ON THE INTERCOMPONENT EMISSION IN CLOSE BINARY SYSTEMS

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Abstract. An empirical relationship is discovered for RS CVn type close binary systems between their absolute luminosity, \( L(\text{MgII}) \), of the ultraviolet magnesium doublet 2800 \( \text{MgII} \), and the intercomponent distance \( a \) of the system. It has the following form: \( L(\text{MgII}) \sim a^n \) (Figure 1). It is shown that for the overwhelming majority of binary systems \( n = 1 \) (Figure 4). This correlation presents itself as a direct confirmation of the intercomponent origin of the observed emission, particularly, in the magnesium doublet in close binary systems. The basic relationship of intercomponent emission is derived in the form: \( L(\text{MgII}) = 1.0 \times 10^{32} a \) ergs s\(^{-1}\). At the same time, accidental statistical divergences from this correlation are possible on both sides: as \( n > 1 \) as well \( n < 1 \) (Figure 4). The correlation \( n = 1 \) determines also the character, i.e. cylindric for a stream of the transfer of gaseous matter from one component of the system to the other, and in the general gas dynamics of the intercomponent medium.

The existence of a new category of stellar atmosphere, which we call roundchrom, is predicted, representing the common chromosphere of a superclose binary system, surrounding or blending both components of the system (Figure 3). The boundaries between the three most important divisions of magnesium doublet emission – chromosphere of single stars, roundchrom of superclose binary systems and intercomponent space – are established for RS CVn type systems. Finally, a number of new problems, both observational and theoretical, are brought forward.

1. Introduction

The emission power of the ultraviolet doublet 2800 \( \text{MgII} \) in RS CVn or Algol type binary systems is one-two orders higher compared with that which we have in single stars of medium spectral classes, later than \( F \). In contrast to single stars, in which this doublet is invariantly of chromospheric origin, the observed magnesium emission in close binary systems is generated almost completely in their intercomponent space. A positive correlation between absolute magnesium luminosity, \( L(\text{MgII}) \), in \( k \) and \( h \) \( \text{MgII} \) doublet, and linear distance, \( a \), between the components of binary system, should be taken as a determining argument in favour of this concept.

This correlation was discovered empirically on the basis of analysis of one group of sixty RS CVn type systems for the \( k \) and \( h \) \( \text{MgII} \) doublet, generated by gaseous matter during its transfer from one component of the system to another. Among the various results, some parameters of the motion of the gaseous stream in the intercomponent space are derived as well.
2. Dependence of Magnesium Emission on Intercomponent Distance

In order to establish the dependence of the MgII(2800) doublet on the intercomponent distance in close binary systems the following data, at least, are required:

a) the period of orbital rotation, $P$;
b) observed flux, $F(MgII)$, in $k$ and $h$ lines;
c) distance of star (binary system),
d) as additional data, the spectral and luminosity classes of the components and their masses.

These data are enough in order to determine, firstly, the absolute luminosity, $L(MgII)$, of the system in units of ergs s$^{-1}$ according to the relationship:

$$L(MgII) = 4\pi D^2 F(MgII) 10^{0.4D\alpha}$$

(1)

where the last term to the right takes into account the common interstellar extinction around $\lambda = 2800$ Å with specific absorption $\alpha_\lambda = 2$ mag on 1 kpc (Nandy et al., 1975). Secondly, the intercomponent distance $a$ is found with the help of relationship:

$$a = P^{2/3} \left( \frac{k}{2\pi} \right)^{2/3} \left( \frac{m}{m_\odot} \right)^{1/3} = 1.96 \times 10^{-2} P^{2/3} \left( \frac{m}{m_\odot} \right)^{1/3},$$

(2)

where $a$ measured in AU, $P$ in days, and $m$ is the total mass of the system. The dependence of $a$ on $m$, as we see, is rather weak, hence even an approximate value of the mass of the system is enough for a reliable determination of the intercomponent distance.

As a rule, the orbital periods $P$ are determined with high reliability, which is not the case for the distance $D$. In the majority of cases, the individual distances of RS CVn type systems, obtained by various investigators, differ not very much from each other. However, in some cases the differences are rather large – a factor of two or more. Therefore, an individual approach is required for every object, taking into account various factors or considerations.

The observed fluxes $F(MgII)$ were obtained using only IUE recordings of the profiles of $k$ and $h$ MgII lines. In this case knowledge of the orbital phase of observations is not so important. For the solution of our problem it is enough to know a mean flux only. The dependence with orbital phase affects mainly the form and power (strength) of the central self-absorption kernel (Simon et al., 1982; Gurzadyan, Perez, 1991).

In view of the foregoing demands, the data, more or less homogeneous, are collected for 60 objects – RS CVn type or Algol systems – and are presented in Table I. Here, the periods of orbital rotation $P$, spectral types and luminosity classes of components, as well as the distance $D$, with certain exceptions, are from Strassmeier et al. (1988). The observed flux of magnesium emission $F(MgII)$ are presented in fifth column with main references in sixth column (Basri et al., 1985; Schrijver, and Zwann, 1991; Budding et al., 1982) and more detailed references for each object. In the last two columns the numerical magnitudes of Log $a$ and Log $L(MgII)$, obtained with the help of relationships (1) and (2) are given.