Comm. in Asteroseismology
Volume 161, May 2010

Photometric observations and frequency analysis of the δ Scuti star IP UMa*

D. Sinachopoulos[1], P. Gavras[1] and Chr. Ducourant[2]

[1]Institute of Astronomy and Astrophysics, National Observatory of Athens
I. Metaxa and Bas. Pavlou, GR-15236 Athens, Greece
[2]Observatoire de Bordeaux, 2 rue de l'Observatoire, BP 89
FR 33270 Floirac, France

Abstract

IP UMa is a δ Scuti star discovered by Hipparcos. 2642 observations of this target were acquired with the 20cm telescope of the Nea Lesbos Observatory in 10 nights from June 2 to July 9, 2009 using the Bessel V filter.

These data confirmed the pulsation frequency of the star listed in the Hipparcos Catalogue (10 c/d).

Accepted: May 25, 2010

Individual Objects: IP UMa

1. Introduction

IP UMa (HD 118954, BD +48 2141, HIP 66609) is listed in the revised catalogue of δ Sct stars by Rodriguez et al. (2000) as an A5 variable star with mean V=7.67, (B-V)= 0.32, amplitude 0.05 magnitudes and frequency 10 c/d. The relevant entry in this catalogue was based on information taken from Kazarovets et al. (1999), which introduces GCVS names for 3153 variable stars discovered by the Hipparcos mission. The data of the Rodriguez et al. catalogue were adopted from the corresponding Hipparcos catalogue entry (ESA 1997).

*Based on observations collected at the Nea Lesbos Observatory, Greece.

2. Observatory, Instruments, Observations

We searched for IP UMa pulsations by means of photometric observations, which were performed in ten photometric nights in the period June 2 - July 9, 2009 at the Nea Lesbos Observatory (38° 03' 14.1" N, 23° 49' 36.3" E, 270m altitude).

All data were collected using the 20cm VIXEN VISAC (f/9) telescope. Its SBIG 6303E science CCD camera has an array of 3060x2040 square pixels with dimensions 9x9 microns, corresponding to a surface of 27.5x18.4mm. The device is attached to the Cassegrain focus of the telescope, where each pixel corresponds to 1.03"x1.03" and the CCD array to a field of view (FOV) of 53'x35'. In this relatively large FOV one can usually find appropriate comparison and check stars. The temperature of the CCD was set to -10°C for lower DARK noise. Standard flat-fielding, BIAS and DARK corrections were always performed to the raw data.

All observations were autoguided using an ATIK 16IC CCD camera attached to a 5 inch Celestron telescope. This Schmidt-Cassegrain instrument has been mounted in parallel to the VIXEN 20cm. The two telescopes are attached to the same automatic SkyWatcher EQ6 SynScan Pro equatorial mount.

All devices are controlled via the (partially wireless) computer network of the observatory. Science CCD frames are automatically transferred to a dedicated workstation in the telescope warm-room. ESO-MIDAS software monitors the observing conditions and proceeds with the photometric data reduction.

We tried to position the stellar images to almost the same place of the CCD each night, in order to minimize systematic effects of the instrumental photometry. Observations were terminated when an airmass of 2.0 was reached. Exposure time was usually 18 seconds, but 10 seconds was also used. 2642 measurements of the field centered on IP UMa were collected, using the Bessel V filter.

The median of the seeing conditions is 2.4 arcseconds, corresponding to a well sampled stellar PSF, which is needed for accurate photometry. The minimum observed seeing was 1.2". In such cases we were defocusing the telescope slightly, so that the stellar images come to a FWHM of two pixels or more. Table 1 gives a journal of observations providing an overview of HJD, the total number of data points collected and photometric hours per night.

3. Comparison and Check Stars

There were only few suitable candidates for comparison and check stars in the FOV. We chose HIP 66713 (V=8.37, (B-V)=0.39) as comparison and HIP 66485 (V=8.57, (B-V)=1.01) as check star for obvious reasons.

Table 1: Journal of Observations

HJD [+2400000]	DURATION [Hours]	Exposures No
54985	3.3	194
54987	6.0	385
54991	4.5	295
54993	5.2	314
54995	5.5	327
54997	5.1	372
54998	2.6	87
55020	2.4	185
55021	2.3	231
55022	3.1	252

We checked these two stars for variability performing their relative photometry each night. The stars were not variable within the observational run of 38 days. We performed a linear regression to the results of each night. In this way we checked whether the magnitude difference between comparison and check stars changes systematically with airmass due to extinction effects caused by their colour difference. The slopes of the linear regressions were always found to be statistically zero with a mean R.M.S. error of 0.013 magnitudes. The mean magnitude difference of the two stars at the zenith was ΔV=0.243 $\pm$0.002 magnitudes.

4. Frequency analysis

Once the observations were reduced and magnitude differences of each exposure determined, we applied a mean filter to the results with a size of four observations, before proceeding to the frequency analysis.
At a first glance the light curves show moderate variations from night to night. The largest peak-to-peak amplitude is 0.13 mag. The Fourier analysis was performed using Period04 (Lenz & Breger 2005). The frequency resolution of this run is 0.04 c/d (Loumos & Deeming 1978), or lower. The spectral window is shown in Figure 1a.

After the Fourier analysis of the magnitude differences ΔV, the frequencies, amplitudes and phases were improved by a least squares fit. The first frequency found (f_1) is the one detected by Hipparcos (10.0 c/d) as shown in Figure 1b. A search for a second frequency in the prewhitened data was performed, revealing

10.95 c/d. The $(1\ \mathrm{day})^{-1}$ ambiguity caused by the 1 c/d aliasing is shown in Figure 1c. After fitting f_1 and f_{1a} the sigma of the residuals has a standard deviation of 0.0096 magnitudes.

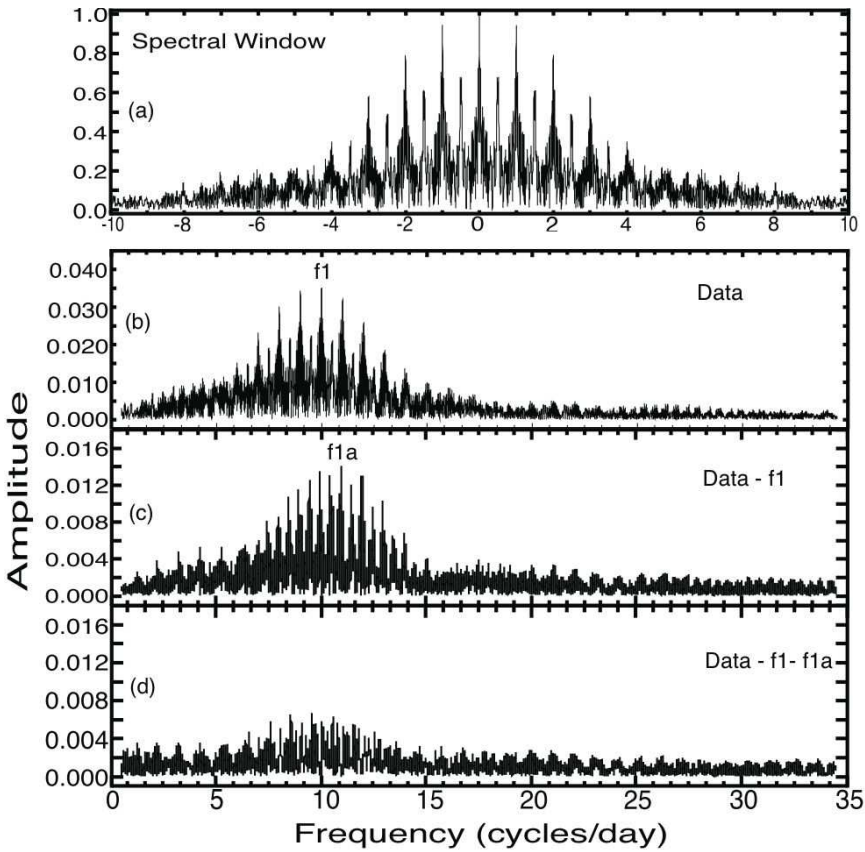

Figure 1: Amplitude spectra of the June 2 - July 9, 2009 data

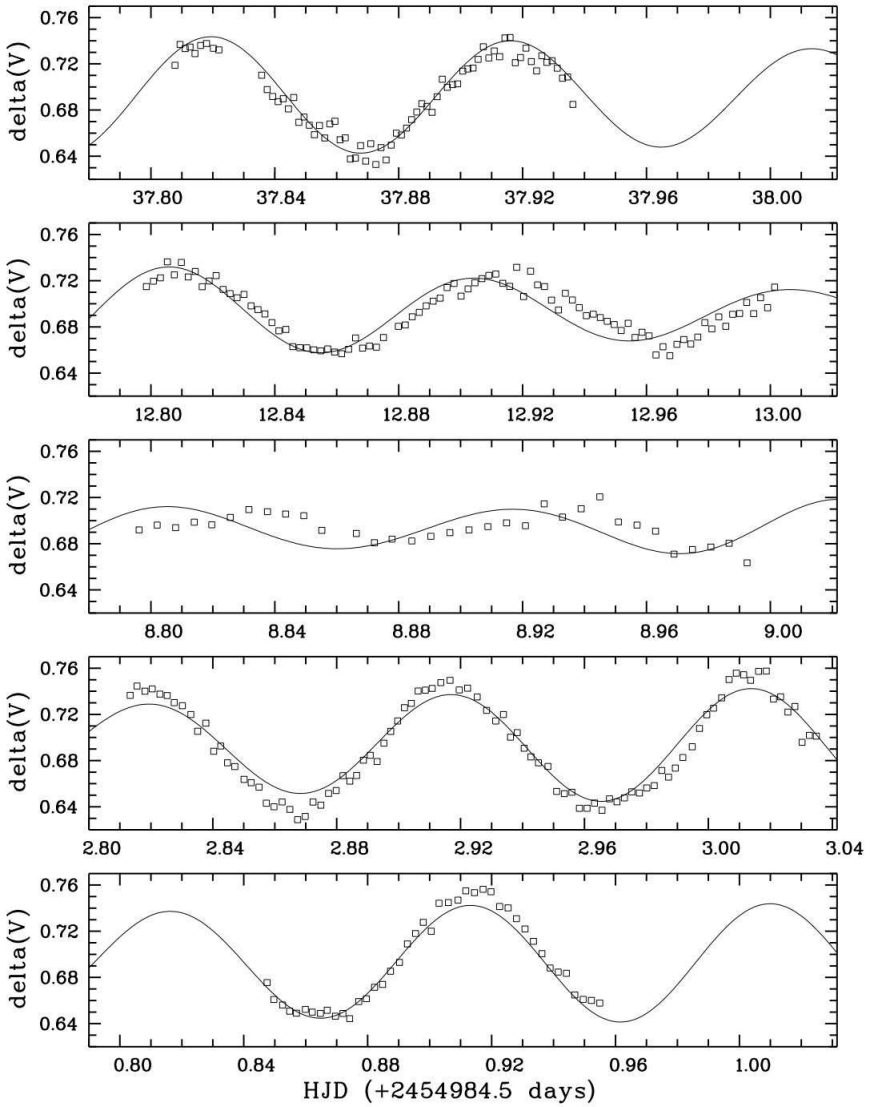

Figure 2: Observations of five selected nights of the observations of IP UMa carried out in 2009, together with the fit of the frequencies found

Table 2: Computed frequency for IP UMa (V-data) and its alias

Id.	Frequency [c/d]	Semi-ampl. [mag]	Phase [cycles]	S/N
f_1	9.9972	0.0340	0.206	14
σ_{f_1}	0.0003	0.0007	0.003	

Table 2 contains the characteristics of frequency f_1. The first line contains the frequency, its semi-amplitude, phase and signal to noise ratio. The second one lists uncorrelated uncertainties of the corresponding values in line one as calculated by the least-squares-fit.

Figure 2 shows data of five selected nights of our observations of IP UMa. Heliocentric Julian date is shown in the abscissa with an offset of -2,454,984.5 days, which corresponds to midnight (UT) June 02, 2009 CE. The magnitude difference, plotted in the ordinate, is the one between comparison (HIP 66713) and IP UMa. The f_1 and f_{1a} are also shown fitted to the data.

Acknowledgments. The authors are very thankful for the comments of the anonymous referee.

References

ESA, 1997, The Hipparcos and Tycho Catalogues, ESA SP-1200

Kazarovets, A. V., Samus, N. N., Durlevich, O. V., et al.1999, Information Bulletin on Variable Stars, 4659, 1

Lenz, P., & Breger, M. 2005, CoAst, 146, 53-136

Loumos, G.L., & Deeming, T.J. 1978, ApSS, 56, 285

Rodriguez, E., Lopez-Gonzalez, M. J., & Lopez de Coca, P. 2000, A&AS, 144, 469-474