Observing Variable Stars at the University of Athens Observatory

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Abstract

In 1999 the University of Athens installed a 0.4-m Cassegrain telescope (CCT-16, by *DFM Engineering*) on the roof of the Department of Astrophysics, Astronomy and Mechanics, equipped with a ST-8 CCD camera and Bessel UBVRI filters. Although the telescope was built for educational purposes, we found it can be a perfect research instrument, as we can obtain fine quality light curves of bright variable stars, even from a place close to the city center. Light curves of the δ Scuti star V1162 Ori and of the sdB star PG1336-018 are presented, showing the ability of a 40-cm telescope to detect negligible luminosity fluctuations of relatively bright variable stars. To date, we succeed in making photometry of stars down to 15th magnitude with satisfactory results. We expect to achieve even better results in the future, as our methods still improve, and as the large number of relatively bright stars gives us the chance to study various fields of CCD photometry of variables.

1 Introduction

The rapid development of astronomy in the last decades and the necessity to observe fainter and fainter objects, and reach higher spatial and spectral resolutions has led to the construction of a large number of 8-m or higher class ground-based, optical telescopes in various countries. The newest telescopes are placed in the very best sites in the world, which, however, are few and remote. The access to large observing facilities is restricted only to a few professional astronomers and the allocation of observing time is done on a competitive basis. On the other hand, the diminishing availability of small (<1 m) telescopes at national facilities and the inadequate funding for the smaller (public and private) observatories, pose serious threats to the quality of educational projects and research on specialized topics that can be undertaken in the 21st century. The users of those facilities, mainly faculty members and students of University Astronomy Departments, and in some cases highly competent amateurs, must participate in the decisions affecting those facilities, which support their research and education.

A new small observatory has already been built at the University of Athens Campus in Panepistimiopolis, Zographos (Niarchos & Laskarides 1999). The observatory, apart from the 5-m dome, includes a large office and a small apartment for overnight accommodation of the observer and for occasional accommodation of foreign visitors to the Department. The telescope was installed in March 1999. The observatory and its telescope were a gift by Mr. Lukas Gerostathopoulos.

2 Instrumentation

The main characteristics of the new telescope are as follows:

OPTICS

- Cassegrain reflector (CCT-16, *DFM Engineering, Inc.*, 1998)
- Pyrex primary mirror; diameter: 40 cm
- focal ratio F/3 for primary mirror
- effective ratio of F/8
- low temperature (-40°C) operation for the optical encoders
- 2-speed motorized focusing
- finderscope: 9×60 with illuminated reticle

TELESCOPE MOUNT

- equatorial fork mounting
- RA and DEC axes driven by DC servo motor/encoders
- combination of steel and aluminum construction
- tracking accuracy: (2.0 arcsec in 2 minutes, 20.0 arcsec in 1 hour)
- pointing accuracy better than 1 arcminute RMS
- optical incremental position encoder drives independent of motor drives
- cool operation - low heat generation at the telescope (<10 W average)
- up to 20 kg instrument load, limited to 18 cm behind mounting surface

CONTROL SYSTEM
The Telescope Control System (TCS) provides a user-friendly interface to the telescope, with continuous position display, status reporting, and easy-to-use, menu driven, command set of 28 commands. Pointing corrects for precession, nutation, aberration, atmospheric refraction, mount misalignments and flexure. Characteristics include:

- remote control system (up to 50 m away from the telescope)
- built-in library of astronomical objects

- compatible with commercial autoguider systems
- extensive system protection via computer-calculated limits
- hand paddle functions: guide, set, slew, focus and dome rotation
- dome control using existing motor

AUXILIARY INSTRUMENTS

- Photoelectric Photometer
- SPP photon-counting photometer with Johnson UBV filters
- CCD camera
- ST-8 (SBIG), KAF-1600 chip (9 micron pixels), F.O.V. 15×10 arcminutes
- filter wheel with UBVRI filters
- cooling down to 30°C below ambient temperature
- Solar filters
- *Thousand Oaks Optical* visual and H? prominence filter

SOFTWARE

- *The Sky* (can control the CCD camera and process images)
- *EZPhot* (can perform multiobject photometry with automatic image correction)
- *CCDSharp* (can sharpen CCD images by applying the Lucy-Richardson deconvolution algorithm)
- *CRL Script* (can run scripts, controlling telescope, CCD camera, filter wheel and image processing packages)

3 Results of Observations

In the frame of international collaboration we included in our program the following variables:

V1162 Ori: This is a high-amplitude δ Scuti star, located at $\alpha_{2000} = 05^h32^m01.9^s$, $\delta_{2000} = -07°15'05''$ (**??**,**??**). Its minimum apparent visual magnitude is V=9.89 and it has B−V = 0.38. Its pulsational period and amplitude have changed during the last decade, according to Hintz et al. (1998)observations. The 1999-2000 campaign, organized by T. Arentoft and C. Sterken (Arentoft & Sterken 2000) , has already given a more precise estimation of period and amplitude. Our preliminary analysis of our 60-hour observations shows that the period decreases from a T_{max} = 2451460.579 +

$0^d.07869 \times E$ and the amplitude oscillates around the value Δm = 0.17. In the same field, a new suspected variable, GSC 4778-324, has been found at $\alpha_{2000} = 05^h32^m34.46^s$, $\delta_{2000} = -07°12'40.12''$, having V=10.26 and an amplitude of only 0.02 magnitudes. Its light curve, along with the light curve of V1162 Ori, is presented here (Fig. 7).

PG1336-018: The sdB star PG1336-018, located at $\alpha_{2000} = 13^h38^m48^s$, $\delta_{2000} = -02°01'49''$ (3,4), is a very short period eclipsing binary, similar to HW Vir, but with rapid oscillations of the scale of ~3min (Kilkenny et al. 1998). Its orbital period of 0.1010174 d is one of the shortest known for a detached binary. Our 25-hour long observations resulted in a light curve (8), in which the rapid oscillations are just visible.

Monitoring of cataclysmic variables: In addition, the stars of Table 1 have been observed to date, again in the frame of international collaboration.

Table 1. Observed cataclysmic variables

STAR	Minimum m_V	Total hrs of observations
BZ Cam	13	60
V795 Her	12.3	55
V Sge	14	25
TT Ari	11.2	12

Limiting magnitude: We participated in an observing project on EX Dra, a cataclysmic variable star of $m_V = 15$ (16 during eclipse). The star was easily seen in our 4-min exposures in both V and R filters.

4 Future Prospects

The rapid advancements in detector technology upgraded small telescopes and made them capable of doing what large telescopes did in the past (Huchra 1996). Some kinds of observations, like photometry of variable stars, can be done much better and easier with small telescopes (Rucinski 1986, Sterken 1986) since new detectors (CCDs) and powerful methods of reduction and analysis are available now. It is widely admitted that small telescopes are needed both for the astronomical education and for carrying out some research programs. The high quality of our telescope in combination with the CCD camera would allow us to carry out, under certain circumstances, some specialized research projects, like:

- Discovery and photometry of variable stars (with the use of CCDs)
- Supporting multi-wavelength observations from space and those made from ground-based observatories by large optical and radio telescopes
- Photometry of eclipsing binaries and cataclysmic variables
- Monitoring the gravitational microlensing events in the Milky Way

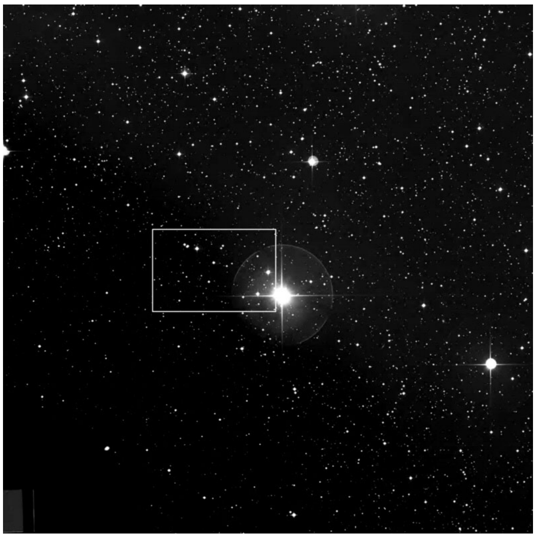

Figure 1: The region (60×60 arcminutes) of V1162 Ori. The boxed area corresponds to the field of Figure 2. V1162 Ori appears very close to the bright star υ Ori, a fact that posed an interesting challenge of trying to keep light contamination from the latter outside from our photometric CCD field; it was a good test for the optical quality of the new telescope, as this was its first target.

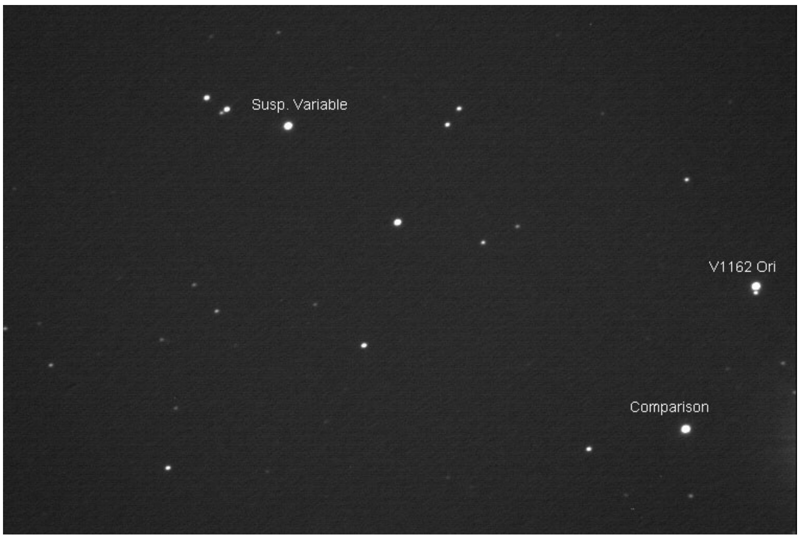

Figure 2: The field of V1162 Ori (15×10 arcminutes) imaged by the telescope of the University of Athens Observatory, showing the comparison star GSC 4778-00019 (magnitude V=10.0, B−V=1.40) and the suspected variable GSC 4778-324.

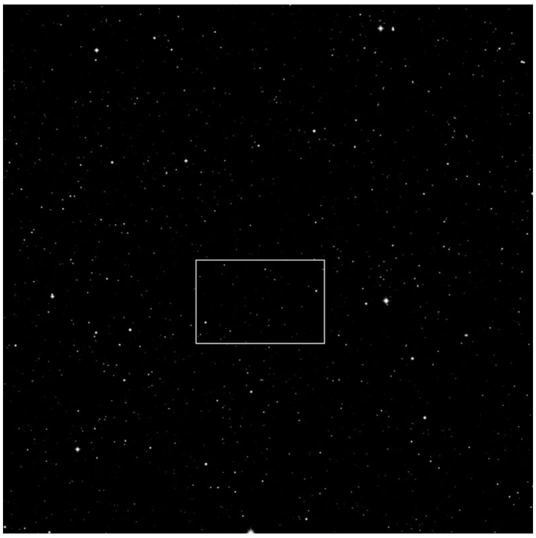

Figure 3: The region (60×60 arcminutes) of PG1336-018. The boxed area corresponds to the field of Fig. 4.

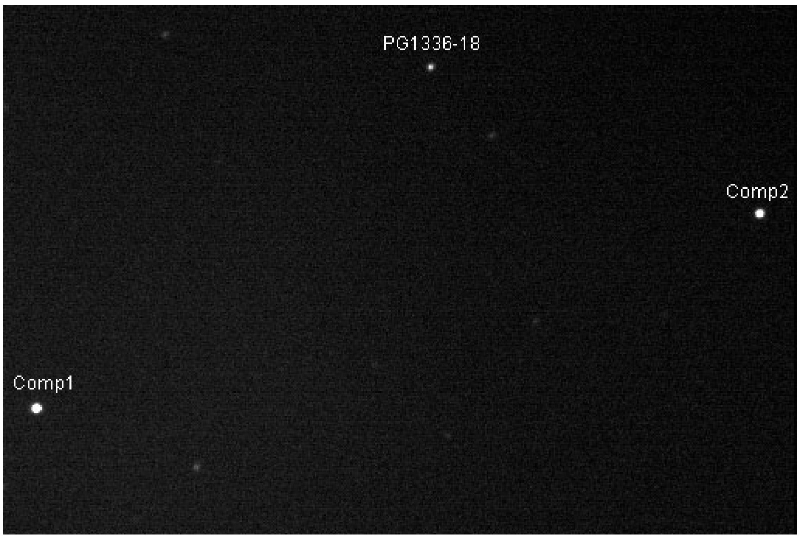

Figure 4: The field of PG1336-018 (15×10 arcminutes) imaged by the telescope of the University of Athens Observatory

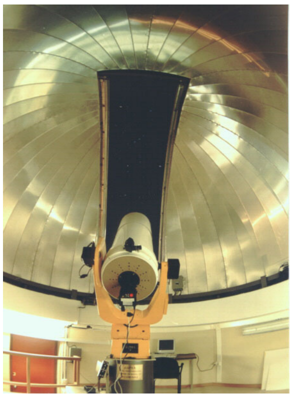

Figure 5: The new telescope, pointing at its first target, V1162 Ori.

Figure 6: The University of Athens Observatory, facing north.

- Solar observations in the optical region

Among the most suitable research programs for small telescopes are the long-term projects, since it is easier to obtain long observational time in small telescopes than in large ones. Usually, such projects are part of international observational campaigns, where small telescopes in the range 0.5–1.0 m belong to a network (24-hour coverage) and are dedicated to long-term monitoring. The small telescopes could join other international networks, such as the Whole Earth Telescope (WET), the Backyard Center of Astrophysics (CBA) and the North European Observatories Network (NEON). The advantages from the participation in such a network are obvious.

5 Summary

The new University of Athens Observatory will revolutionize the astronomical education in undergraduate and postgraduate level. Modern methods of observations and data reduction will be possible with the use of telescope's modern instrumentation. The high quality of the new instrument guarantees

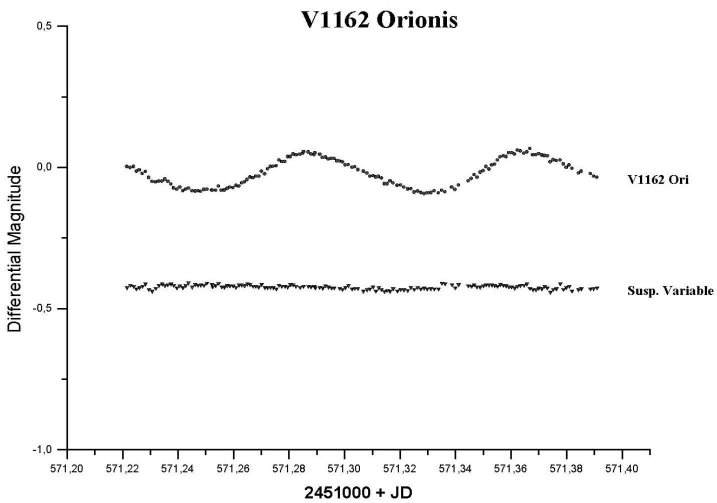

Figure 7: Light curves of the δ Scuti star V1162 Ori and of the suspected variable GSC 4778-324.

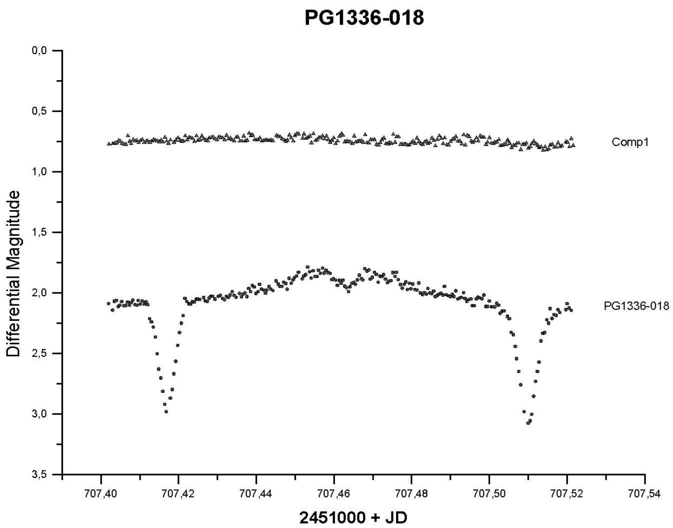

Figure 8: Light curve of the sdB star PG1336-018, a very short period eclipsing binary.

its use for carrying out some specialized research programs and participation in international networks.

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