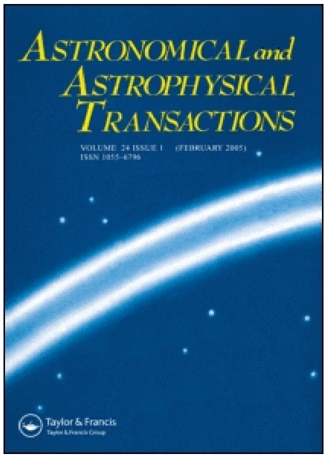
This article was downloaded by:[Bochkarev, N.]
On: 18 December 2007
Access Details: [subscription number 788631019]
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954
Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Astronomical & Astrophysical Transactions

The Journal of the Eurasian Astronomical Society

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Stream formation at the inner Lagrangian point in close binaries

V. G. Karetnikov [a]; V. V. Nazarenko [a]
[a] Astronomical Observatory, Odessa State University, Odessa, Ukraine

Online Publication Date: 01 July 1996

To cite this Article: Karetnikov, V. G. and Nazarenko, V. V. (1996) 'Stream formation at the inner Lagrangian point in close binaries', Astronomical & Astrophysical Transactions, 10:4, 273 - 276
To link to this article: DOI: 10.1080/10556799608205439
URL: http://dx.doi.org/10.1080/10556799608205439

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article maybe used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Astronomical and Astrophysical Transactions, 1996,
Vol. 10, pp. 273–276
Reprints available directly from the publisher
Photocopying permitted by license only

ASTROPHYSICS

STREAM FORMATION AT THE INNER LAGRANGIAN POINT IN CLOSE BINARIES

V. G. KARETNIKOV and V. V. NAZARENKO

Astronomical Observatory, Odessa State University, T. G. Shevchenko Park, Odessa 270014 Ukraine

(Received November 8, 1994)

Stream formation at the inner Lagrangian point was calculated for different types of binaries on the basis of non-stationary hydrodynamical equations, the "big-particle" code by Belotserkovskii and Davydov and the atmosphere model from Kurucz's grid. The types of binaries are W Ser stars, semi-detached binaries and W UMa stars. Our calculations show that physical conditions for the Roche lobe overflow are different for different binaries and a standard Roche lobe overflow regime does not occur for all the binaries. The stream size is 0.02 (U Gem)–0.15(β Lyr) in units of the orbital separation of the binary components. The degree of the Roche lobe overflow is such that atmosphere layers occur at the inner Lagrangian point with optical thickness equal to 100 for W UMa stars, 70 for W Ser stars, and less than 1 for the semi-detached binaries.

KEY WORDS Non-stationary numerical hydrodynamics, model atmosphere, stream formation, the inner Lagrangian point

We consider formation of a stream near the inner Lagrangian point (L_1) using methods of numerical hydrodynamics for the different close binaries. These binaries are β Lyr, RY Sct and V367 Cyg (as examples of W Ser stars); AO Cas, XZ Cep, V448 Cyg, RY Gem, RY Per, CX Dra and TX UMa (as examples of semi-detached binaries); and W UMa, AW UMa and SW Lac (as examples of W UMa stars). The numerical code is based on the "big-particle" approach of Belotserkovskii and Davydov (1982); non-stationary hydrodynamic equations written in Euler form were used. The present calculations were performed in two planes: the orbital and perpendicular ones. Equations of motion are integrated until physical parameters of the stream settle to steady values. Thus, a stationary stream structure in the vicinity of L_1 is calculated. The initial stream structure is constructed using stellar atmosphere models from Kurucz's grid (Kurucz, 1979). Our calculations take into account the gravitational field of a binary, the centrifugal force of the orbital motion, synchronous rotation of the mass-losing star (the secondary). The calculations show that the Coriolis force does not change the stream radius in L_1, therefore this force is neglected in our calculations. The interaction between the moving gas and radiation was calculated in implicit way, a lower ratio of specific heats

Table 1.

System	$M_1(M_\odot)$	$M_2(M_\odot)$	*T(K)*	$A(R_\odot)$	R_r	$P_0(d)$	$\dot{M}\ (M_\odot/year)$
W Ser-type							
β Lyr	2	12	11,000	55	0.22	13	$6\ 10^{-6}$
RY Sct	10	33	28,000	75	0.27	11	$1\ 10^{-6}$
V 367 Cyg	2.3	3.6	12,000	53	0.35	18	$3\ 10^{-6}$
Semi-detached binaries							
AO Cas	17	23	39,000	33	0.36	3.5	$1\ 10^{-7}$
XZ Cep	14	18	25,000	40	0.36	5.1	$2\ 10^{-7}$
V 448 Cyg	8	21	22,000	45	0.29	6.5	$3\ 10^{-7}$
RY Gem	0.4	2.2	4,220	28	0.23	9.3	$2\ 10^{-7}$
RY Per	2	6.7	5,800	31	0.27	6.9	$5\ 10^{-9}$
CX Dra	2	7	6,500	30	0.27	6.7	$2\ 10^{-8}$
TX UMa	1	3.2	6,800	14	0.28	3.1	$1\ 10^{-8}$
W UMa-type							
W UMa	1.2	0.6	6,000	2.4	0.46	0.46	$1\ 10^{-8}$
SW Lac	1.2	0.7	5,500	2.6	0.46	0.32	$2\ 10^{-7}$
AW UMa	2.5	0.2	7,400	3.4	0.57	0.44	$1\ 10^{-8}$

($\gamma = 4/3$) was adopted. Boundary conditions in the present calculations were the following: deep in the secondary's Roche lobe ρ = constant; T = constant; velocity is equal to zero. On the other boundaries of the computational domain, the values of physical variables involved are calculated from the nearest inner neighboring cells using extrapolation formulae. Thus, the boundary values are determined at the each time step by internal stream structure. The average cell size ranges from 10^{-3} (β Lyr) to 10^{-5} (W UMa). Henceforth, distance is measured in units of the orbital separation of the binary components.

Parameters of the binaries investigated are given in Table 1 where M_1 is the mass of the secondary; M_2 is the mass of the mass gaining star (the primary); T is the effective temperature of the secondary; A is the orbital separation in units of the solar radius; R_r is the average radius of the critical surface of the secondary; P_0 is the orbital period; $\dot{M}$ is the mass transfer rate through L_1 in units of the solar mass per year.

The degree of the Roche lobe overflow by the secondary and the stationary stream structure are determined by the following condition: mass transfer rate obtained from calculations must be equal to that obtained from observational data.

Our calculations show that the stream radius is similar for the binaries of one type and is different for the different types of binaries.

The qualitative stream structure in the vicinity of L_1 is similar for all the investigated binaries. Density varies by a factor of three or four along the stream axis. Temperature distribution in the computational domain is isotermic if the effective temperature is less than 10,000–15,000 K. For higher effective temperature, the temperature changes by 10–20% with respect to that at L_1. Gas velocity at L_1

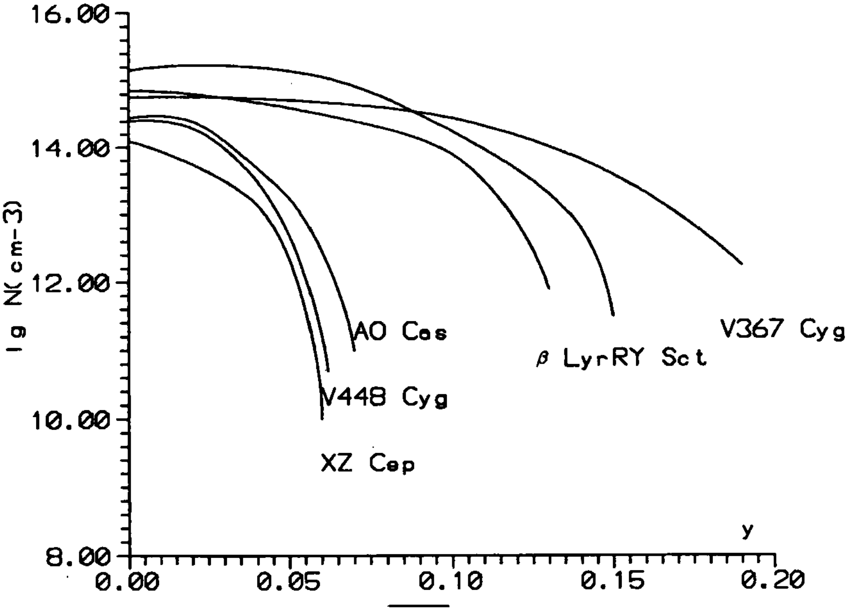


Figure 1 Density distribution in the direction perpendicular to the stream axis at the inner Lagrangian point for W Ser stars and AO Cas stars.

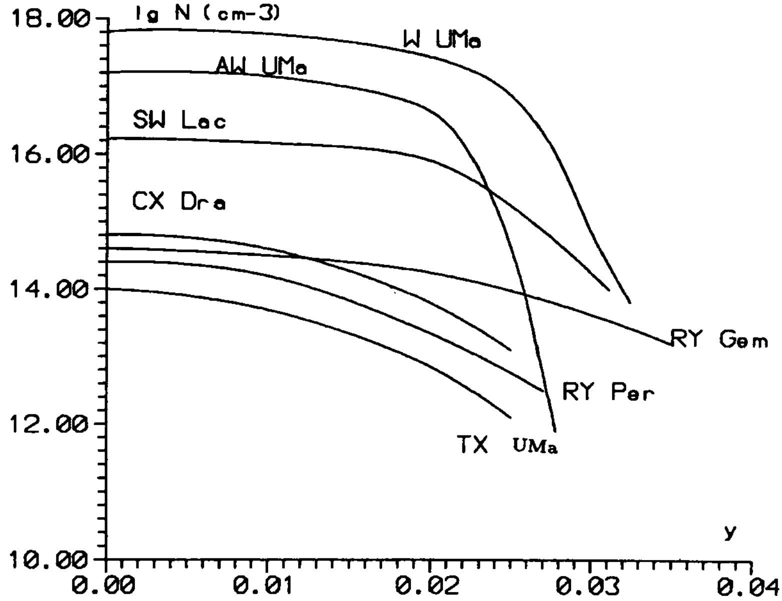


Figure 2 Density distribution in the direction perpendicular to the stream axis at the inner Lagrangian point for the semi-detached binaries (CX Dra, RY Gem, RY Per, TX UMa) and W UMa stars.

is equal to the local sound velocity in all the binaries. The stream radius is defined by the following: the density variation in the direction perpendicular to the stream axis must be equal to that in the initial atmosphere model chosen from Kurucz's grid.

The result of calculations are somewhat unexpected in the case of W Ser stars (Figure 1). In these binaries, the stream radius exceeds by more than 50% the average radius of the secondary's Roche lobe. This apparently explains the physical peculiarity of W Ser stars. The calculated stream radius for the semi-detached binaries shows that these split into two groups: AO Cas, XZ Cep and V448 Cyg have the stream radius equal to 0.05–0.07 (Figure 1). The remaining semi-detached binaries have this radius equal to 0.02–0.04 (Figure 2). The stream radius for W UMa stars is also considerable (about 0.04).

The degree of the Roche lobe overflow for the binaries investigated is the following: atmosphere layers with optical thickness 70–80 reside at L_1 in W Ser stars; those with optical thickness 2/3 occur at L_1 in AO Cas, XZ Cep and V 448 Cyg; they have optical thickness 10^{-1} in the other semi-detached binaries and 100 in W UMa stars.

The main result of the present calculations is the following: the smaller orbital separation in binaries the less stream radius in the vicinity of L_1.

References

Belotserkovskii, O. M. and Davydov, Yu. M. (1982) *The Method of "Big Particles" in Gas Dynamics*, Moscow, Nauka (in Russian).
Kurucz, R. L. (1979) *Astrophys. J. Suppl.* **40**, 1.