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$BVg'r'$ CCD Observations of AS Cas

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1665 magnitude measurements in the B, V, g', and r' filters were acquired for the double-mode Cepheid AS Cas. The light curves for both fundamental and first-overtone modes were constructed.

We performed CCD observations of the Cepheid AS Cas in October 2020–February 2021 (the JD range 2459126–2459265) at the Caucasus Mountain Observatory (CMO, Russia) with the 60-cm telescope using the Andor iKon-L camera, 2048×2048 pixels, with a pixel size of 13.5 microns. The Johnson BV-band filters and $g'r'$-band filters of the ZTF survey system (Masci et al., 2019) were used. Information about the CMO and description of the observing data reduction technique can be found in our previous paper (Berdnikov et al., 2020). We obtained a total of 1665 magnitude measurements with photometric errors close to 0.01 mag.

Observations are available in a text file in the html version of the paper (Table 1). The light curves, constructed with the fundamental period, are shown in Fig. 1.

Using the Period04 code (Lenz and Breger, 2004), we determined the frequencies for the fundamental, F_0, and first-overtone, F_1, modes. Then we used 17 combinations of these frequencies (Table 2; amplitudes in filter B are given for information) to approximate our observations by Fourier series. For this purpose, we converted all observations to intensities and, for each ith observation, set up conditional equations in the form:

$$I_i = I_0 + \sum[(A_j \cdot \sin(2\pi t_i F_j) + B_j \cdot \cos(2\pi t_i F_j)], \quad j = 1 - 17, \tag{1}$$

where I_i is the observed intensity; I_0 is the mean intensity; A_j and B_j are the amplitudes; t_i is the Julian Date of observation; F_j is the frequency. The system of linear equations (1) is solved by the least-squares method for unknowns I_0, A_j, and B_j.

Clearly, the difference between observed intensity, I_i, and the sum (1) without harmonics of any particular mode gives us the intensity for this mode. These intensities, converted back to magnitudes, form the light curves of AS Cas for the fundamental and first-overtone modes given in Table 3 and Table 4 (in the html version of the paper), respectively. They are shown in Fig. 2 and Fig. 3, constructed with the light elements:

$$\text{Max HJD} = 2448874.8469 + 3\overset{\text{d}}{.}024089443 \cdot E \tag{2}$$

and

$$\text{Max HJD} = 2448875.1768 + 2\overset{\text{d}}{.}155014317 \cdot E, \tag{3}$$

respectively for the fundamental and first-overtone modes.

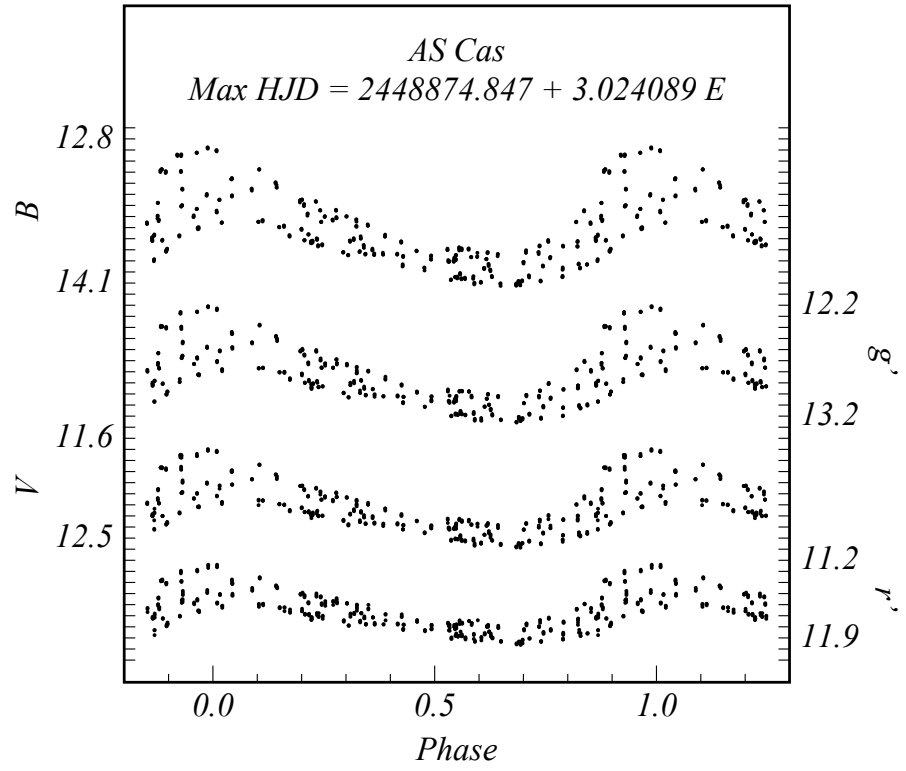

Figure 1. $Bg'Vr'$ observations (Table 1) phased with the fundamental period.

Table 2. Frequencies for equations (1). Amplitudes for the filter B are given

Name of frequency	Frequency, d^{-1}	Amplitude, mag
F_0	0.33067805	0.3366
$2F_0$	0.66135610	0.0961
$3F_0$	0.99203415	0.0361
$4F_0$	1.32271220	0.0062
F_0+F_1	0.79471209	0.1209
$2F_0$+F_1	1.12539014	0.0723
F_1-F_0	0.13335599	0.0686
F_0+$2F_1$	1.25874613	0.0421
$2(F_0$+$F_1)$	1.58942418	0.0288
$2F_0$-F_1	0.19732206	0.0143
$3F_1$+F_0	1.72278017	0.0127
$3F_0$-F_1	0.52800011	0.0080
$2(F_1$-$F_0)$	0.26671198	0.0022
F_1	0.46403404	0.2197
$2F_1$	0.92806808	0.0414
$3F_1$	1.39210212	0.0079
$4F_1$	1.85613616	0.0054

The sum (1) for harmonics of any particular mode gives the template light curve for this mode; these are shown in Fig. 4 and Fig. 5 (for the fundamental and first-overtone modes, respectively) and presented in the html version of the paper as Table 5 and Table 6, which list the B, g', V, and r'-band magnitudes for phases from 0 to 0.995 with a step

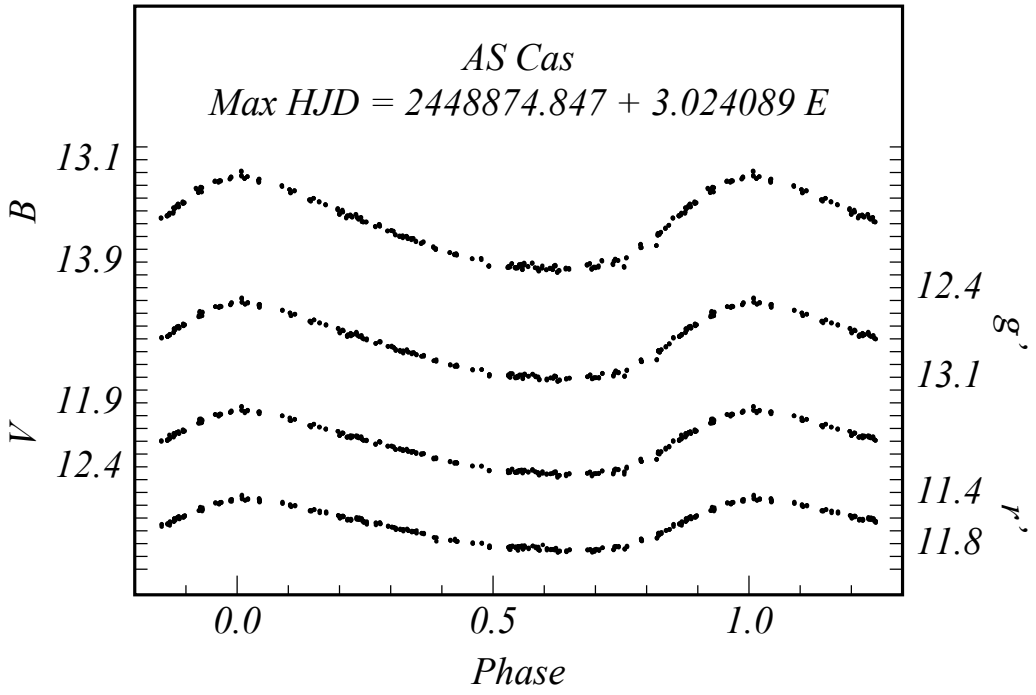

Figure 2. Fundamental-mode light curves of AS Cas.

of 0.005. We plan to use these templates to study the behavior of pulsating periods of AS Cas.

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References:

Berdnikov, L.N., Belinskii, A.A., Shatskii, N.I., et al., 2020, *Astron. Rep.*, **64**, 310

Masci, F.J., Laher, R.R., Rusholme, B., et al., 2019, *Publ. Astron. Soc. Pacif.*, **131**, 018003

Lenz, P. and Breger, M., 2004, *Proceedings IAU Symposium*, No. 224, 786

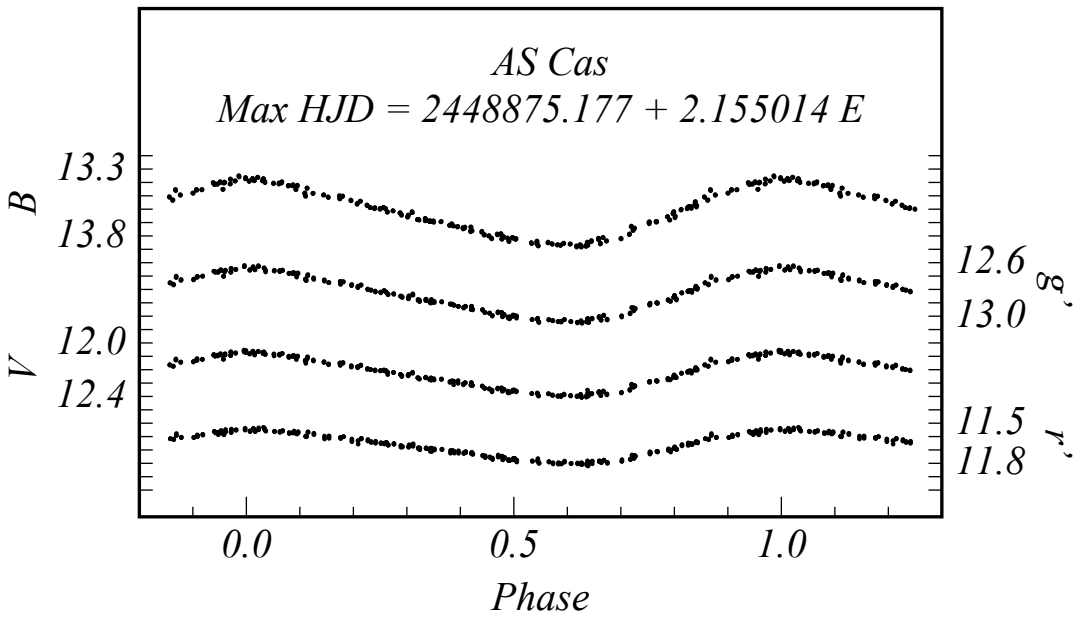

Figure 3. First-overtone light curves of AS Cas.

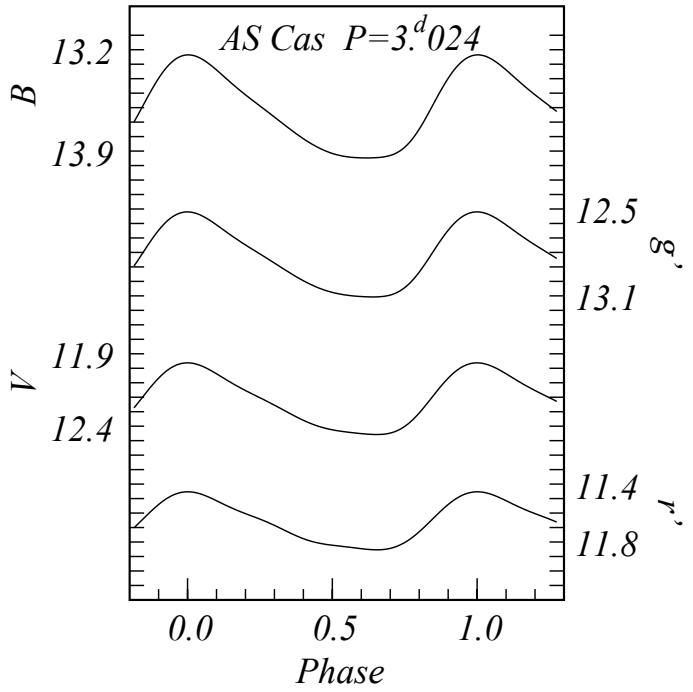

Figure 4. Fundamental-mode template curves of AS Cas.

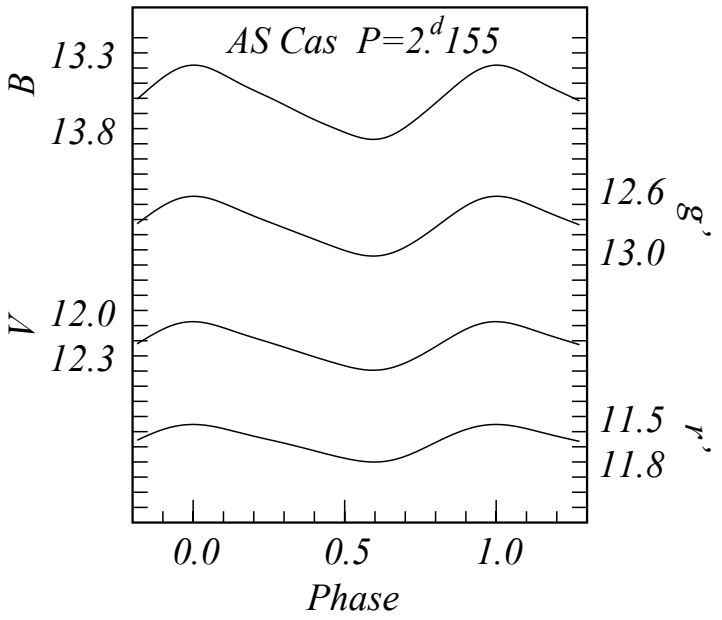

Figure 5. First-overtone template curves of AS Cas.