AE Ursae Maioris

Light curve observed on March 30, 2004 by

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(under supervision of Dr. Tibor Torma)

Generalities

AE UMa is a very fast pulsating variable star of the SX Phe type. These variables are just above the main sequence in the instability strip, and have unusually large amplitudes. The combination of a short period of a few hours and a large amplitude of a half a magnitude makes them the ideal choice of a variable to observe in a university lab setting.

The General Catalog of Variable Stars has the following data:

Name: AE Ursae Maioris

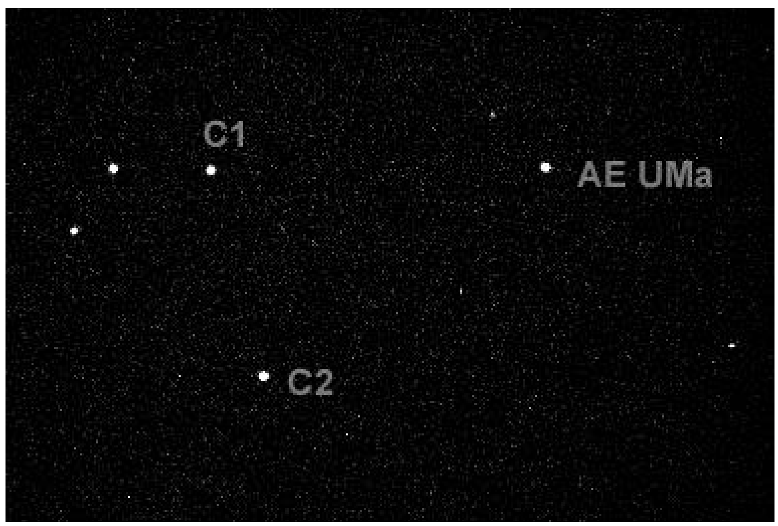
Coordiantes: $9^h 33^m\ 41^s\ +44^o 17'30''$

Type: SX Phe

Period: $2^h 04^m$

Spectrum: A9

Max – Min: 10.86 – 11.52 (V)



There is a comfortable comparison star available only at 7.5’ from the variable (C2) whose B-V indicates a spectrum quite similar to AE UMa. One of the pictures taken has been labelled to indicate the locatgion of the comparision stars:

C1: GSC 2998: 1166 , V= 11.7 mg

C2: GSC 2998: 1249 , V= 11.43 mg, B-V = +0.30 mg

The observation

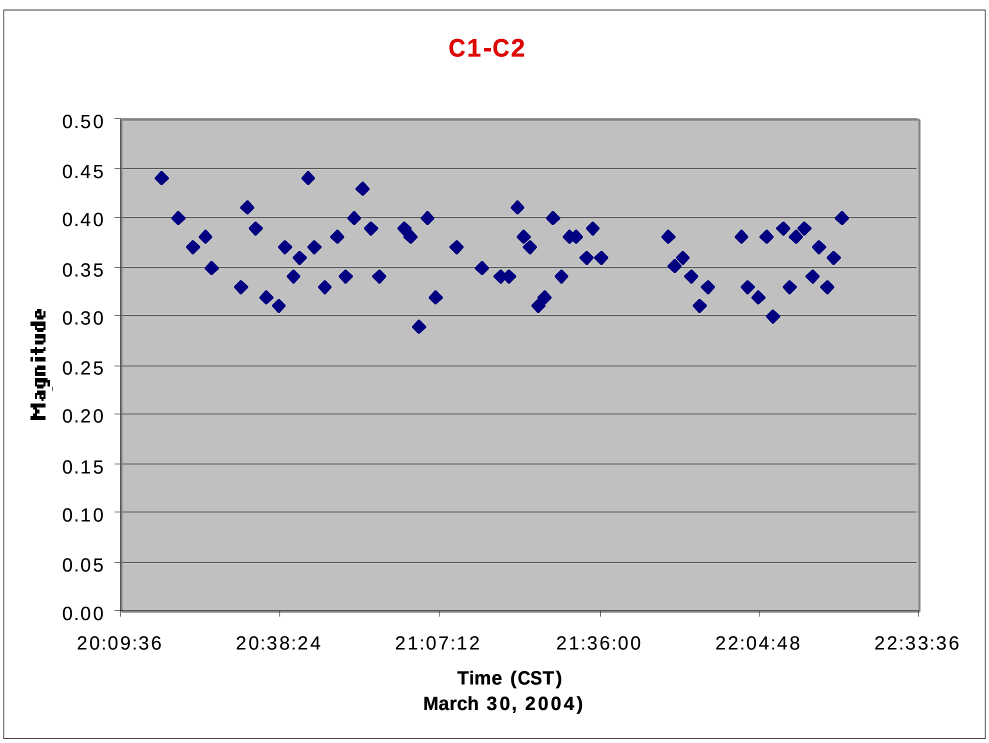
After an initial session used by the students for familiarization with the telescope and camera, we did the actual observation on March 30, 2004, with only Sarah jordan present. The weather was clear from cirri but low-level cumuli were moving, causing an occasional break in the observation. We do **not** think that their presence was a dominant factor in measurement errors. On that night 63 pictures of exposure time 30 sec were taken, spanning a time of 2^h03^m, exactly covering one period.

The images were taken through Kennon Observatory's 12 in Meade telescope with an SBIG ST-7 camera. The optical trin is as follows: Meade 12" -> JMI motorized focuser -> Celestron 0.33 focal reducer -> AO7 tip-tilt mirror -> CFW8 filter wheel (clear filter) -> ST7 camera at –10 C. The telescope data are f/5 (f=60 in), pixel size 1.2" with 2x2 binning (i.e. bin size of 2.4"x2.4"). We used a 10.3 mg star for guiding with the AO7 at tracking exposure of 0.2 sec, and found a 3 Hz guide rate. Sky flats were taken the following night.

The evaluation

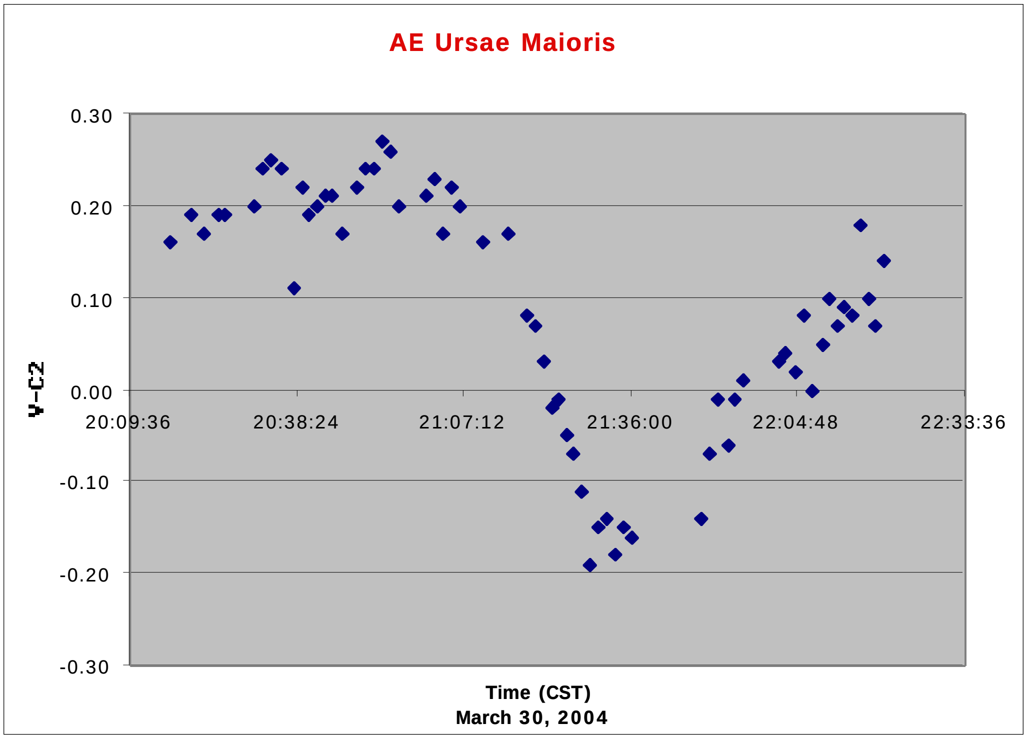
After dark subtraction and flat fielding the brightness of three stars was measured on each image using the SBIG CCDoops program, each time subtracting the background, through a cooperation of all the three students in the project.

The general accuracy of the measurement is indicated by the statistical scatter of the difference in brightness between the two comparision stars. The RMS accuracy of the measurement is **+-0.035 mg**. There is no

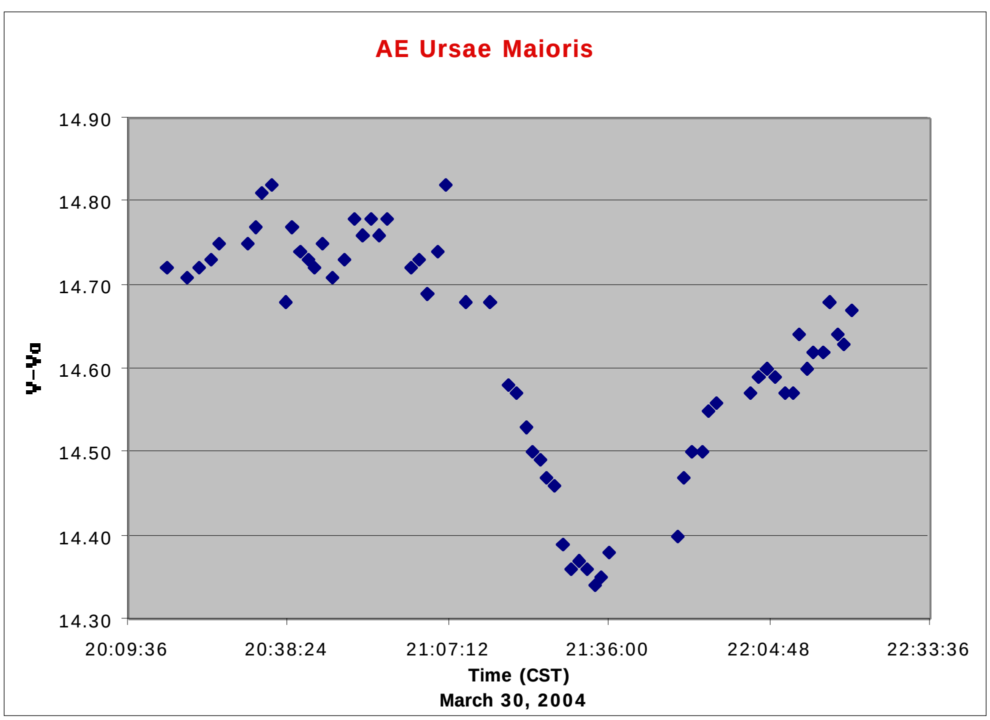


tendency of a change in this difference (indicating the smallness of systematic errors, conceivably due to a change in the air mass).

It turns out that the statistical accuracy of the light curve is better if the absolute brightness (determined by the sensitivity of the camera) is used than when the difference between the variable and the comparison star is used. We do not know the reason for this behaviour.



The $V\text{-}V_0$ magnitude in the picture below with reference to an unknown V_0.



Conclusions

We find that within a span of two hours it is possible to get a full light curve of this variable. The technique is within the reach of students, with proper guidance.

The accuracy of the measurement (+-0.034 mg) is sufficient to establish the variation of stars with amplitudes > 0.1 mg. Also, we expect that much of the error is statistical (the images had a background noise of +-8, and a total ADU from the variable around 12000, which produces a S/N=1500 and a statistical inaccuracy of +- 0.025 mg). This could be improved by a factor of 2-3 by taking 2-5 minute exposures. We expect however, that at least as much systematic error is present due to inaccurate flat-fielding. Because there was significant vignetting or reflections on the flat field images (as much as 10%), we think the bottleneck in improving the accuracy is the optical design.

The epoch of the maximum can be determined from the light curve with reasonable accuracy. However, the epoch of the minimum is not accessible. For that, at least another half a period would have been needed, and best would be to follow the star for 2.5 periods (i.e. 5 hours), unless we can predict the epochs and start the observation at a time in th3e middle between maximum and minimum.