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OBSERVATIONS OF MIRA VARIABLE V407 CYG

KIZILOĞLU, Ü.[1]; KIZILOĞLU, N.[2]

[1] Physics Dept., Middle East Technical University, Ankara 06531, Turkey; e-mail: umk@metu.edu.tr

[2] e-mail: nil@astroa.physics.metu.edu.tr

V407 Cyg is a symbiotic binary system consisting of a white dwarf and a red giant which transfers material to the hot component either by Roche lobe overflow or by stellar wind. The red giant is a Mira variable with a pulsation period of about 745 d (Meinunger 1966). The system was detected and discovered by Hoffmeister (Ahnert et al., 1949) in 1936. In August 1994, Munari et al. (1994) reported the bright and active phase of V407 Cyg. The next active phase of the system occurred in 1998 (Kolotilov et al. 2003; Tatarnikova et al. 2003). During this phase (1998-2002) emission lines, superimposed on the M6-M7 red giant continuum (Kolotilov et al. 1998), were observed. The binary is inside a nebula which is formed by the red giant wind. Munari et al. (1990) suggested an orbital period of 43 years considering the time between two minima of the mean system brightness.

V407 Cyg has been recently detected in bright optical outburst (Nishiyama et al., 2010) on March 10, 2010 (JD 2455266). In the present study, we report observations of V407 Cyg obtained in the period 2004-2010. The observations were carried out by the 45 cm robotic ROTSEIIId telescope (located at Bakırlıtepe, Turkey[1]) which operates without filters (Akerlof et al. 2003). After the report of the outburst of V407 Cyg, we analyzed the observations of V407 Cyg which is found in the same CCD frames with our target, the Be-X ray binary system SAX J2103.5+4545 (Kızıloğlu et al. 2009). ROTSEIIId magnitudes were calibrated by comparing all the field stars against USNO A2.0 R-band catalog, after obtaining the instrumental magnitudes by aperture photometry. Details on the reduction of data were given previously in several studies (Kızıloğlu et al. 2005; Baykal et al. 2005).

The behavior of the binary system V407 Cyg in the period 2004-2010 is presented in Fig.1. As apparent from the figure the pulsations are seen superimposed on an increased mean brightness of the system. The bottom panel in Fig.1. shows high time variability in the minimum state of its brightness. There is an inflection during the rise to the maximum of pulsation. When we fit a parabola to each of these three inflection minima, we find minima times as JD 2453520.6, 2454310.2, and JD 2455077.3. The average time interval between the two inflection minima is found as 778 days. These inflection features can be due to the newly formed dust layers or are caused by shock waves in the stellar atmosphere (Feuchtinger et al. 1993; Smith et al. 2002).

[1] `http://www.tug.tubitak.gov.tr`

The parabolic fit is also applied to the two pulsation minima and the times of the two minima are found as JD 2453275.9 and JD 2454815.4 giving an average time interval of 769.8 d between the two pulsation minima. We give an ephemeris for the minima of pulsations as T= 2453275.9 + 769.8 E d. However, the other ephemerides given for the pulsation maxima T= 2429710 + 745 E d in R and B band (Munari and Jurdana-Sepic 2002; Munari et al. 1990) and T= 2445326 + 762.9 E d in K band (Kolotilov et al. 2003) differ from our findings. Munari and Jurdana-Sepic (2002) gives a pulsation period in R band similar to the value given from blue photographic observations (Meinunger 1966). The discrepancy in R band between the pulsation periods in two different studies could be due to the dust envelope, beating phenomena and difficulty in determining the minima (or maxima) positions of the pulsations.

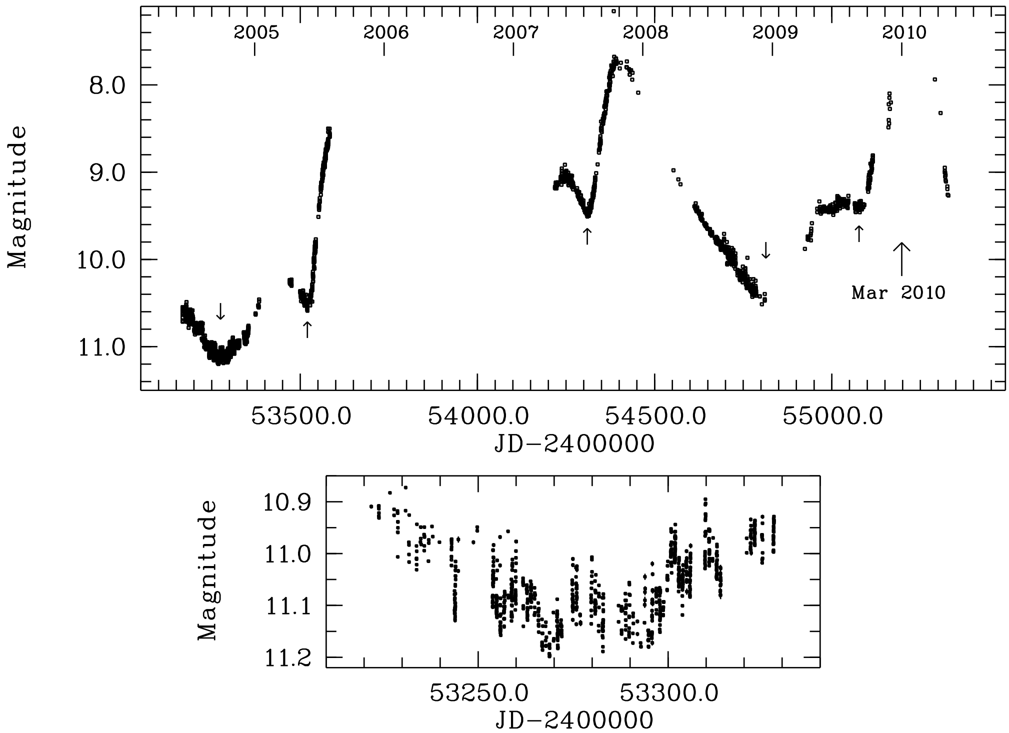

Figure 1. ROTSEIIId light curve of the binary system V407 Cyg. Downward and upward arrows show the pulsation minimum and inflection minimum, respectively.

Kolotilov et al (2003), making a Fourier analysis of the light curve of V407 Cyg, found periods of 18 and 33 minutes. Gromadzki et al (2006) determined periods of 2h, 72 and 45 minutes. We searched for any time variability using Period04 [2], Scargle (Scargle 1982) and Clean (Roberts et al. 1987) algorithms. We used differential magnitudes for the time series analysis. No short term variability was found in our light curve. We also searched for a possible variability during the first brightness minimum between JD 2453220 and JD 2453330 which is shown in the bottom panel of Fig.1. Two periodic variations at 5.261 d and 21.497 d were detected. These variations can be due to the Mira. In Fig.2 the power spectrum by clean algorithm is shown together with the light curves folded with the given periods.

[2]http://www.univie.ac.at/tops/period04

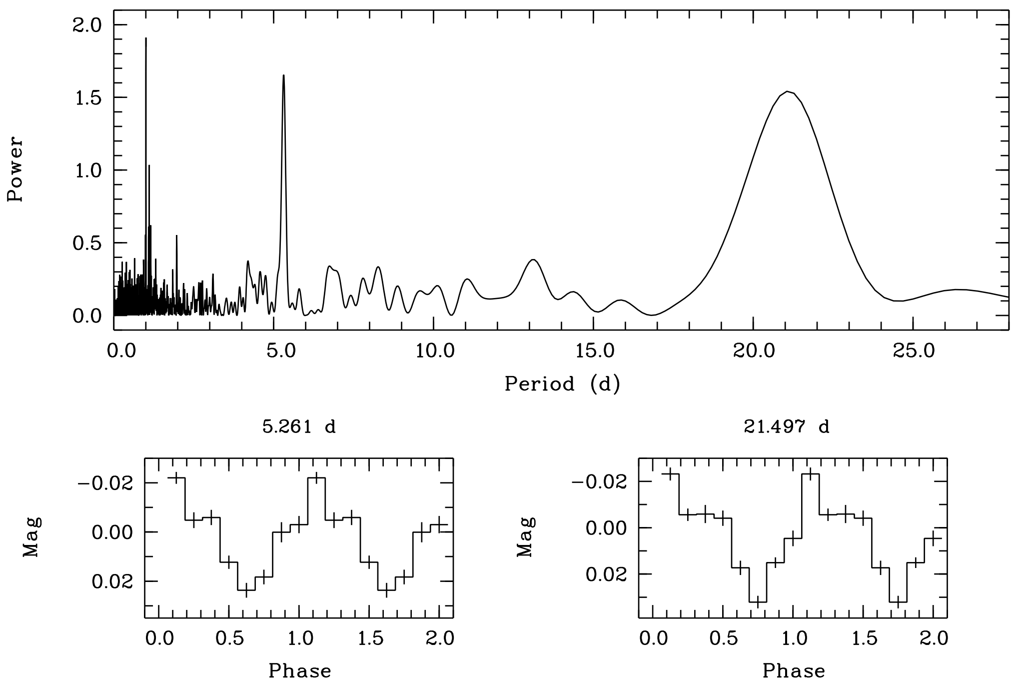

Figure 2. Upper panel: Power spectra of V407 Cyg obtained in the period between JD 2453220 and JD 2453330. Lower panel: Light curves with the given periods. Ephemerides for the minimum brightness are, T=JD 2453175.0 + 5.261 E d and T=JD 2453182.6 + 21.497 E d, respectively.

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