AUTOMATED MINOR PLANET LIGHT CURVE GENERATION

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We describe a system that autonomously generates a lightcurve for one or more desired minor planets. Specifically, the automated process was started with the press of a button, it ran during the night, and the next morning the computer screen displayed the lightcurves for two simultaneously observed minor planets: 631 Philippina and 246 Asporina. Their lightcurves are consistent with their previously known periods.

This paper presents an automated system that generates a lightcurve for one or more minor planets. In short, the system allows one to "Press the start button at the beginning of the night, go to bed, and have the minor planet lightcurve greet you in the morning." Specifically, this method meets the challenge put forth by Professor Richard P. Binzel (Binzel 1991; 2001).

System Description

The components of the system include: a celestial object database program capable of recognizing the name of a minor planet, calculating its position, and providing positions of stars for astrometry and photometry purposes. The system also provides a telescope control and modeling program that controls the robotic telescope hardware and accurately positions the telescope by accounting for systematic telescope errors. Additional capabilities include a camera control and image-processing program capable of controlling a camera and computing astrometry and photometry for raw lightcurve data. Results are shown by a graphing program capable of displaying the lightcurve graph from the raw data.

The celestial object database program can be commanded externally to provide the position of any named minor planet. The list of all known minor planets maintained by the Minor Planet Center can be easily incorporated into the database program so that the position of any minor planet can be determined. Orbital integration is used to produce a very accurate minor planet position. This program also serves as a database for reference stars for astrometry and photometry purposes.

The telescope control program can be commanded externally to move the telescope to any desired position. Integrated with the telescope control program is telescope modeling to correct for systematic errors common to most every telescope mechanical system. The major systematic errors include out of round gears, non-perpendicular axis, polar misalignment, mechanical flexures and offset errors. The telescope-modeling program quantifies and rigorously corrects for these systematic errors, enabling the telescope to point to the desired minor planet.

The camera control program can be externally commanded to acquire digital images. The image-processing portion of this program analyses the images acquired. An astrometric solution is generated by recognizing and correlating stellar patterns on the image itself along with stellar patterns in the associated field of the celestial object database program. Through astrometry of the image and the celestial object database program, appropriate reference stars are used, their flux noted, along with the minor planet's flux. It should also be noted that as the images are acquired, they are reduced accounting for bias and dark current. Then a flat field is applied.

System Integration

An end-to-end demonstration of the system was performed successfully on UT 2001 July 17 at the Software Bisque Observatory using an SBIG ST-9 attached to a Celestron C-11 on a Paramount GT-1100S. At the beginning of the night, the process was initiated by the press of a button. The celestial object database program recognized the name of the first minor planet to be observed, 631 Philippina, and calculated its position. The telescope control and modeling program instructed the telescope to slew to this minor planet position. The camera control and image-processing program, acquired an image of the minor planet, reduced the image, computed an astrometric solution, and logged the instrumental magnitudes of the reference stars and the minor planet. This process was repeated for a second minor planet, 246 Asporina , and the system operated throughout the night by slewing between the two minor planets. At the conclusion, the resulting lightcurves were displayed on screen. The lightcurves for the two minor planets are shown in Figure 1 and Figure 2. The lightcurve of Philippina is consistent with its known period of 5.92 hours as is the lightcurve of Asporina consistent with its longer known period of 16.222 hours.

The system successfully met the challenge at hand by automating the process of generating light curve for two minor planets. It could be easily adapted to apply to most any type of celestial object, for example variable stars and satellites.

References

Binzel, R. P. (1991). "Robotic Observations of Asteroids." In *Robotic Observatories: Present and Future*, (S. Baliunas and J. Richard, eds.), pp. 219-223. Fairborn Press, Arizona.

Binzel, R. P. (2001). "Automated Lightcurve Prize." MPB **28**, 59.

EDITOR'S NOTE: The authors are to be congratulated for accomplishing this challenge set out a decade ago. The Editor hereby declares Matthew L. Bisque and his team as winners of both offered prizes.

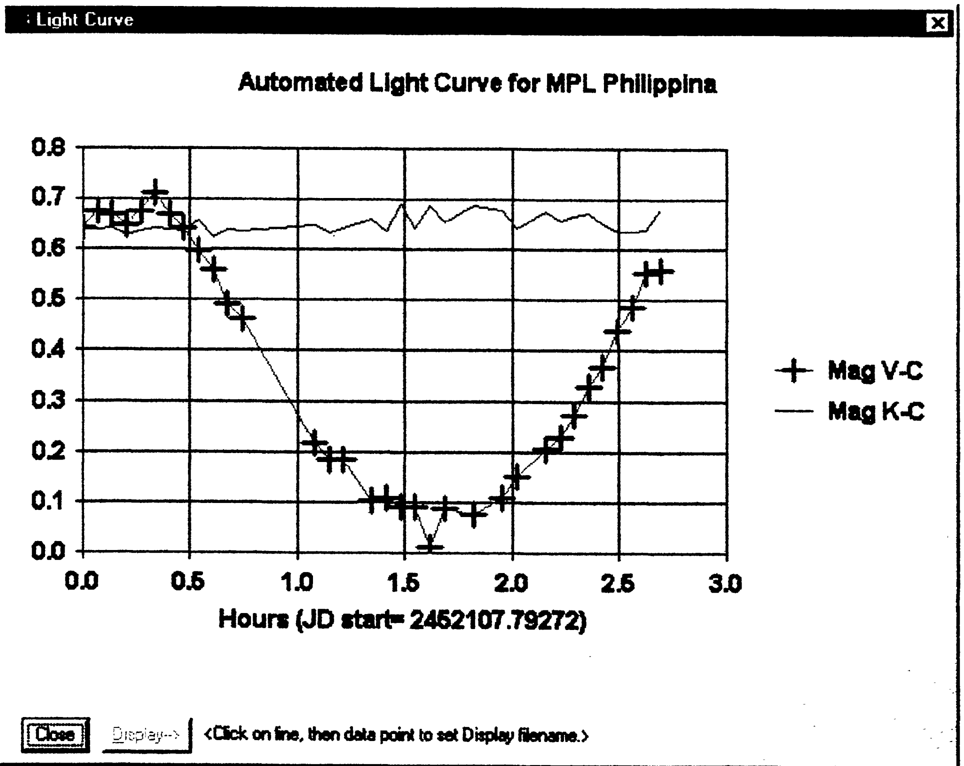

Figure 1. Automated light curve for minor planet 631 Philippina obtained on 2001 July 17.

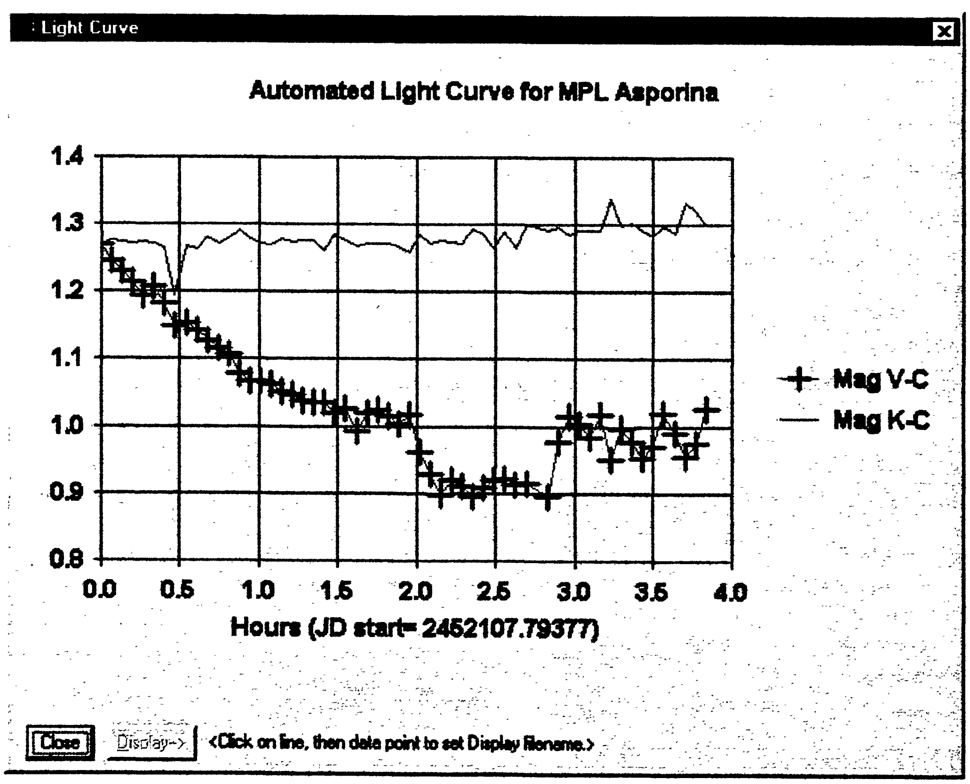

Figure 2. Automated lightcurve for minor planet 246 Asporina obtained on 2001 July 17.