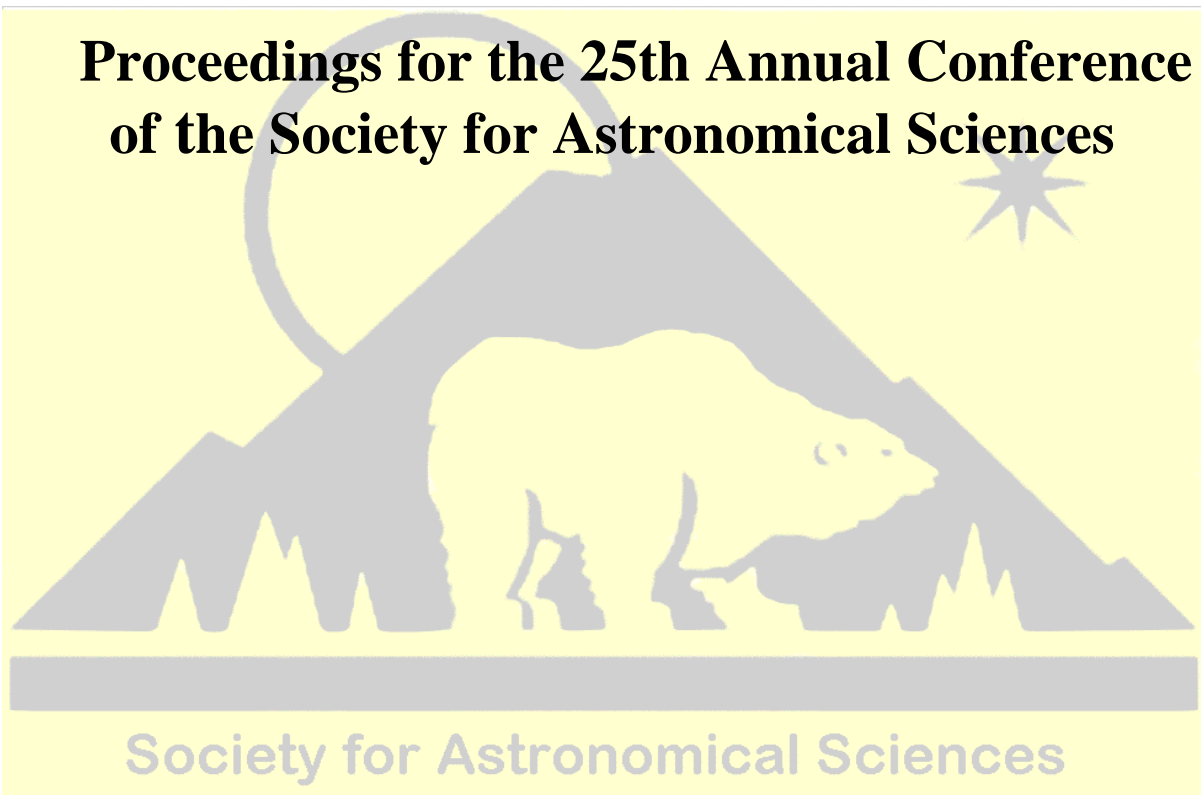

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Serendipitous Discovery of Variable Stars While Gathering Asteroid Lightcurves

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Abstract

Altimira Observatory is located in southern California and has primarily been used for asteroid photometry. Instrumentation consists of an 11-inch Schmidt-Cassegrain (Celestron NexStar-11) operating at F/6.3, a CCD imager (ST-8XE NABG), and filter wheel (CFW-8A) with Johnson-Cousins B, V, and R filters. A detailed description of the observatory, the calibration of the instruments, and some reported results, can be found at the author's website (http://www.geocities.com/oca_bob), or by e-mail request (rbuchheim@earthlink.net). © 2006 Society for Astronomical Sciences.

1. Introduction

Most asteroid lightcurve projects start with a night-long series of images containing the asteroid – between 50 and 200 images (1-minute to 5-minute exposure, depending on the brightness of the target asteroid) of the same FOV. Differential photometry is used to detect variations in the asteroid's brightness. Since comparison-star brightness is assumed to be stable during the night, ensemble-photometry (i.e. up to 5 comp stars) is used to confirm the stability of the selected comp stars. Each comp star's brightness is checked relative to the average of the other four comp stars through the night, thereby identifying any significant change in the brightness of any selected comp star during the course of the night. The photometry program MPO Canopus simplifies this process.

During the past year, two interesting variable stars were discovered accidentally in this way – they just happened to have been selected as comp-stars for an asteroid.

2. GSC 0376-0596: A High-Amplitude Delta Scuti type Star in Hercules

In May 2005, during a photometric study of asteroid (6327) 1991 GP1, one of the “comparison stars” used for differential photometry was found to be a variable star. Identification data for this star are:

RA(2000) = 16:20:02
Dec(2000) = +4:28:41
Cross- identifications = UCAC2 3316055
= GSC 0376-0596

A search of references showed that it had not been previously reported as being variable.

The other comp stars in the field showed the expected trend of raw instrumental magnitude – brightness rising slightly as the star rose from the horizon, peaking at culmination, and fading again as they set. This trend is the signature of atmospheric extinction.

The raw instrumental (unfiltered) light curve of “comp star 4” was clearly unusual: its brightness varied by over 0.5 magnitude in a bit less than 3 hours.

Since I was providing my asteroid data to Brian Warner for this project, when we compared notes we were surprised to find that we had both discovered variable stars in this same field of view, on the same night – and that they were two different stars, both previously unrecognized!

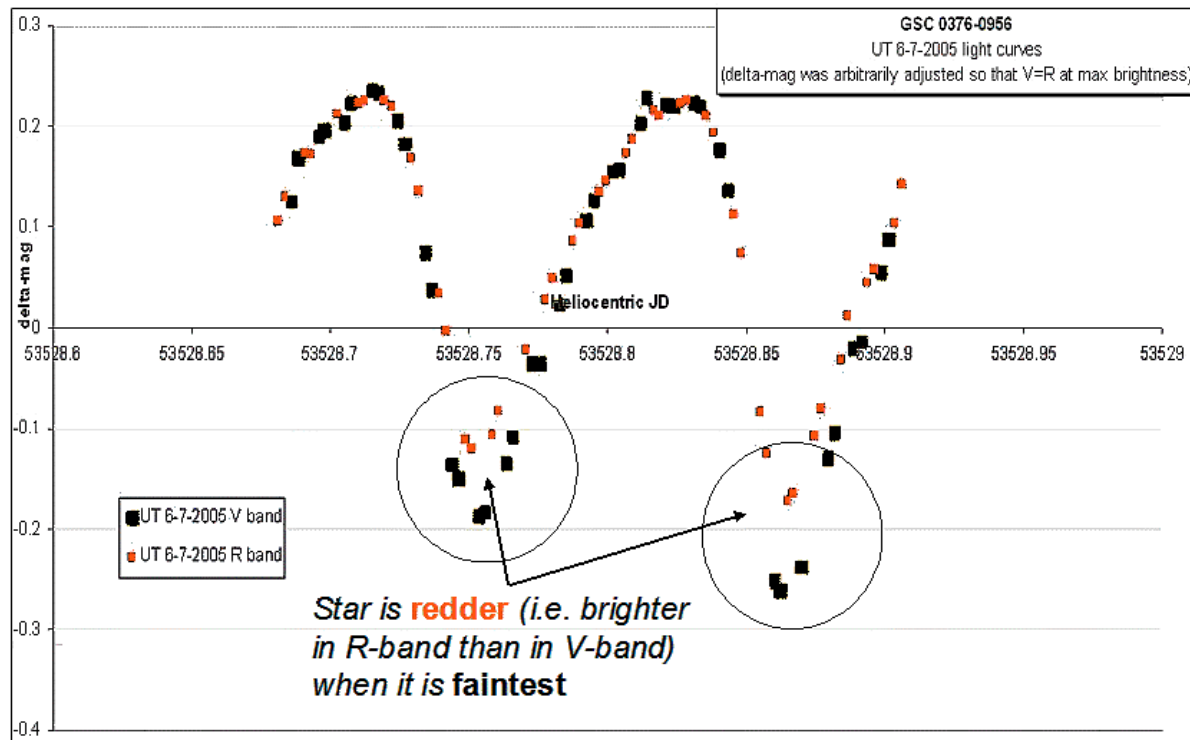
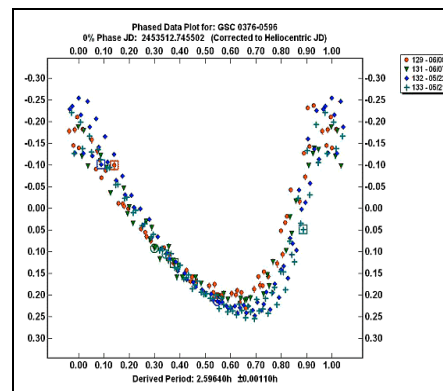
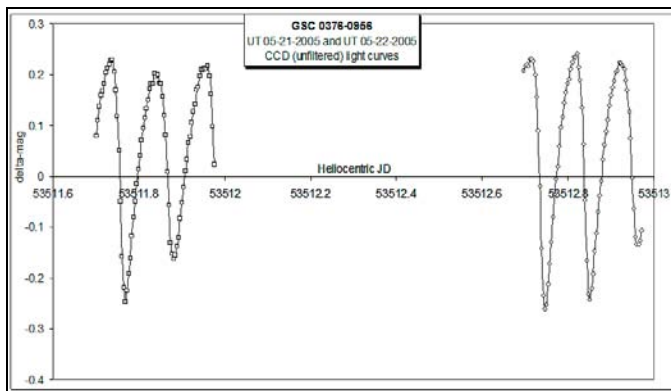
Differential photometry (unfiltered) for two nights confirmed the $\Delta m \approx 0.5$ mag (p-p) brightness fluctuation. I had the opportunity to show these two nights to Dr. Arne Henden at the 2005 SAS meeting, and he pointed out that this star displays many of the characteristics of Delta Scuti type variable stars:

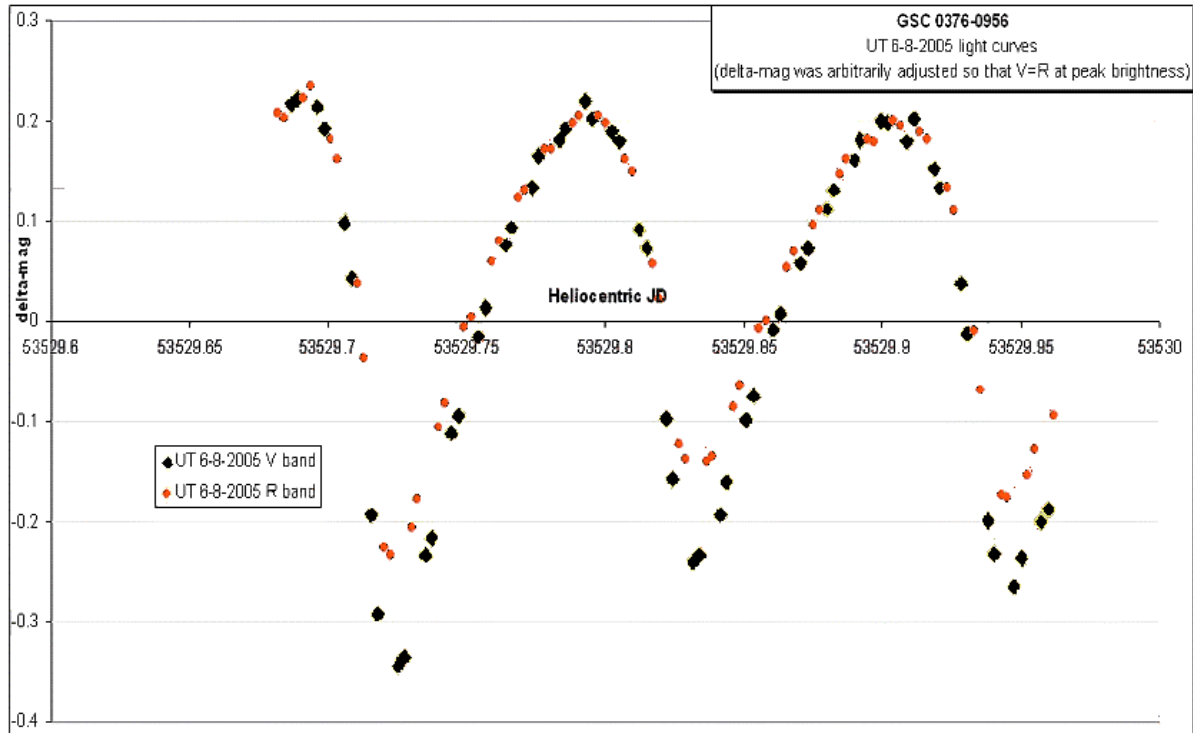
1. The period is quite constant
2. The amplitude of light variation is not constant (each cycle has a slightly different P-P amplitude, similar to an amplitude-modulated carrier).

A primary period $P=2.5964$ hours was determined from 4 nights of data (approximately 8 hours per night of continuous monitoring). A phased light-curve, wrapped to this period, is shown below.

Delta Scuti's are pulsating variable stars. The theory of stellar oscillations predicts that the temperature (and hence, the color) of the star should change as it pulsates. Specifically, when the star has expanded it will be cooler, redder, and fainter. When it has contracted, it will be hotter, bluer, and brighter. In order to investigate this, I took two nights of data through V and R band filters. The imaging sequence of V-V-R-R-... was continued all night, throughout both nights.

The filtered CCD photometry confirms that the star's color does, indeed, change slightly during its brightness fluctuation cycle. Displayed in the plots below are the instrumental V and R band lightcurves (from UT 06-07-2005, and UT 06-08-2005, respectively). In these plots, the R band curve has been adjusted downward by an arbitrary amount, so that it overlays the V band plot at maximum brightness. This makes it easier to see the color variation. The star is somewhat redder at minimum brightness than it is at maximum brightness, confirming the expected result for a pulsating variable star.





The V and R band data from these two nights was calibrated using Landolt standard stars as the primary reference. The characteristics of this star, on the standard Johnson-Cousins photometric system, are

Average (mid-point) brightness is $V \approx 12.87$

The peak-to-peak amplitude variation is about $\Delta V \approx 0.6$ magnitude

max brightness $V \approx 12.58$

min brightness $V \approx 13.14$

the P-P amplitude changes by up to 0.1 V-mag from cycle to cycle

The color changes with the brightness – it is about 0.12 magnitude redder at minimum brightness than it is at maximum brightness.

max brightness (V-R) ≈ 0.1

min brightness (V-R) ≈ 0.22

Absolute photometry accuracy is estimated to be ± 0.03 magnitude.

3. Acknowledgement

I am grateful to Dr. Arne Henden (Director, AAVSO) for his encouragement and advice.

