Photometric Study of the FU Orionis Object
BBW 76 from the Bamberg Observatory
Southern Sky Survey

A. Borisova, K. Tsvetkova, M. Tsvetkov
Institute of Astronomy, Bulgarian Academy of Sciences,
72 Tsarigradsko Shosse Blvd., Sofia-1874, Bulgaria

Abstract
The Bamberg Observatory Southern Sky Survey provided 93 photographic plates with the FU Orionis object BBW 76, clearly detectable in the time interval 1963-1976. We perform aperture photometry of BBW 76 from the scanned with the Epson Expression 1640 XL flatbed scanner 2 × 2 degrees area near target star. For each plate a transformation of plate magnitude to the GSC 2.2 magnitudes in B photographic band was found out for selected reference stars, and used for deriving B magnitudes of BBW 76. The analysis of the photometric behaviour of BBW 76 is presented.

1 Introduction
The star BBW 76 from the list of nebulous stars of Brand, Blitz and Wouterloot (1986) with $RA = 7^h50^m35.5^s$, $D = -33\degree06'24''$ (J2000.0) is located in the constellation Puppis close to the Gum nebula. The star at the distance of 1.8 kpc is associated with a small molecular cloud and has a distinct curved reflection nebula (Figure 1). The star is proved spectroscopically to be a FU Orionis type star – a small group of eruptive variable stars situated in star forming regions and associated with dark clouds and reflection nebulae, such stars show multivwavelength phenomena associated with active accretion from a circumstellar disk. The width and shape of the absorption lines, the P Cygni profiles of the Balmer lines, the blue shift of the absorption components, the bolometric luminosity and colour temperature clearly identify the star as belonging to the FU Orionis type stars (Reipurth 1990, Eisloeffel et al. 1990, Reipurth 1997). The other distinctive characteristics of the FU Orionis type stars – photometric outburst, has been not observed despite the fact that Reipurth (2002) examined some old Harvard plates, the oldest one going back to March 1900 and found the
Figure 1. BBW 76 on different plates from the Bamberg Observatory Southern Sky Survey.
star seen at approximately its present brightness. Another existing plate taken for the Franklin-Adams charts in 1927 shows again BBW 76 at approximately the same brightness. On a few occasions between 1983-1994 Reipurth (1997) obtained the V magnitudes of the object and noticed that the star is slowly fading with a rate of about 0.023 mag/yr (V) in this period. Comparing the magnitude in 1900 and in 1994 it is obvious that this rate is not steady, or the star has undergone the periods of irregular variability. In the infrared region (J, H and K bands) the brightness decline for the period 1983 – 1991 is either halted or slowed in dependence on the considered band. The monitoring data of the star in the optical and infrared wavelengths are summarized in the paper of Reipurth et al. (2002).

According to the long-term brightness changes at optical wavelengths (Clarke et al. 2005) and at infrared wavelengths (Abraham et al. 2004) the FU Orionis type stars after the outburst show brightness declines – sometimes with switch from the long-time plateau to accelerated declines or with transient dip-like changes. The data is well represented by disc instability models and wind-envelope interaction. The dimming and irregular variations in the post-outburst phase are consistent with occultation of the source by a variable dust screen, which is a result from the interaction between the wind and an infalling dusty envelope.

2 Observational Material

The Bamberg Observatory Southern Sky Survey was taken in the period 1963-1976 for monitoring and identifying variable stars. The plates were taken with the 10 cm cameras, located in the observatories Boyden station (South Africa), Mt John (New Zealand) and San Miguel (Argentina). The plate emulsions are

Figure 2. The distribution of the scanned plates by time and observer.
mainly Agfa, Gevaert 67A50, which provide B photographic band magnitudes. 93 plates received in the period 1963–1976 contain the images of BBW 76. Their distribution by time and observer is given in Figure 2. These plates were scanned with an Epson Expression 1640XL flatbed scanner in 14-bit (16383 grey levels) FITS format. The resolution is 5.25 arcsec/pix. Ten plates from the selected ones could not be used because their low quality. More details for the Bamberg Observatory Southern Sky Survey and for used method of plate photometry are presented in the paper of Innis et al. (2004) and can be also obtained from the Wide-Field Plate Database (WFPDB) web page at the address http://www.skyarchive.org.

3 Data Reduction and Analysis

Using standard IRAF aperture photometry tool we derived instrumental magnitudes for BBW 76 and 22 field stars. We used stars in the range 9.3–13.7 as photometric B standards. For each plate a least-squares solution of plate transformation equation (1) was found out

\[ B = a_1 m_B + a_2 m_B^2 + a_3 (B - V) + a_4, \]  

(1)

![Figure 3. Long-time brightness behaviour of BBW 76 from 1963 to 1976.](image)
where $m_B$ is the instrumental magnitude determined by aperture photometry with radius 10 pixels and B is standard Johnson B magnitude. The B magnitudes of the standard stars have been determined by transforming Tycho-2 BT and VT data (ESA, 1997) using interpolation tables presented by Bessell (2000) and GSC-2.2 for stars fainter than 13.0 B mag. The B magnitudes for the standard stars show 1-standard deviation accuracy less than 0.15 mag with mean of 0.10 mag, so we may consider that accuracy of 0.1 mag is reachable for B magnitude interval 11–13.5. The light curve based on our estimations is shown in Figure 3.

According to our data BBW 76 has rather irregular photometric behaviour, B mag changes in the interval 13.83–11.41, with mean value of 12.82 mag. We do not observe steady brightness decline similar to the observed one in V mag for the period 1984–1994 (Reipurth et al. 2002). The right panel of Fig. 3 shows mean-year brightness behaviour of BBW 76. For 1971 and 1972 we do have only one observation and it might be a reason for the great difference from mean B magnitude.

### 4 Conclusions

The monitoring of BBW 76 from the Bamberg Observatory Southern Sky Survey in the period 1963 – 1976 fill in the gap of observations in its historical light curve. The constructed light curve makes BBW 76 the FU Orionis type star with the longest-documented period in a high state. The number of observations spread more or less regularly in the period 1963-1976 reveal that BBW 76 shows irregular brightness variations instead of the expected slow brightness decline typical for its spectral counterpart FU Ori star. Our results confirm the suggestion of Reipurth et al. (2002) that the star has passed periods with irregular variability followed by slow decline phase. For more precise results we need better photometric calibration and standard stars measurements.

### Acknowledgments

We are thankful to the authorities of the Bamberg Observatory for the support. This work was done within the frames of the joint project between the Bulgarian Academy of Sciences and the German Scientific Society (DFG) 436-BUL113/120/0-1 and with the support from Alexander von Humboldt Foundation and Bulgarian National Science Fund (NSF I-1103/2001).

### References