ON THE DETERMINATION OF MASSES OF COMPONENTS USING SPECTRA OF DEVELOPED CIRCUMSTELLAR STRUCTURES AND THE CASES OF RY Sct AND β Lyr

M. Yu. Skulskij
Lvov Politechnic Institute, 290013 Lvov, USSR

It is well known that the masses of the components of binary systems cannot be derived unless the lines of both their components are observed. But there is another possibility how to obtain an information about the masses in the case the lines of some gaseous circumstellar structures in the spectrum are present Skulskij (1976).

The method itself is based on a comparison of the observed radial velocities from the lines of the gaseous stream moving between the components and the lines formed outside the Roche lobe with the parabolic velocities of trial particles ejected through the Lagrangean point L_2 out of the system.

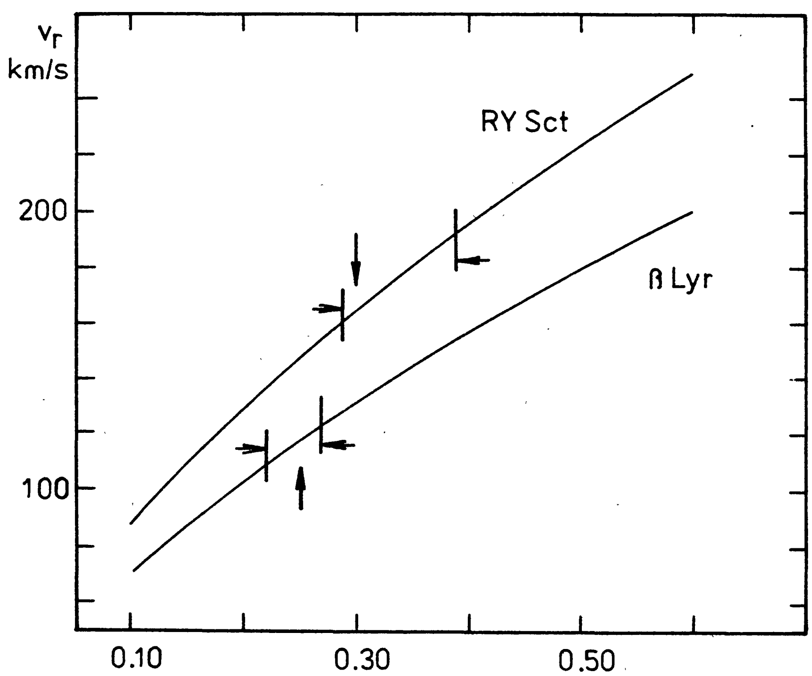
For a practical utility of the method, it is necessary to represent the gravitational field of the binary with a family of equipotential surfaces precisely defined by the Roche model. These equipotentials are well defined when the constans C_1, C_2 and C_3 ($C_1 > C_2 > C_3$) corresponding to the Lagrangean points L_1, L_2 and L_3 are known. In the practical computation, one can normalize the potential so as $C_i = f(q)$, where $q = M_2/M_1$ is the mass ratio of the components. The surfaces are identical with the Jacobi surfaces of zero velocities in the restricted three-body problem and therefore, we can solve the equations of motion of some trial particles and to express the constatnts C_i as a function of the velocity v, or, inversely derive $v = f(q)$. Thus, calculating C_1, C_2 and C_3 for different q (the corresponding tables are in Plavec and Kratochvíl (1964), one can derive the parabolic velocity of the particles, because $v_{par.\ rel.} = \sqrt{C_1 - C_2}$. After introducing the orbital velocity units

$$v_{orb} = 2\pi A/P = [G(M_1 + M_2)/A]^{1/2} ,$$

A is the distance between the mass centers of the components and P the orbital period, and after transforming the dimensions of the stars into the absolute units, we can find the absolute parabolic velocity $v_{par.\ abs.} = v_{orb.} \times v_{par.\ rel.}$.

Then, once the radial velocity of one component was determined, A, M_1, M_2, $v_{orb.}$ and $v_{par.\ abs.}$ in a wide range of q can be calculated. In other words, have derived the critical potentials, one can compare the parabolic velocity with the velocities of the gaseous matter within and outside the Roche surfaces and, in this way, inversely to determine the limits of the mass ratio for a concrete close binary systems. From this point of view the method is indepenedent of all other methods used for determination the masses of components of binary systems.

The method was applied to two systems - β Lyr and RY Sct (Skulskij, 1976; 1985). In both stars, one can observe two independent systems of spectral lines: the first one is characterized with strong absorptions in H and He I formed in the matter moving inside the external Roche surfaces. Their radial velocities are less than parabolical and are negative in all phases from -30 km/s to -110 km/s for β Lyr and from -100 km/s to -170 km/s for RY Sct. The matter, flowing from the bright component as anisotropic star wind that grows stronger in the vicinity of the weak component and surrounds the latter with a system of fanlike gaseous streams. The second system of spectral lines consists of He I lines at a lower meta-stable state (for example He I λ 3888) in which narrow and deep components possessing in the absorption the constant radial velocity during all orbital phases can be observed. Their radial velocities exceed the parabolic: -122 km/s for β Lyr and -192 km/s for RY Sct. They prove that there are expanding external gaseous envelopes embedding both components in the both binaries.



Fil. 1. The parabolic velocities given by the curves separately for RY Sct and β Lyr. The arrows limit the mass ratio as derived from the observational data. The vertical arrows define the mass ratios as derived from the radial velocity curves in the common way.

Comparing the calculated $v_{par.\ abs.}$ with the maximum observed valocities in the gaseous streams and in the external envelope we obtained $0.22 \leq q \leq 0.27$ for ß Lyr and $0.29 \leq q \leq 0.39$ for RY Sct. The direct determination mass ratio by means of absorption lines of both components corresponds to $q = 0.25$ for ß Lyr and $q = 0.30$ for RY Sct (Skulskij, 1975; 1990), Fig. 1.

One can conclude that in spite of some mathematical simplifications the method brings a new possibility of obtaining an important information about the masses of components in close binaries and, therefore, can be used for a practical application.

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