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TU UMi: A CONTACT BINARY IN A TRIPLE SYSTEM

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Photometric variability of the star BD+76 544 (HIP 73047, $V \simeq 8.8$ mag.) was discovered by the Hipparcos mission. In the Variability Annex of the Hipparcos Catalogue (ESA, 1997), the star has been assigned the name TU UMi. The full, peak-to-peak amplitude of the variability is about 0.06 mag. and quality of the light-curve is rather poor. Consequently, TU UMi could only be classified as a periodic variable with the period 0.188546 days. Duerbeck (1997) used the period-color relation for contact binaries (Rucinski, 1993) to search for contact binary candidates in the Variability Annex of the Hipparcos catalogue (ESA, 1997). TU UMi was found to be one of them and listed with the doubled period. Nevertheless the possibility of it being a pulsating variable could not be ruled out. In fact, the star has been included in the catalogue of δ Sct stars (Rodríguez et al., 2000).

In the nights 2003 March 26/27 UT, April 09/10 UT and April 11/12 UT, TU UMi was observed spectroscopically at the David Dunlap Observatory, University of Toronto. The obtained spectra have been analyzed using a broadening-function method (Rucinski, 2002). Figure 1 presents a map of broadening-functions plotted against corresponding orbital phases. The most pronounced feature in this plot has a constant radial velocity of about +30 km s^{-1}. It corresponds to the third body in the system. The peak of the signature of the primary (more massive) component in the close binary is roughly five times lower than the peak corresponding to the third body. This broad feature is best visible at the phases around 0.25 at radial velocities in the range from -50 km s^{-1} to +150 km s^{-1}. The peak of the signature of the secondary component of the close binary is over ten times lower than the peak corresponding to the third body and is barely detectable in the figure. This feature is visible at phases around 0.25 with radial velocities about -150 km s^{-1} and at phases around 0.75 with velocities about +200 km s^{-1}. The plot clearly shows that TU UMi is a triple system containing a close binary. The small amplitude of the photometric variability is explained, at least in part, by the fact that about 55% of the total light comes from the companion star ($L_3/(L_1+L_2) = 1.25 \pm 0.15$). This causes difficulties in the analysis of the spectroscopic data with large uncertainties in the K_i amplitudes. The results will be published in the 10-th paper of the DDO spectroscopic radial-velocity series (Rucinski et al., 2004).

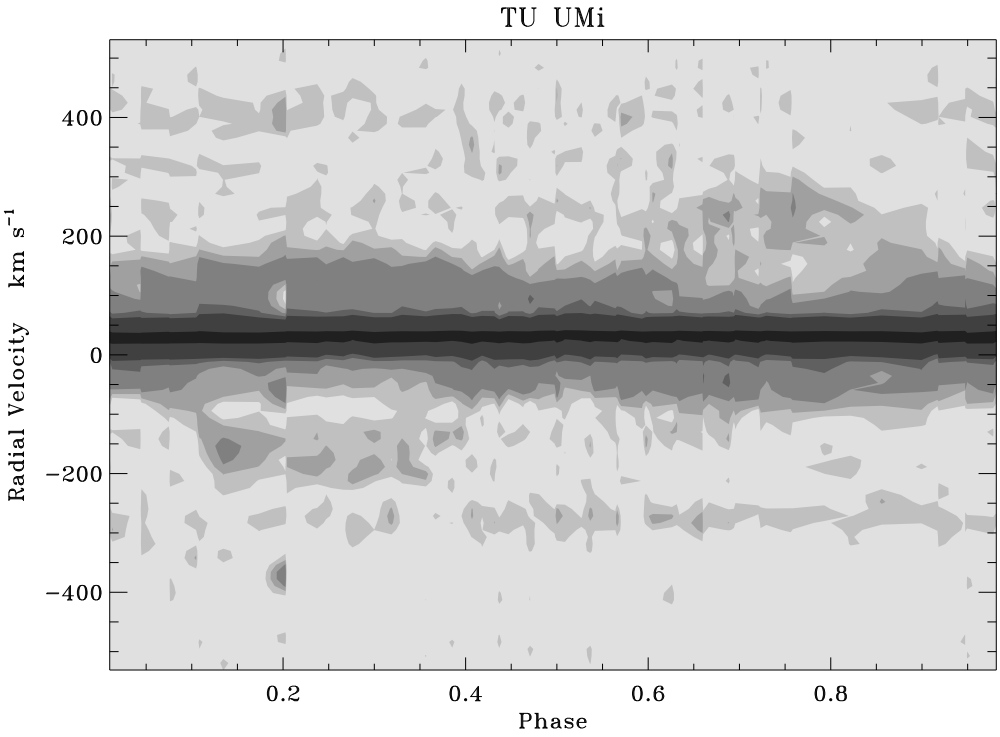

Figure 1. Broadening-functions

Simultaneously with the spectroscopic observations, we conducted unfiltered photometry of TU UMi. We were using a 15 cm refractor finder of the main 1.88m telescope, equipped with SBIG ST-6 CCD camera. The data have been reduced using procedures within IRAF[1] package. The aperture photometry has been done using DAOPhotII package (Stetson, 1987). Figure 2 presents the finding chart from our observations. The size of the field is about 18×15 arc minutes. The sum of the light from stars marked as C1 and C2 has been used as the comparison for differential photometry. Phased light-curve is presented in Figure 3. The times of the minimum were calculated using Kwee and van Woerden (1956) method and are listed in Table I. A linear least squares fit to our times of minimum yields the following linear ephemeris:

$$\text{HJD MIN} = 2452725.6262(64) + 0.37730(19) \times E$$

Since the temporal spacing between time of the minimum from the Hipparcos Catalogue (HJD=2448500.0690) and our observations is longer than 10,000 orbits, we are not able to predict this number with a precision better than 2 orbits. Thus we cannot calculate the mean orbital period based on both sets of photometric data.

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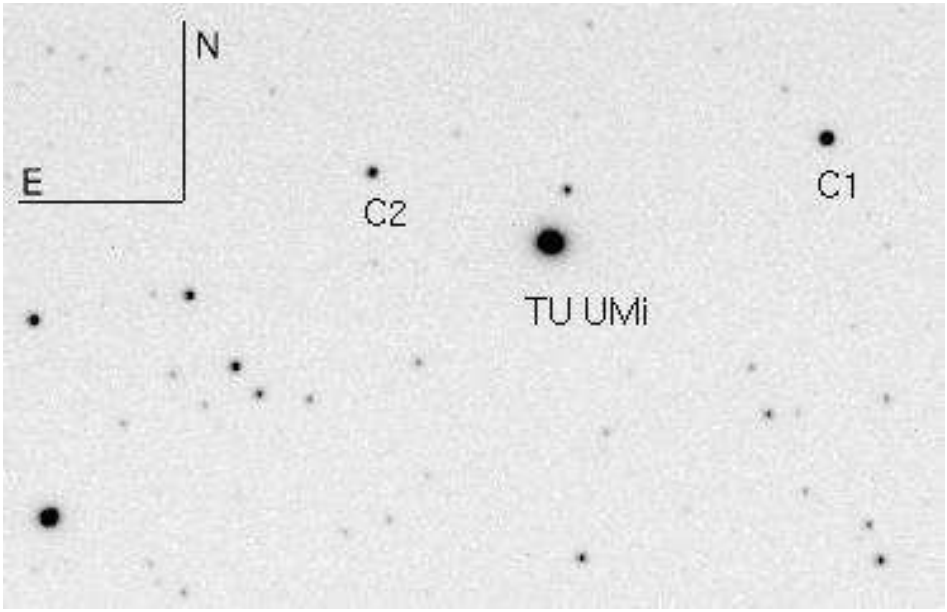

Figure 2. Finding chart

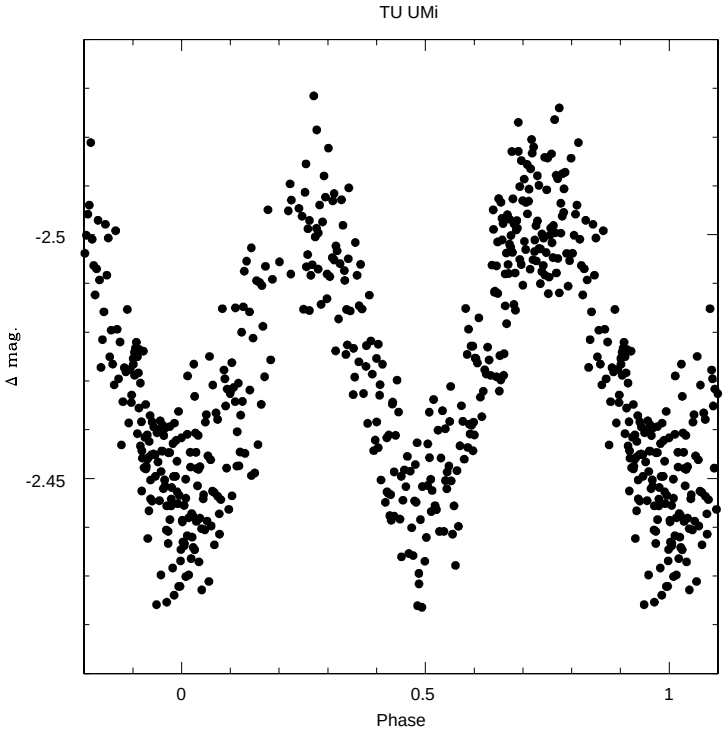

Figure 3. Light-curve

Table I. Times of Minimum of TU UMi, 2003

Type	HJD (2450000.+)	Error	Epoch	O-C
Primary	2725.62604	0.00035	0.0	-0.000166
Primary	2739.59307	0.00036	37.0	0.006779
Secondary	2739.76890	0.00076	37.5	-0.006041
Secondary	2741.66087	0.00029	42.5	-0.000569

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