CHEMICAL EVOLUTION IN ALGOLS

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ABSTRACT. We discuss the chemical abundance in Algol-type systems produced by different authors. Till this time most evolutionary changes in the chemical abundance of the components of Algols were studied by carbon depletion. We obtained the following results: 1) detections of carbon abundance in the atmosphere of donor were reported in two articles, but them don't show dependence from the mass ratio and the mass donor, 2) the carbon abundance in the atmosphere accretor for the same system in research different authors is very different, also it isn't dependency from the ratio of the masses and the masses of accretor. Summary: while were observed evolutionary changes in the carbon abundance for Algol's component, but a precision was low and studied the small number of systems and can not link to the carbon abundance and mass ratio and also the masses of the components – the basic parameters of the binary system evolution.

Key words: Stars: binary: abundances – binaries;close – stars; evolution – stars.

1. Introduction

The theory of evolution of close binary stars (CBS) predict significant changes of chemical composition of components as a result of nuclear processes inside stars couples and by exchange of matter, and, in contrast to the single stars, additional mechanisms of mixing in binary systems. De Greve & Packet (1990) have made calculations of the evolution of CBS with the analysis of the changes the chemical composition of the components in the case A (burning hydrogen in the core), and came to the conclusion that we can not explain the change in the chemical composition of the exchange only mixing in their atmospheres. In articles Sarna (1992) and Sarna & De Greve (1997) more fully present theoretical calculations of the change in the chemical composition of the components of CBS first phase of mass exchange for the evolutionary case AB and early B. Calculations of the evolution of CBS made using Pachinsky (1970) assumption: the total mass of $M = 4,6,10\ M_\odot$, the mass ratio $q_0 = 10/9$ and $10/4$, the relative abundance of hydrogen in the core for donor $X_C < 0.1$, nucleasynthesis calculate as Flower et.al 1975, in the case of non-conservative exchange accounted loss of angular momentum of the wind and the magnetic loss mass and angular momentum of the system of stellar winds. The change in the chemical composition of the atmospheres of the components are calculated according to the following mechanisms of mixing: 1) convective mixing in the donor, which can effectively change the CNO, only in the case of initial masses $< 3 \times M_\odot$ (mixing length $l > 0.1$) during a phase of slow exchange; 2) the accretion as a mechanism for mixing of the atmosphere accretor until the accretion rate is $\dot{M}_{accr} > 10^{-7} M_\odot$/year; 3) the thermohaline convection in the accretor, where the change of the molecular weight is positive $d\mu/dr > 0$ and the gradient transfer of radiative energy less gradient transfer of convective energy $\nabla_r < \nabla_{ad}$ is possible, when the time of accretion is much more time efficient diffuse mixing $\tau_{\dot{M}} >> \tau_{diff}$; 4) common envelope phase leads to equalization of the chemical composition of the components. The main conclusions of this work are as follows. 1) Were founded the real difference between the systems evolving from initial mass ratios of $q_0 = 10/4$ and $q_0 = 10/9$. The system with $q_0 = 10/9$ show twice the depletion of carbon of those with q0 = 10/4. It is concluded that the correlation between the carbon abundance and the mass ratio Algol, in a paper Cugier (1989), show only the bimodality of the initial mass ratio distribution for proto-Algol-type stars. 2) The conservative models have explained well the observed carbon abundance in accretor. 3) There is no significant differences in the chemical composition between case AB and early case B mass transfer. Determination of chemical composition of the components of Algol very difficult task for the following reasons: the high speed components, the total spectrum of the two components, the effect of gas envelopes on the spectral lines, the effect of gas envelopes at the level of the continuous spectrum of the system, the effects of reflection. Hence, in the spectra of these systems are observed mainly strong blended lines. So the definition of evolutionary change in the chemical composition of Algol-type systems on the same line as were done in Cugier, 1989; Ibanoglu

et al., 2012 may not be accurate and may lead to incorrect conclusions. In last years were published works in which the chemical composition of Algol-type systems is determined for all the lines in a wide range of wavelengths. The purpose of this paper is to review all the published definitions of chemical elements in the spectra of components of Algol, calculating correlations of carbon content on the main parameters of the system and the comparison with theoretical studies.

2. Comparison values of carbon abundance for Algol-type systems

In Table 1 are collecected all available observational determinations for carbon and other chemical elements abundatce in Algol-type systems. There data are from Parthasarathy et al., 1983 (1), where the analysis of molecular lines CH 4310A, CN 4215 and 3883 for the donor systems U Cep and U Sge with accuracy 0.3 dex; Cugier 1989 (2) studied multiplets of CII 1324 and 1335 Å for accretors 6 systems with accuracy 0.2 dex; Yoon & Honeyocutt, 1992 (3) searched g-band of the CH molecule for 12 donors of Algol-type systems with precision 0.15 dex (standard lgN_C=8.43); Tomkin&Lambert 1989 for R CMa (5) and Tomkin et al., 1993 (5) studed carbon abandance using line CII 4267 for accretors 8 systems with precision 0.15 dex, (standard $lgNC = 8.28$), Tomkin & Lambert, 1994 (4) analysis CI,NI and OI lines of visual and near-ifrared regions in the donor of system V356 Sgr with accuracy 0.1 dex, Ibanogly et al., 2012 (6) studed the line CI 4267 Å in accretors for 15 systems with precision 0.2 dex (standard lgN_C=8.52). The first six columns of Table 1 are the names of the systems, the donor (II) or accretor (I), the orbital period, mass ratio and mass of accretor and donor. The next six columns are carbon abandance $[N_C/N_{tot}]$ and abandance other chemcal elements with references for these values. We took lgN_C = 8.52 for the solar abandance in Table 1 adopted from Grevesse and Sauval (1998). As we can see, that all attempts to study the chemical evolution of Algol were based on an analysis of mostly one element – carbon.In column 10 (4) of Table 1 shows the abandance of elements CNO cycle and iron for Algol-type systems, obtained by high-resolution spectra in the following work: R CMa – Glazunova et al., 2009, RZ Cas – Tkachenko et al., 2009, TW Dra – Tkachenko et al., 2008, TX UMa – Glazunova et al., 2011, V365 Sgr – Tomkin & Lambert, 1994. Model parameters for atmosphere accretors these components were refined over the observed and synthetic spetra in long wavelengths region, which allowed us to obtain a reliable estimate of the abandance of various elements.

We have calculated the coefficient of correlation between the carbon abandans and the basic pa-

rameters of the system – the mass ratio q and the component's masses of M_{don} and M_{accer}. Coefficient of correlation between the mass of the accretor and its carbon abandance is 0.25, and between the ratio of the mass and carbon abandance – 0.01. Coefficient of correlation between the ratio of the masses and the carbon abandance of the donor is also equal to 0.01, and between the carbon abandance in the atmosphere of the donor and his mass – 0.1 (excluding V356Sgr). As we can see, there is no relationship between the ratio of the masses and the chemical composition of the carbon, as the theory predicts, and were obtained in 1989 to 6 Cugier systems. Ibanogly et al.2012 for 15 Algol were obtained dependent deficit of carbon abandance in atmocphere of accretors of mass transfer rates in the systems, but this relation is uncertain, as virtually all of Algol their list are located in the phase of slow exchange with mass transfer rate $< \dot{M} = 10^{-9}M_{\odot}$/year.In this evolution phase the period of change mainly quasi-periodically or abruptly in consequence of the chromospheric activity of the donor, so the accuracy of the determination mass transfer rate out of the period of the change could not be better order.

3. Conclusions

1) Systems listed in Table 1 have a significant deficit of carbon. The mean values of the carbon abandance in the atmosphere of the donor (-0.65) and accretor (-0.57) were similar and significantly higher than the deficit of carbon for single giants (-0.24). 2) Lack of atmospheric carbon donor in 9 systems in Table 1 does not depend on its mass, and therefore there is no mechanism for the transfer of dependence – convection or radiant, although theoretical studies predict such a relationship. 3) Comparison of carbon in the atmosphere accretor obtained by different authors, such as system or δ Lib, RS Vul and others, show large differences exceeding the accuracy of its determination in these works. It is related to the accuracy of atmospheric parameters and with the methods of calculation of the chemical composition. For example, to determine the chemical composition of the accretor TX UMa used the following temperatures: Cugier, 1989 (2) – 12900 K, Glazunova et al., 2011 – 12900 K, Tomkin et al., 1992 (4) – 13300 K, Ibanogly et al., 2012 (6) – 13600 K. Hence the carbon abundance to differ for this system because has a strong dependence of the equivalent widths of carbon on temperature. Important to consider blending the lines of the secondary component, depending on the phase of the orbital period, so the equivalent width of the line carbon CI 4267 AA Systems for RZ Vul different authors is very different: 88mA – Ibanogly et al., 2012 (6) and 144mA – Tomkin et al., 1992 (4).

Table 1: Observed binary systems.

name	comp	P(day)	q	M_{accr}	M_{don}	(1)±.2	(2)±.15	(3)±.15	(4)±.15	(5)±.1	(6)±.2
RV Psc	II	0.6	0.6					CH(-1.22)			
X Tri	II	0.99	0.51		1.2			CH(-.41)			
R CMa	I	1.13	0.14	1.8			C(.0) N(.4) O(.3) Fe(.1)		C(.07) N(-.04) O(.01) Fe(.02)		
RZ Cas	I	1.17	0.34	2.0					C(.03) O(-.13) Fe(-.16)		
IM Aur	I	1.30	0.33	2.4							C(-.72)
V1898 Cyg	I	1.50	0.2	6.1							C(-1.26)
V548 Cyg	I	1.8									C(-.25)
RW Mon	II	1.9	0.39		0.99			CH(-1.08)			
HU Tau	I	2.1	0.27	4.5							C(-1.12)
U Her	I	2.1	0.36	7.8			C(-.1)			C(-.58)	
δLib	I	2.3	0.35	4.8			C(-.1)			C(.0)	C(.54)
U Cep	I	2.5	0.58	4.0							C(-1.24)
	II				2.3	C(-.45) N(.5) O(0)					
Z Vul	I	2.5	0.41	5.4							C(-.69)
TZ Eri	II	2.6	0.19		0.37			CH(-1.26)			
DM Per	I	2.7	0.28	7.3							C(-.78)
TW Dra	I	2.8	0.47	1.6					C(.08) O(-.14) Fe(.16)		C(-.34)
	II				0.74			CH(-.61)			
RR Dra	II	2.8						CH(-.18)			
RW Tau	II	2.8						CH(-.81)			
βPer	I	2.9	0.22	3.7			C(-.35)			C(-.46)	
TX UMa	I	3.1	0.3	4.5			C(-.32)		C(-.31) O(.05) Fe(.0)	C(-.59)	C(-.46)
WW Cyg	II	3.3	0.31					CH(-.55)			
U Sge	I	3.4	0.34	5.7			C(-.02)			C(-.42)	C(-.1)
	II				1.9	C(-.5) N(.55) O(.0)					
U CrB	I	3.5	0.29	4.8			C(-.41)			C(-.86)	C(-.80)
λ Tau	I	4.0	0.26	4.8			C(-.40)			C(-.72)	
TW And	II	4.1	0.19		0.3			CH(-.47)			
GU Her	II	4.3						CH(-.34)			
RS Vul	I	4.5	0.31				C(.0)			C(-.40)	C(-.99)
GT Cep	I	4.9	0.34								C(-1.91)
TU Mon	I	5.1	0.21	12.7							C(-1.41)
UX Mon	II	5.9	1.15		3.7			CH(-.68)			
V365 Sgr	II	6.8	0.39		4.7				C(-2.05) N(.8) O(-.33) Fe(-.32)		
RY Gem	I	9.3	0.18	2.8						C(.13)	
S Cnc	I	9.5	0.09	2.5						C(-.53)	
	II				0.23			CH(-.53)			
AU Mon	I	11.1	0.15	5.97						C(-1.88)	

For the determination of carbon in accretor system U Sge used parameters: Teff = 13,200 K, W (4267) = 58 mA – Tomkin et al., 1992 (4), and Teff = 13 900 K, W (4267) = 104 mA – Ibanogly et al., 2012 (6) and so long. Consequently, we must be very careful using the values of chemical elements from research, in which were defined the chemical abundance without taking into account the orbital phase and blending the lines of the secondary component, and without specifying the model parameters by comparing the observed and synthetic spectra over a wide wavelength range.

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