоих компонентов в спектре. В списке представлены надежные значения орбитальных элементов (период, большая полуось) и физических параметров (масса, радиус, температура, светимость, спектральный класс) компонентов ~120 систем.
- Обсуждается существующая система классификации полуразделенных систем (горячие, классические алголи, холодные).
- Специальное внимание уделяется представителям редких наблюдательных классов: системам с инверсией параметров (случаи, когда более горячий компонент имеет меньшую светимость или массу), обсуждается их эволюционный статус.

List of SD DLEB

- Catalogue of semi-detached eclipsing binaries with spectroscopic orbit (Surkova & Svechnikov 2004) contains 96 systems, its bibliography is complete till 2003. We have updated information on 31 of those 96 systems.
- Ibanoglu et al. (2006): 61 systems
- Polushina 2004
- Catalogue of Algol type binary stars (Budding et al. 2004)
- Avvakumova et al. 2013

- The final SD DLEB list contains 117 systems

List of SD DLEB

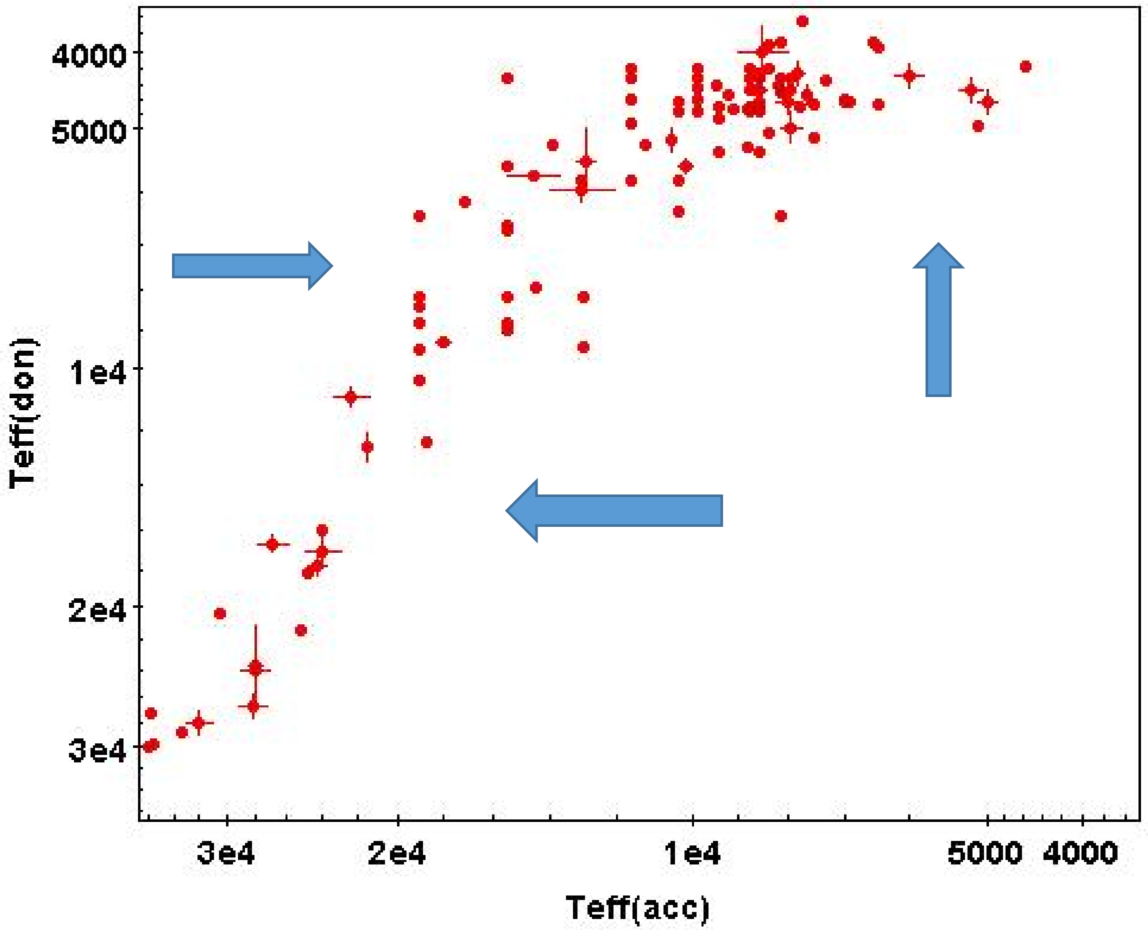
Name	P (d) / a ($R_\odot$)	M ($M_\odot$)	R ($R_\odot$)	T_{eff} (K)	$\log L_{bol}$ ($L_\odot$)	Sp / Ref
TW And	4.12276035	1.685	2.35	7520 ± 25	0.63	FV+KIV
	13.64	0.325	3.33	4658	1.16	Manzoori (2014)
WW And	23.28525	3.18 ± 0.09	3.25	8150	1.62	A5+F3p
	53.0 ± 0.5	0.51 ± 0.09	12.47	4500	1.76	Siwak et al. (2012)
RY Aqr	1.9665826	1.27 ± 0.07	1.39 ± 0.07	7650	0.77 ± 0.07	A7+G8III
	7.6	0.26 ± 0.02	1.91 ± 0.11	4520 ± 122	0.13 ± 0.09	Manzoori & Salar (2016)
XZ Aql	2.139181	2.42 ± 0.14	2.45 ± 0.07	8770	1.48 ± 0.08	A2
	9.94 ± 0.21	0.45 ± 0.06	2.43 ± 0.06	4744 ± 5	0.40 ± 0.08	Zola et al. (2016)
KO Aql	2.864055	2.53 ± 0.05	1.74 ± 0.07	9900	1.41 ± 0.06	AV+[G8IV]
	12.05 ± 0.05	0.55 ± 0.01	3.34 ± 0.07	4426	0.56 ± 0.06	Soydugan et al. (2007)
QS Aql	2.513294	4.07 ± 0.09	4.08 ± 0.15	14500	2.80 ± 0.07	B5V+[A8IV]
	13.78 ± 0.11	1.49 ± 0.05	1.65 ± 0.20	7910 ± 78	0.96 ± 0.06	Zasche et al. (2017)
V337 Aql	2.7338794	17.44 ± 0.31	9.86 ± 0.06	28000 ± 500	4.73 ± 0.04	B0V+B3V
	24.12 ± 0.11	7.83 ± 0.18	7.48 ± 0.04	23640 ± 500	4.20 ± 0.04	Tüysüz et al. (2014)
TT Aur	1.332735	8.10	3.90	24850	3.72	B2V+B4
	12.14	5.40	4.20	18170	3.24	Surkova & Svechnikov (2004)
IM Aur	1.24728912	2.38	2.6	12930	2.23	B7V+A5V
	7.14	0.77	2.0	8150	1.20	Surkova & Svechnikov (2004)
IU Aur	1.8114743	11.99 ± 0.08	6.3 ± 0.2	33331 ± 130	4.64 ± 0.03	O9.5V+B0.5IV-V
	16.83 ± 0.08	6.07 ± 0.04	5.2 ± 0.2	28823 ± 194	4.22 ± 0.04	Surina & Kang (2009)
Y Cam	3.305689	2.08 ± 0.09	3.14 ± 0.05	8000 ± 250	1.56 ± 0.06	A7V+gK5
	12.77 ± 0.19	0.48 ± 0.03	3.33 ± 0.05	4629 ± 150	0.66 ± 0.06	Hong et al. (2015)
S Cnc	9.4845011	2.33	2.18	9880	1.61	B9.5V+G8IV
	25.64	0.18	4.83	4590	0.97	Surkova & Svechnikov (2004)

Hot, classical and cool semi-detached binaries

- Hot SD: the more massive systems in which the hotter component is an early B-type star and the cooler of type B or early A.
- Classical algols: the systems of lower mass, in which the more massive component lies in the range from middle B to early F, and the other is of type F or later.
- Cool SD: the later type subgiant and giant SD systems.

- Popper (1980)

Hot, classical and cool semi-detached binaries

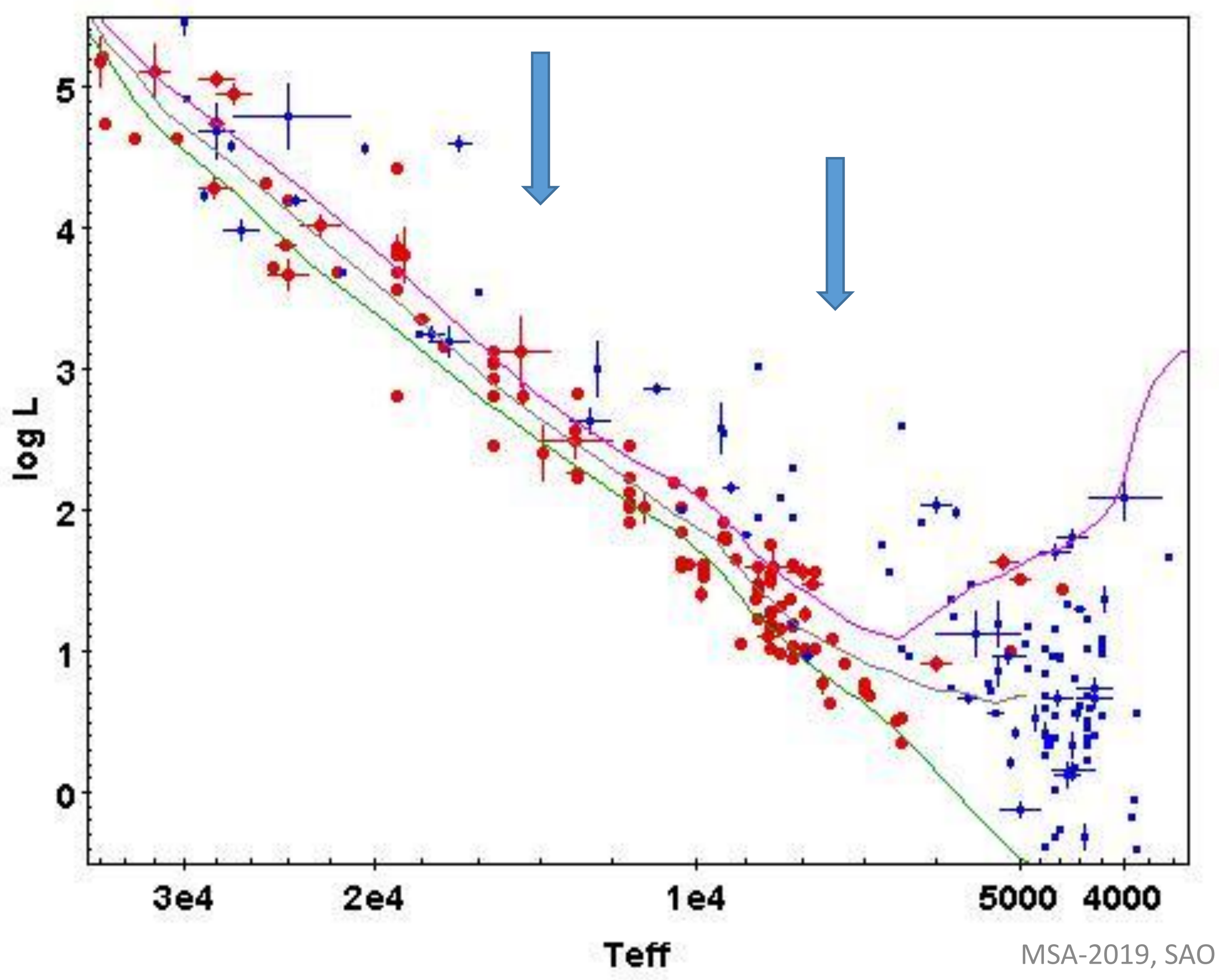


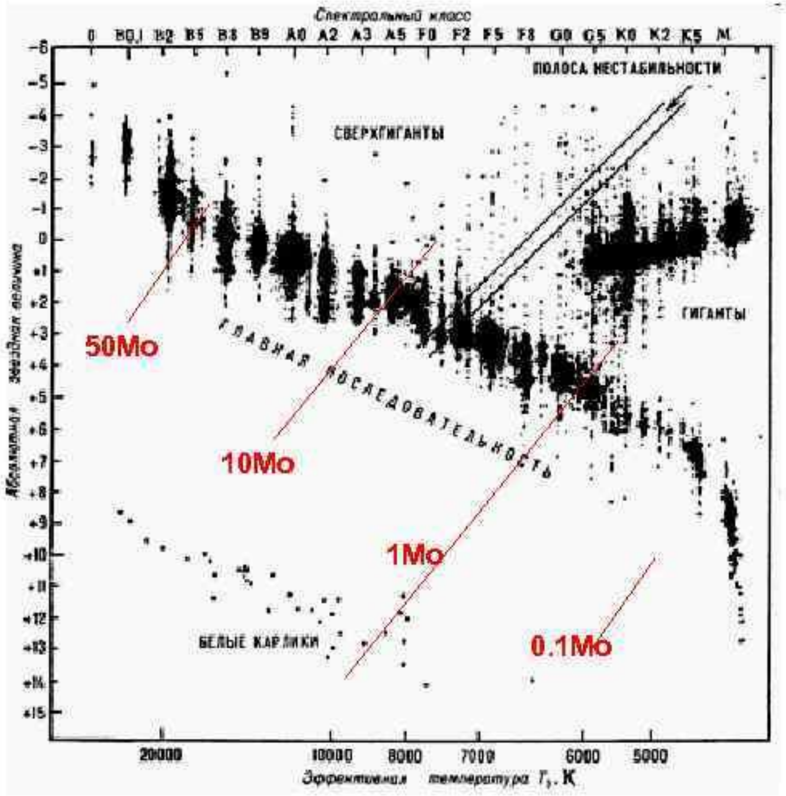
- There is an evident dissection between classical and hot SD in the "temperature-temperature" plot in the Teff (donor) = 7 500±500 K area.
- One can see another dissection, in the Teff (donor) = 14 000±1500 K area, separating hot and so called ultra-hot SD.
- Cool SD are located in the upper top and have Teff (accretor) < 6 000 K.

“Hot - classical” SD gap

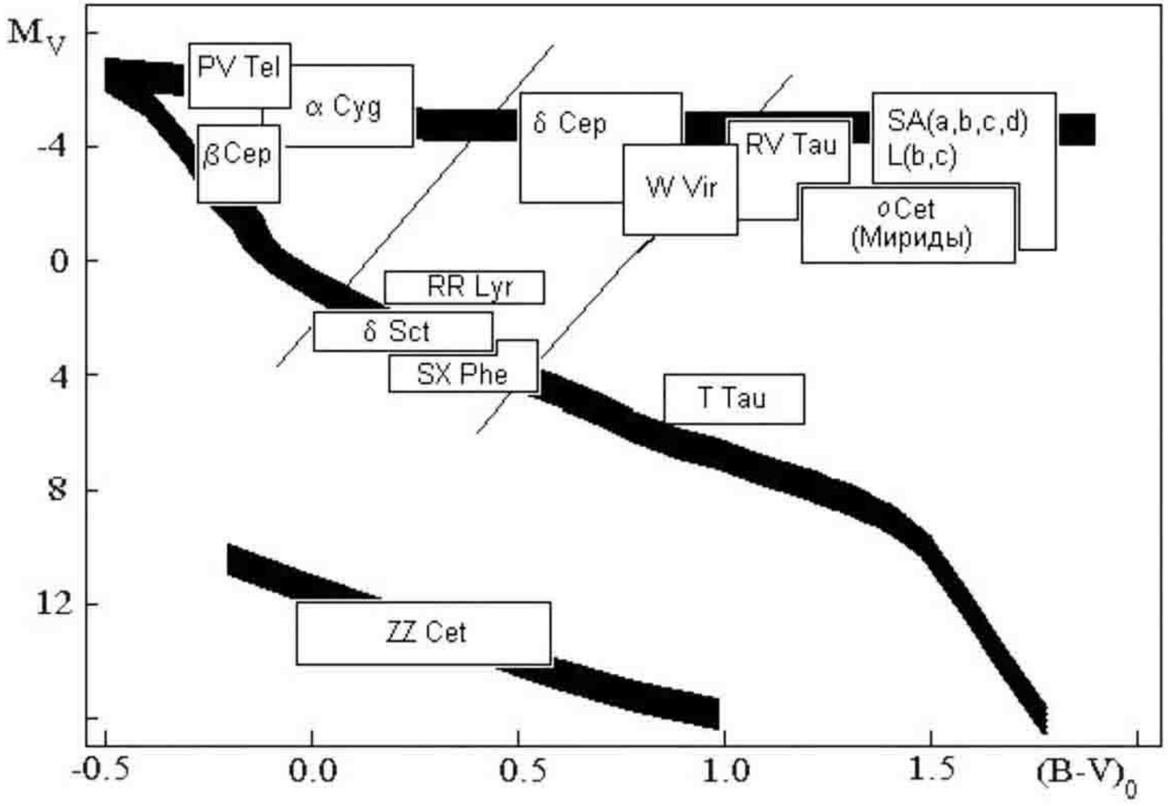
- Neither ``hot -- classical'', nor ``ultra-hot -- hot'' SD gap can be explained by a natural lack of such stars in the solar neighbourhood.
- Also, evolutionary scenarios do not predict any exhaustion of SD systems in these areas in the HR diagram.
- A possible ``hot -- classical'' SD gap explanation is that its location in the HR diagram coincides with the location of the instability strip. Crossing the instability strip in its evolutionary way in the HR diagram, a donor begins to pulsate as an RR Lyr (or probably del Sct) type variable. High amplitude pulsations can mask lower amplitude eclipses in the light curve. Consequently, the system is registered as an RR Lyr variable and is excluded from the SD statistics.

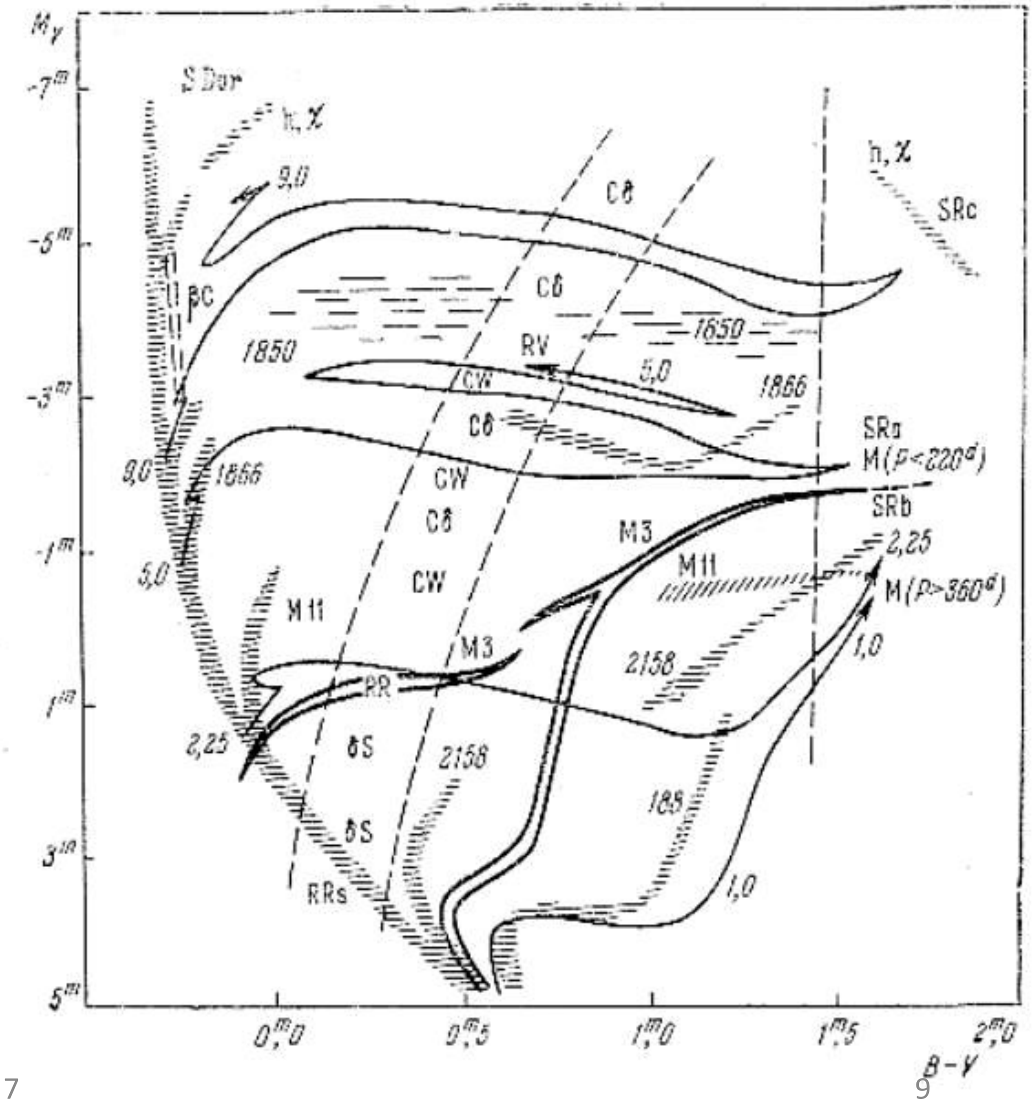
“Hot - classical” SD gap





Instability strips





Cool SD

- Two giant/subgiant stars can be formed in the Case AG of SD evolution computed by Nelson and Eggleton (2001) (the initial masses of components are about 3 and 2.5 solar mass, the initial period is about 2 days).
- However, in the Case AG, the accretor is always (after the initial phase of rapid mass transfer) more luminous than the donor, which is true for AV Del and may be true for RZ Cnc and RT Lac subgiant systems, but is not true for AR Mon and V1251 Tau giant systems.
- So the evolutionary stage of cool SD systems should be the object of further studies. Even an alternative detached status with the cooler component slightly underfilling its Roche lobe should not be completely ruled out.

Semidetached binaries with inverted parameters

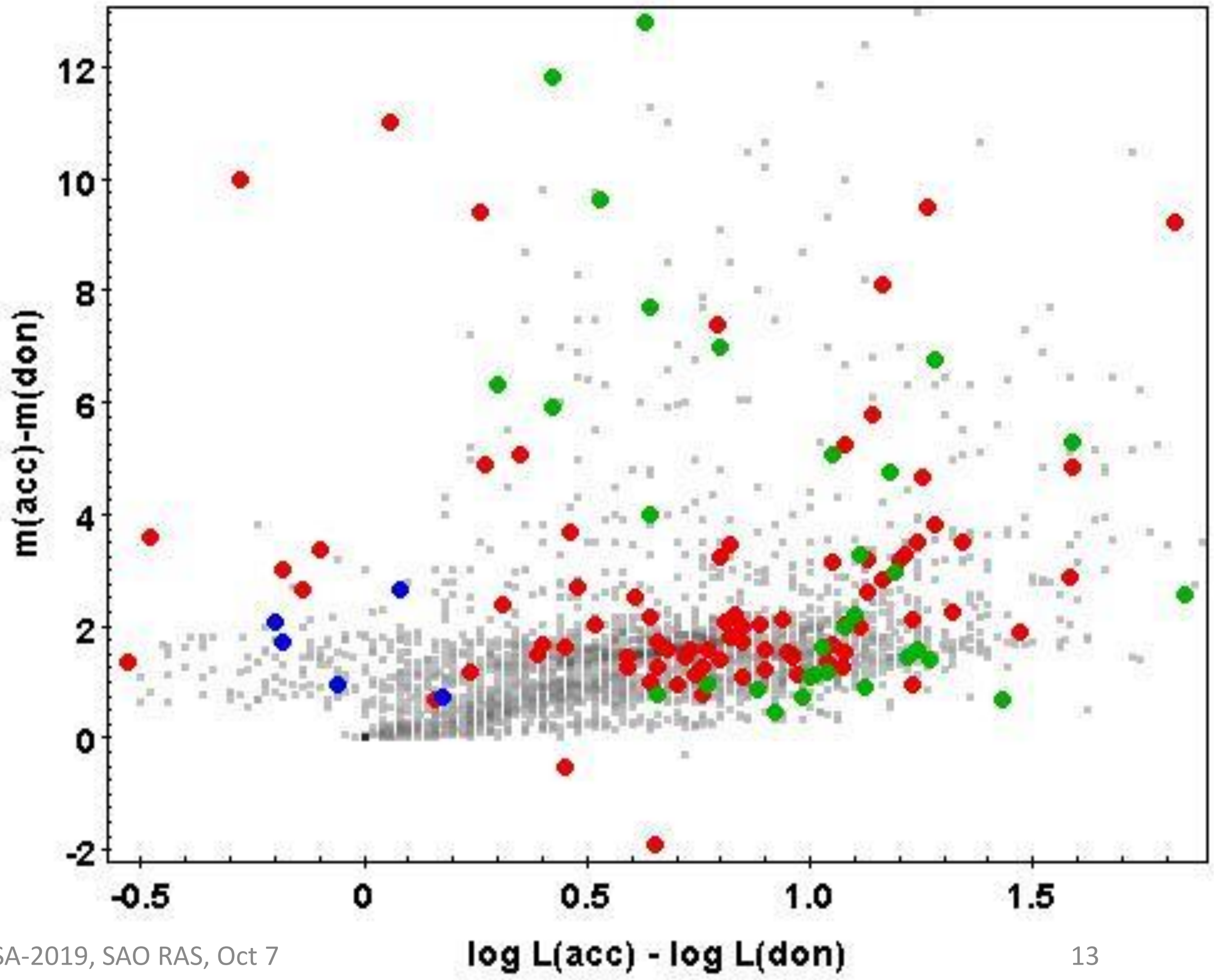
- Accretors are usually smaller, brighter, and more massive, and they are **always hotter** than donors. However, there are some exceptions to the rules.
- In the majority of SD systems, the accretor is **smaller** than the more evolved donor. However, in 31 (26%) systems in our sample the accretor is already larger than the donor. Obviously, all of them are among short-period binaries: the closer the system the more intensive the mass transfer.
- Two systems from our sample (UX Mon and SV Cen) are at the rapid mass transfer stage, and their accretors are still **less massive** than donors.

Semidetached binaries with inverted parameters

- Accretors of some SD systems demonstrate **smaller luminosity** than donors. Two groups of systems demonstrate luminosity inversion, namely (i) some of cool SD and low-luminosity classical algols, and (ii) the most luminous (ultra-hot) SD. As to the latter group, it is apparently Case AB of SD evolution computed by Nelson and Eggleton (2001) (the initial masses of components are about 8 and 6.3 solar mass, the initial period is about 3.5 days), where accretor and donor can have similar (and rather high) luminosities on some stages of their evolution.

Semidetached binaries with inverted parameters

- Luminosity difference vs. mass difference for components of SD systems.
- Large circles represent SD DLEB: blue circles are cool SD, green circles are systems with radius inversion, red circles are other SD DLEB.
- Smaller grey dots are SD from Catalogue of approximate photometric and absolute elements of eclipsing variable stars (Svechnikov and Kuznetsova 2004)



Conclusions

- Semi-detached (SD) eclipsing binaries provide an exceptional opportunity to measure fundamental properties of interacting stars. In the present study, we have compiled a comprehensive list of SD double-lined eclipsing binaries (DLEB), containing 117 systems with light curve and radial velocity curve solution.
- We have discussed a well-known ``hot -- classical -- cool'' SD classification scheme and shown that pulsation of donor stars can explain the ``hot -- classical'‘ SD gap in the HR diagram.
- We have indicated and discussed systems with inversed components' parameters (radius, luminosity, mass). Representatives of rare classes (cool SD, SD with mass inversion) require further study.
- The SD DLEB list will be uploaded to the VizieR database.

Благодарности

- РФФИ 19-07-01198, 18-02-00890
- ADS, SIMBAD, VizieR, Topcat
- Аудиторию – за внимание