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CCD time-series photometry of BQ Ind*

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Abstract

We present CCD time-series photometry of BQ Ind, which is either a Population I large-amplitude δ Scuti star or an SX Phoenicis star.

1 Introduction

BQ Ind (HD 198830 = HIP 103290) was discovered to be a pulsating star by the Hipparcos satellite (ESA 1997), with $P = 0\overset{\mathrm{d}}{.}0820, \Delta V = 0\overset{\mathrm{m}}{.}250$ (Rodríguez et al. 2000), but no ground-based observations of BQ Ind were so far reported in the literature.

Sterken et al. (2003) obtained new data and in a first analysis reported the presence of a primary $f_1 = 12.1951$ d^{-1} and a secondary frequency $f_2 = 15.7686$ d^{-1} (see Fig. 1 as an example). The period ratio $P_2/P_1 = 0.7734$ made them to suggest that BQ Ind is a double-mode SX Phe star. (SX Phoenicis stars are pulsating Population II stars with low metallicities and high spatial motions which are found in the blue-straggler region in a globular cluster H-R diagram and within the lowest section of the classical Cepheid Instability Strip).

Double-mode SX Phe stars are rare, but time-series observations possibly allow to identify the pulsation modes in some cases and to infer some physical properties of the star from the ratio between the two periods and the main-mode period (Petersen & Christensen-Dalsgaard 1996).

*Based on observations obtained at ESO La Silla Observatory.

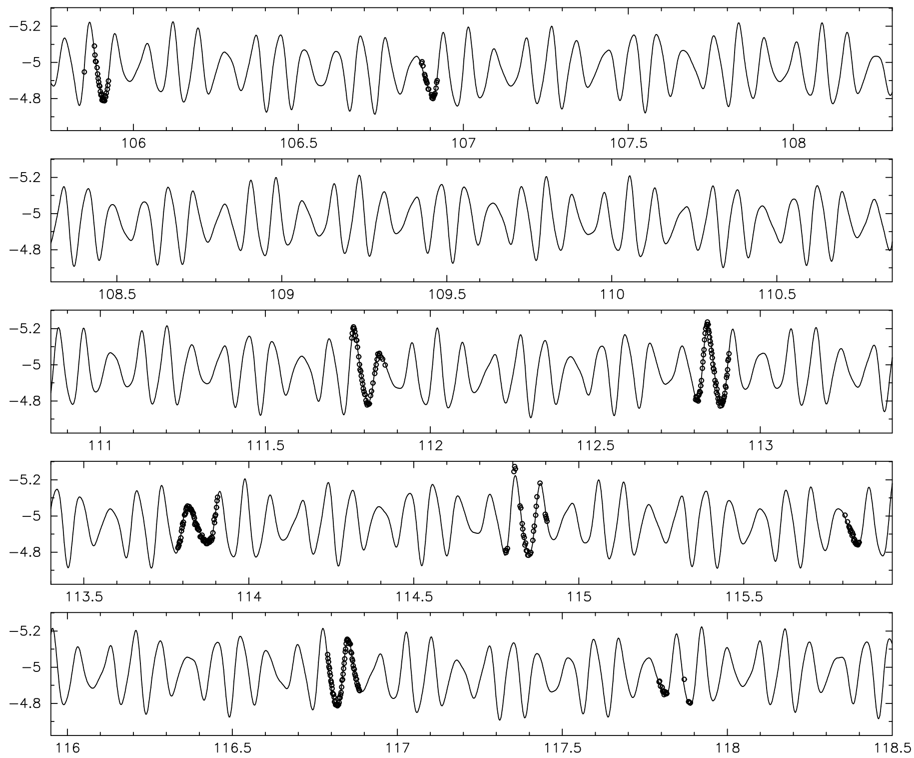

Figure 1: Light curves of BQ Ind in b, July 2001 (Sterken et al. 2003).

2 The data

We obtained Strömgren b and v time series in July 2001 at the Dutch 0.90-m telescope (510×510 CCD detector, ESO La Silla) and another sequence of 68 frames in Johnson V at the Danish 1.54-m telescope (DFOSC camera, 1024×1024 CCD) in September 2001. All frames were bias-corrected and flatfielded. Figure 2 illustrates the field (± 7 arcmin diameter) surrounding BQ Ind. Tables 1 and 2 give the coordinates of the comparison stars. Data reduction was carried out using the software package MOMF (Kjeldsen & Frandsen 1992) that combines aspects of PSF and aperture photometry. We shown in Fig. 3 an example light curve (Johnson V band).

2.1 Dutch telescope CCD frames

The field of the Dutch camera being small, these frames only contain BQ Ind and the neighboring stars GSC 8800 1107, 872 and 678. These nearby stars served as comparison stars and are much fainter than the program star, which unavoidably results in CCD frames that are at times overexposed. This problem has been thoroughly discussed in Sterken et al. (2003).

In order to save disk space, the individual CCD images have been decomposed

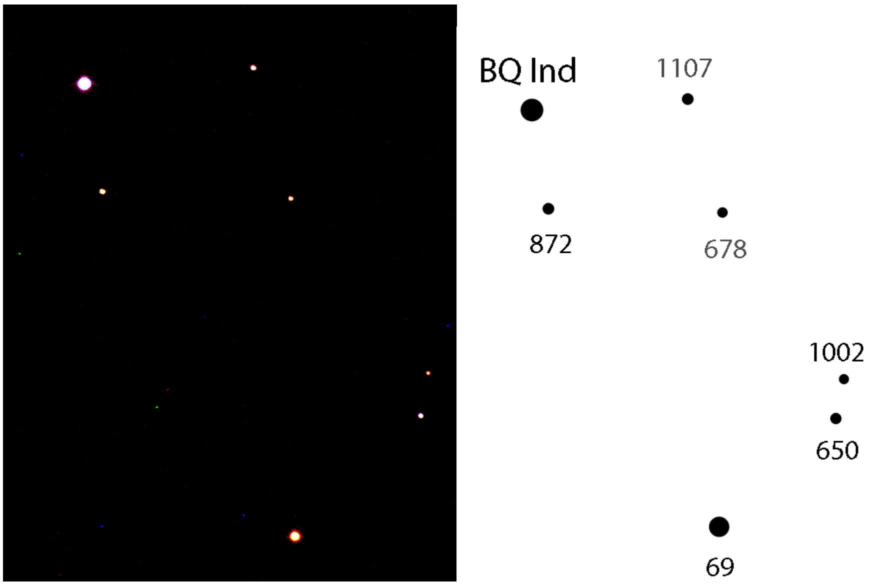

Figure 2: BQ Ind field at the Danish telescope. N is up and E is left. Comparison stars GSC 8800 1107, 872, 678 and 69 are indicated.

Table 1: Identification of the stars in the dutch-telescope frames.

	Identif.	α_{2000}	δ_{2000}
Variable	BQ Ind=HD 198830	20:55:33.67	-56:44:31.10
Comp1	GSC 8800-01107	20:55:24.084	-56:44:24.91
Comp2	GSC 8800-00678	20:55:21.983	-56:45:24.88
Comp3	GSC 8800-00872	20:55:32.714	-56:45:21.45
Comp4	GSC 8800-00005	20:55:48.444	-56:46:03.93

in artificial fields of 50×50 pixels, and were recombined in a set of artificial images (see Fig. 4 as an example). The b images are available in directory `dutch_b`, the reconstructed v frames are in directory `dutch_v`. The ASCII tables with the differential results (HJD, magnitude) are in files `dutch_b.dat` and `dutch_v.dat` (460 and 1157 useful frames, respectively)[1].

An area of 60×60 pixels around BQ Ind and around each of the comparison stars was combined into one artificial field in which every sub-image was separated from the preceding one by a 2-pixels wide column with ADU=2500, yielding a 304×50 array. The order of stars in the image is, from left to right: BQ Ind, Comp1, Comp2, Comp3 and Comp4. The raw image header remained untouched.

Note that comparison star 4 is not the same star in both sets of images, while comparison stars 1–3 are the same stars in both sets.

[1]The discrepancy between the number of b and v frames is to be ascribed to the fact that more than 50% of the b frames had saturated images

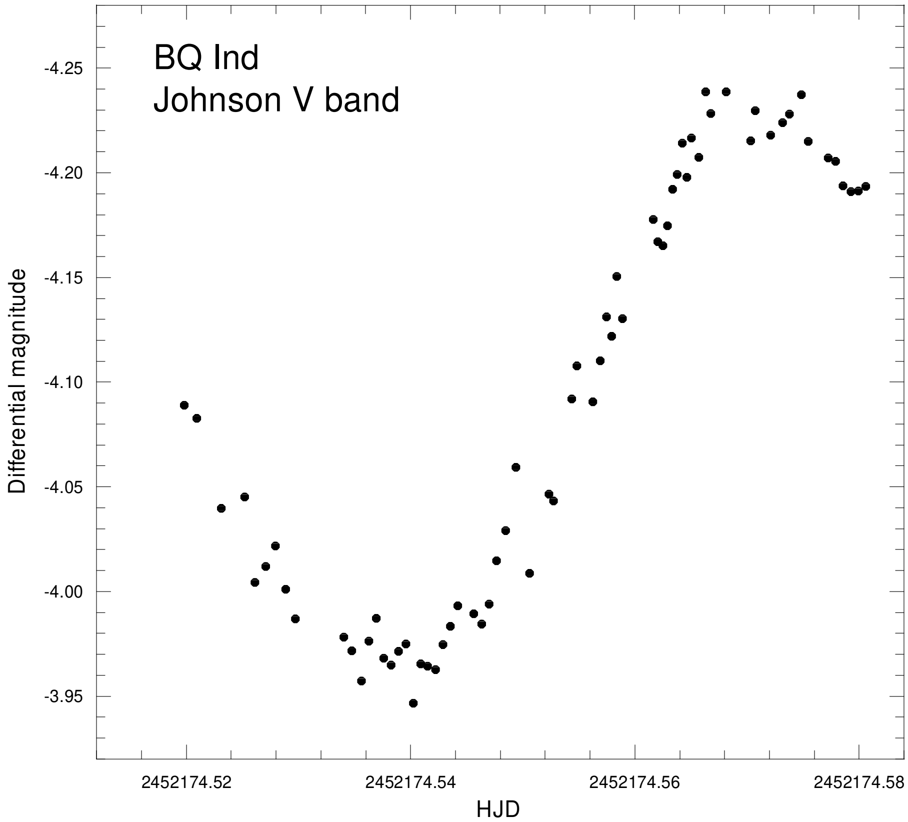

Figure 3: Johnson V light curve of BQ Ind.

2.2 Danish telescope CCD frames

The DFOSC frames also recorded GSC 8800 69, a nearby (but very red) star of brightness comparable to BQ Ind. An area of 50×50 pixels around BQ Ind and around each of the 4 comparison stars was combined into one artificial field in which every sub-image was separated from the preceding one by a 2-pixels wide column with ADU=2500, yielding a 254×50 array. The order of stars in the image is, from left to right: BQ Ind Variable, comp1, comp2, comp3, comp4. The raw image header remained untouched. 68 frames were reconstructed, and the rearranged frames are in directory `danish_v`, the ASCII tables with the differential results are in file `danish_v.dat`.

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Comp3	GSC 8800-00872	20:55:32.714	-56:45:21.45
Comp4	GSC 8800-00069	20:55:22.061	-56:48:04.01

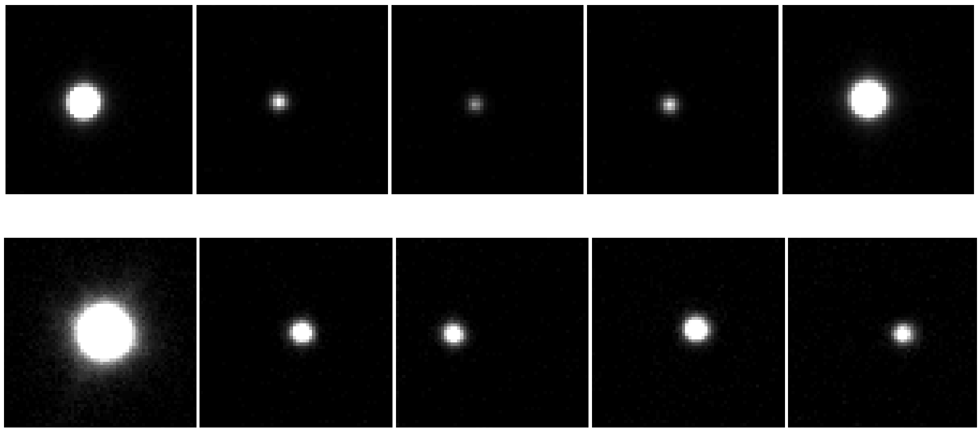

Figure 4: Reconstructed frames: Danish telescope (top), Dutch telescope (bottom).

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References

Kjeldsen H., Frandsen S., 1992, PASP 104, 413

Petersen J.O., Christensen-Dalsgaard J. 1996, A&A 312, 463

Rodríguez E., López-González M.J. 2000, A&A 359, 597

Sterken C., Fu J.N., Brogt E. 2003, in *Interplay between periodic, cyclic and stochastic variability in selected areas of the H-R diagram*, ASP Conf. Ser. in press

Sterken C., Zhou, A.Y., Fu J.N. 2003, *Comm. in Asteroseismology*, submitted