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# A comparison of the infrared magnitudes of the eclipsing variable star $\varepsilon$ Aur obtained during two primary minima using observations from 1980 to 2015

I.A. Maslov[1,2,*], O.G. Taranova[2], A.M. Tatarnikov[2], V.I. Shenavrin[2]

[1]*Space Research Institute (IKI), 117997, 84/32 Profsoyuznaya Str., Moscow, Russia*
[2]*Moscow State University, Sternberg Astronomical Institute, Universitetsky pr., 13, Moscow 119991, Russia*

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The results of the $JHKLM$ photometric observations of the long-period eclipsing variable $\varepsilon$ Aur in the two primary minima 1982 and 2010 are presented. We noted the similarity of light curves during both eclipses, their asymmetry, and possible short term brightness increases. We detected the phase variability of the J-M color index with the short-time interval of the more blue color at the moments during the beginning and the end of the eclipses.

*Keywords*: Eclipsing variable, Epsilon Aurigae, circumstellar matter, infrared photometry

## 1 Introduction

The eclipsing system $\varepsilon$ Aur (HD 31964) consists of a class F supergiant orbiting (with a period 27.1 year) a more massive and invisible hot component, surrounded by a disk of dust particles. A reliable parallax and orbital parameters were determined by Kamp (1978) on the basis of astrometric data. The primary minimum occurs when the supergiant is partially eclipsed by the disk, this was confirmed by interferometric observations of Kloppenborg et al. (2010). Maslov et al. (2014) indicated the presence of a secondary minimum when the supergiant eclipses the central part of the disk, which is heated by the massive component. Spectrophotometric analysis of Taranova and Shenavrin (2001) and Hoard et al. (2010) shows the presence of an infrared excess in the spectrum, which indicates that the dust particles in the disk are heated. Budai (2011) proposed that the disk consists of large-size dust particles with a strong forward scattering for short wavelength.

*Email: imaslov@iki.rssi.ru

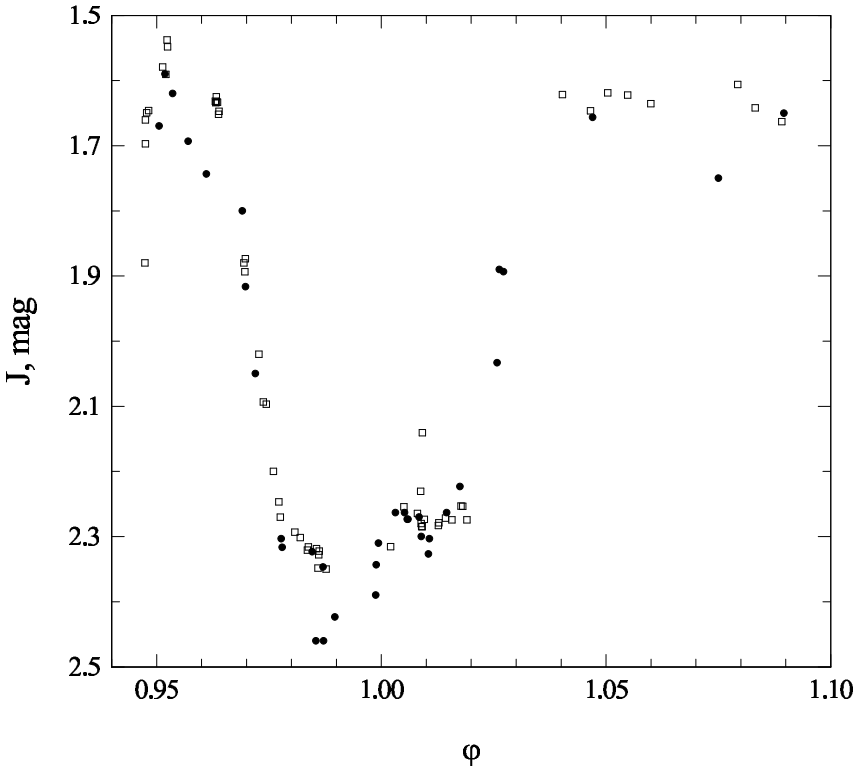



**Figure 1** J-estimates dependent on the orbital phase near the primary minima observed in 1982 (circles) and 2010 (squares).

## 2 Observations and results

The photometric observations of Epsilon Auriga in the infrared region have been carried out by us since 1980 with the 1.25-cm telescope of the South Laboratory of the Sternberg Astronomical Institute. Until 1985 we used a two-channel photometer on the bands of 1.2–2.2 microns based on PbS-detector; see Nadzhip (1986). After 1985, the observations were obtained in five bands (from 1.2 to 4.8 micrometers) with a modulation mode photometer based on the liquid nitrogen cooled InSb-photodiode; see Moroz (1979). Photometric calibration was performed by observing the star BS1454. Figure 1 shows the light curves in the J band near primary minima in 1982 and 2010. There is a similarity between both of the light curves. Both demonstrate an asymmetrical eclipse and a possible existence of the short term brightness increases near orbital phase $\varphi \approx 1.05$. Figure 2 shows the dependence of the color index J–M on the orbital phase. For clarity, we averaged the data of our measurements in groups of 3 to 13 nights; mean values and their errors are also presented in Fig. 2. For comparison, Fig. 3 shows a similar dependence for the binary separation of $\varepsilon$ Aur.

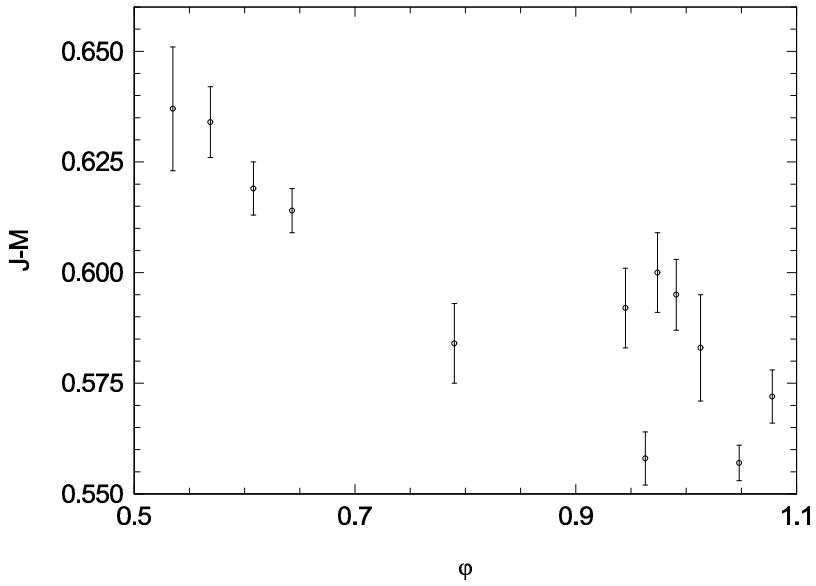



**Figure 2** The dependence of the color index J–M on the orbital phase.

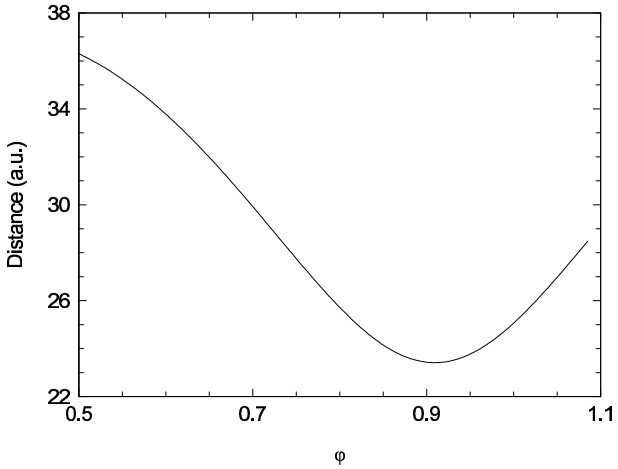



**Figure 3** The dependence of the binary separation of ε Aur (a.u.) dependent on the orbital phase.

## 3 Conclusion

The near infrared light curves obtained in both primary minima (1982 and 2010) are similar to each other. They are asymmetric near zero phase, which is probably due to the asymmetry of the disk. The possible existence of the short term brightness

increases near orbital phase 1.05 is explained by the decreased thickness of the disk in its central parts (near heavy component of the system). The phase changing color index J-M can be explained by the fact that distance from the disk to the F-star is variable. As a result, the temperature of the dust particles are also variable and the dust contribution to the total flux may change. In addition, we are detected the J-M color variations. The color was more blue at the moments of the beginning and the end of the eclipse. We attribute this effect to a scattering of light at the edges of the dust disk. This is possible if the angular distribution of the light scattering on the dust extended significantly forward at a wavelength of 1 micron compared to a wavelength of 5 microns.

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