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ON THE MONOPERIODICITY OF THE SUSPECTED δ SCUTI STAR IOTA BOOTIS

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The light variation of ι Bootis (= 21 Boo = HR 5350 = HD 125161 = HIP 69713, spectral type A9V) was discussed earlier by Albert (1980), Szatmáry (1988), Gál et al. (1994) and Kiss (1995). The principal period of light variation around 38–40 min was unambiguously revealed. Handler & Paunzen (1995) have not found convincing evidence for variability, but they have not given any further detail. Rodríguez et al. (1994) listed the main parameters of the star, such as the period, amplitude (0.027 days and 0.03 mag – values given by Albert 1980), and various photometric indices ($B-V = 0.20$, $U-B = 0.06$, $b-y = 0.128$, $m_1 = 0.198$, $c_1 = 0.834$ mag). Unfortunately, the earlier measurements had very short time-spans and consequently, the stability and possible multiperiodicity could not be studied. The main aim of this note is to present new observations and a reanalyis of earlier data together with the new measurements.

Photoelectric BV observations were carried out at Szeged Observatory (Hungary) on May 5, 1998. The data was obtained using a single-channel Optec SSP–5A photometer attached to the 0.4-m Cassegrain telescope. We carried out differential photometry relative to HR 5360 ($V = 6.19$, $B-V = 0.07$ mag). The achieved accuracy in V was about $\pm 0\overset{\mathrm{m}}{.}01$. Further observations were obtained at Sierra Nevada Observatory (Spain), on 4 nights in June, 1998 (19th, 20th, 23th and 24th), using the 0.9-m telescope equipped with a four-channel $uvby$ photometer. Here we made all-sky photometry monitoring the extinction curves by following two Strömgren standards (HR 6577 and HD 185734). The accuracy in y was ± 0.002–0.007, depending on the weather conditions. We analysed the y measurements combined with the V data. The colour-dependent standard transformations could be neglected, as the $b-y$ index does not change more than 0.002 mag, implying y data to be only slightly shifted relative to the Johnson V. The observational data are available upon request from the first author.

The new observations alone revealed the well-known periodicity of 38 min bearing an amplitude (ΔV) somewhat smaller than 0.01 mag. We put together all new data (V and y) with earlier measurements by Kiss (1995) after subtracting the mean values. This step can be questioned, as similar subtraction can significantly change the determined frequency content. However, two observational facts were considered before doing this. First, the

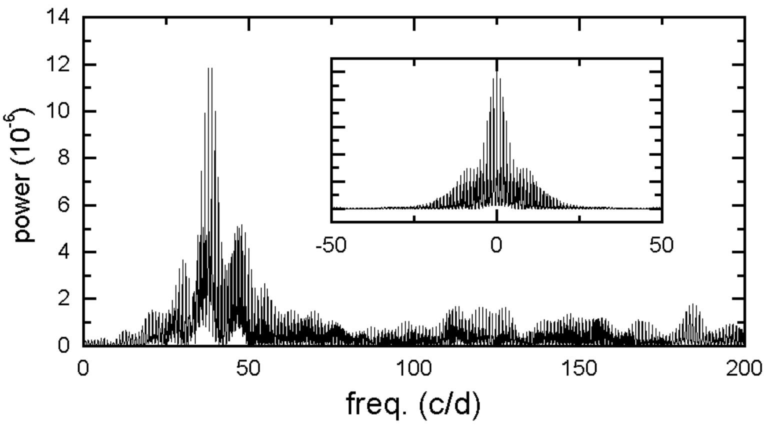

Figure 1. The power spectrum of the whole dataset. The inset shows the window function.

10 main cycles observed by Kiss (1995) suggested the lack of long-term variation of the mean brightness. Second, photometric observations of lower accuracy by the Hipparcos satellite (ESA 1997) did not confirm the period value listed by Rodríguez et al. (1994), nor any other significant light variation with higher amplitude.

We calculated the Discrete Fourier Transform (DFT) of the whole dataset using Period98 (Sperl 1998). We plotted the power spectrum with the window function in Fig. 1. The spectrum contains one principal peak at $f = 37.750 \pm 0.001$ c/d (which corresponds to a period of 38.145 ± 0.001 min) with a semi-amplitude of 0.0035 mag. The quoted very small uncertainty of the frequency is due to the very stable light variation. A lower limit for the relative stability of the period ($\Delta P/P$) is $2.62 \cdot 10^{-5}$. This is well illustrated by the phase diagram based on all observations between 1995–1998. Although they span more than 40000 cycles, the combined phase diagram (Fig. 2) has quite small scatter, not exceeding the usual observational errors.

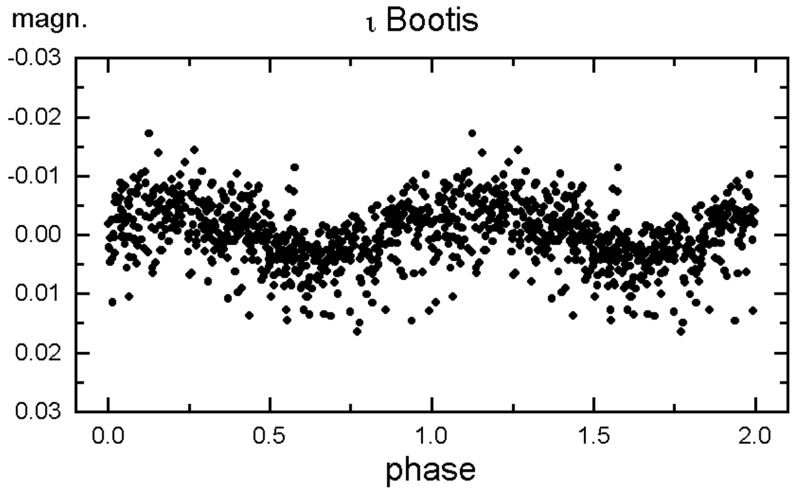

Figure 2. The combined phase diagram of all data.

After pre-whitening with the principal frequency, the remaining amplitude spectrum does not contain any peak higher than 0.001 mag. Thus, we conclude that ι Bootis has a highly monoperiodic light curve, which can be fitted quite well with a one-component sine function. This can be seen in Fig. 3, where the new data are plotted with the fitted function ($A = 0.0035$ mag, $f = 37.750$ c/d, $\phi = 0.117$).

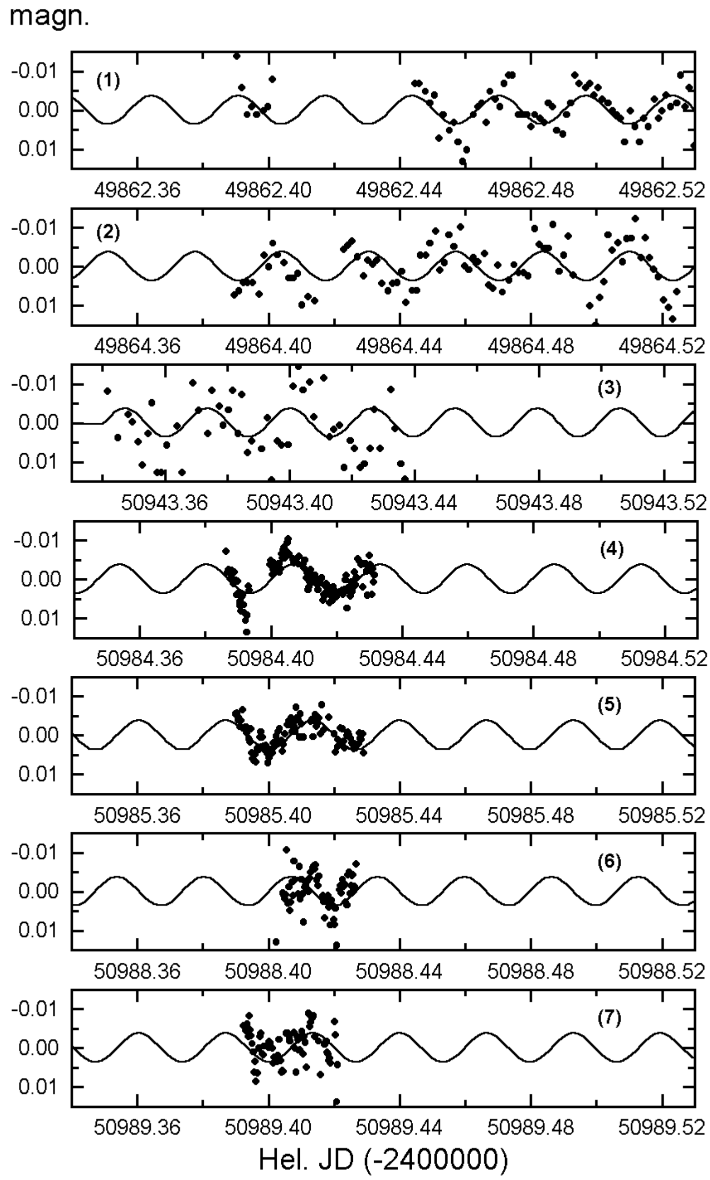

Figure 3. The V light curves of ι Bootis. The solid lines represent the one-component fit. Data in panels (1)–(3) were obtained in Szeged, (4)–(7) in Sierra Nevada.

This relatively long term stability of the period raises the question whether the light variation can be associated with pulsation. Such rapid variations with periods of 30–50 min were also observed in other δ Scuti candidates (e.g. Rodríguez et al. 1999). While ι Bootis is a fast rotating star ($v \sin i = 130$ km s^{-1}, Abt & Morrell 1995), the presence of high-order non-radial oscillations is very possible (see, e.g., Mantegazza 1997). Unfortunately, this issue can be studied only with the help of high resolution spectroscopy in order to detect line profile variations. Therefore, further spectroscopic observations are desirable to answer two questions: *i*) Is the observed variation due to pulsation?; *ii*) If yes, which mode is excited?

Another important problem is the determination of fundamental physical properties. To our knowledge, the only publication listing accurate parameters is that of Malagnini & Morossi (1990), who derived luminosities, effective temperatures, radii, masses and surface gravities for a selected sample of field stars with help of spectrophotometric observations and trigonometric parallaxes. Their calculation strongly depends on the stellar parallax available that time (48.1 mas, 25% error). However, the new parallax measurement of the Hipparcos satellite is 33.54 mas (s.e. 0.56 mas), being more than 30% smaller, corresponding to a distance of 29.8 pc. Thus, we repeated the calculations with replacing the parallax, and using the recent synthetic colour grids of Kurucz (1993). The assumption of solar metallicity, $b-y = 0.128$ and $c_1 = 0.834$ infer an effective temperature of 8000 K and $\log g = 4.3$. The estimated uncertainties are about ± 200 K and ± 0.1 dex, where the effect of fast rotation exceeds the photometric errors (Michel et al. 1998). For $V = 4.75$ mag and $d = 29.8$ pc, we get a visual absolute magnitude of $M_{\rm V} = 2.38$ mag. The bolometric correction for an A9V star is $BC = -0.09$ mag, resulting in $M_{\rm bol} = 2.29$ mag. $M_{\rm bol}$ and $T_{\rm eff} = 8000$ K give a radius of $R_* = 1.6 \pm 0.1$ $R_\odot$, while $\log g$ and radius infer a stellar mass of $M_* = 1.9 \pm 0.4$ $M_\odot$. These values strongly suggest that ι Bootis lies on the main sequence (see, e.g., Appendix E in Carroll & Ostlie 1996).

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