THE ECLIPSING BINARY SYSTEM BM ORI

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ABSTRACT. Photometric and spectroscopic features of eclipsing binary system BM Ori can be described well by a model in which the components are the primary star B3 ZAMS, the secondary F2 pre-main sequence star and a dusty envelope of large grains around the secondary. The eclipse on ingress and egress phases has been produced by a dust envelope only, but during the total phase the F2 star makes yet the partial eclipse.

Eclipsing binaries in which the major puzzle is a nature of an eclipsing body are considered. Some parameters indicate that candidates to relative objects to BM Ori can be ϵ Aur, TY CrA, θ^1 Ori A and variable stars in multiple systems.

Key words: Stars: eclipsing binaries, young stars

BM Ori is a wellknown eclipsing binary in Trapezium Ori. It is among extremaly young objects. Its age is estimated from $2x10^4$ yr (Wilson 1972) to $3x10^5$ yr (Vitrichenko 1996c, 1997b). Photometric and spectral features of this system allow to call it as unique object (Zakirov, Shevchenko 1982).

The major puzzle of star is a nature of eclipsing body. There are some models to explaine the secondary origin: it may be a star (Parenago 1947; Antokhina et al. 1989); a disk (or a ring) around an invisible star, which may be a black hole (Wilson 1972); semitransparent envelope around invisible star (Shevchenko, Zakirov 1977), a disk, in which a luminosity of central part corresponds to F or G star (Zakirov, Shevchenko 1982).

These models describe well enough the light curve in V band, but further observations in different spectral ranges are required to confirm or except them.

The new photometric and spectroscopic study of BM Ori were made in 1994-96. The photometric results are based on the original and earlier published UBVRI and infrared observations and present the photometric behaviour of BM Ori up to 10.7 mkm (Bondar, Vitrichenko 1995, 1996a,b,c; Vitrichenko, Larionov 1996).

In general the following features have been taken. The secondary minima did not discovered in any UBVRI band. Analysis of O-C for all data and on ingress, egress and total phases show no changing in period on observing interval covered about 70 years. This fact excepts the mass loss in the system. The depth of minimum depends on wavelenghts. Analysis of this dependence reveals a presence of non-selective absorption produced by the envelope grains. Change of the minimum form has been suspected. If it is real the dimension of eclipse body is changing on 0.03 % per year.

The light curve is unstable. There are detected flares on outside and on eclipce with duration ~ 2 hours and amplidute up to $0^m.5$ in U. The energy distribution of flare corresponds to Rayleigh-Jeans law. The probability of the flare activity is estimated ~ 15 %. The calculations shown that continuum in region 0.36–10.7 mkm can be presented as the sum of the flux from the primary star B3 ZAMS, the secondary pre-main sequence F0 star and a dust matter around it with temperature about 1100^o K.

The spectroscopic data allow to derive physical parameters of system (Vitrichenko et al. 1996).

Amplitude of radial velocity determined from hydrogen lines is less than amplitude determined from helium lines. The cause of such difference is the doublicity of star. Hydrogen lines are the superposition of lines of main and secondary stars and helium lines are formed only on the main star. The syntethic spectrum corresponds well to observing one in assuming that lines are produced by the main star B3 and the secondary F2 (Vitrichenko, Tzymbal 1996).

Basing on photometric and spectposcopic results a following model of BM Ori were considered in detail (Bondar', Vitrichenko 1997; Vitrichenko 1997b). The primary B3 ZAMS star is eclipsing by the dust envelope surrounding the secondary pre-main sequence F2 star. The ingress and egress phase are produced by the dust envelope and near to the central part of total eclipce the F2 star makes the partial eclipce yet.

The nature of dust is discussed by Vitrichenko (1997a). The best agreement with observations are given the envelope from SiO_2 drops and grains which sizes are ~ 2 mkm. The suggestion that extensive dust envelope around the secondary may be responsible for the eclipce in BM Ori system were proposed earlier by Shevchenko, Zakirov (1977).

It is interesting to search for relative objects to BM Ori. Such question were discussed by Wilson (1972).

He considered some observational arguments indicating a similar origin of eclipsing body in ϵ Aur and BM Ori and introduced a common model for these systems in which the secondary is a black hole. Earlier such model were propesed for β Lyr, but soon he declined it. New observations of ϵ Aur in 1982-84 did not confirm this model too. A hot early B star was found in system from IUE observations (Ferluga, Hack 1985). But the idea that BM Ori and ϵ Aur would have a common mechanism of eclipce remains interesting to consideration.

Search for an analogy between these stars is based on the quantitative characteristics. Basic features of these stars are given in Table 1.

Some parameters described light curves and spectrum in eclipse are similar. It is not rule out that ϵ Aur is a young system too and the difference in evolutionary stage of these systems can be explained by the difference in masses of their components. Hack (1984) proposed too that ϵ Aur would be on a short scale of evolution.

TY CrA may be suspected as relative object to BM Ori (Vitrichenko et al. 1995). Some arguments indicate a precense of dust in the system. Radius of secondary F2 star is greater one of normal star. Infrared excess has been detected in the system radiation. As in the case of BM Ori the eclipce can be explained by a dust matter. Spectral features confirm an analogy between these stars too. There are detected in spectrum of secondary only NaD line.

According Zakirov (1979) photometric behaviour of θ^1 Ori A may be explained similar to BM Ori. New facts taken from spectrographic and photometric investigations confirm this suggestion (Bondar', Vitrichenko 1997).

The considered samples allow to assume that stars related to BM Ori are exhibited the excess of radii and infrared flux and would be detected with a high probability in the star formation regions, particular among the stars in multiple systems.

Table 1. Comparison of features of two binary systems

Features	BM Ori	ϵ Aur
Photometric properties		
The depth of eclipse in V	$0^m.7$	$0^m.8$
The flat bottom during total eclipce	+	+
Non-selective absorption by secondary	0.36-0.97	0.17-4
The secondary minima is not detected	+	+
The form of minima is changing	+	+
The duration of eclipse to duration of total eclipse (D/d)	1.93	2.16-1.65
The brigthness is irregular on outside and on eclipce	+	+
Spectral properties		
The spectrum of primary star is visible always on the all phases	+	+
The spectrum of secondary is invisible on the total phase	+	+
The flux from secondary dominates in the region	IR	UV
The dust radiation is detected	+	+
Physical parameters		
$M_1/M_\odot$	6.3	1.5–16
$M_2/M_\odot$	2.5	4-15
$R_1/R_\odot$	2.5	> 150
$R_2/R_\odot$	1.9	3-5
M_{v_1}	$-0^m.98$	$-8^m.4$
M_{v_2}	$-0^m.85$	
Spectral type	B3+F2	FOI+B3
Other characteristics		
Multiple system	8	6
The region of star formation	Trapezium Ori	Aur OB1
Distance	400 pc	580 pc
Period	$6^d.47$	27.1 yr
The estimates of age	$10^4 - 10^5$	$10^3 - 10^6$

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