ABOUT 21st RUN OF WET: PG 1336-018

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ABSTRACT. We briefly communicate about 21st run of the Whole Earth Telescope (WET) in April 2001, where the eclipsing short period binary sdB system PG 1336-018 was the primary target.

Key words:Stars: hot subdwarfs: stars: individual: PG 1336-018, stars: oscillations, stars:: variables: EC 14026

1. The WET

The Whole Earth Telescope (WET) is a collaboration of astronomers who agree to observe a target star in such a way that observations can continue around the globe 24 hours a day, from site to site. The WET was organised in 1988, as an instrument to solve the alias problem which appears when on tries to interpret the time series amplitude spectra for a multimode pulsator from one single observatory. In order to resolve close modes, long nearly continuous coverage is necessary. So both the length of a run and the number of observatories that participate and their distribution in longitudes on the Earth are important parameters. Due to the wish of as global coverage as possible the campaigns are named as XCOVs for EXtended COVerage. A summary of the first 10 years of WET operations was given by Kleinman (1999).

So far telescopes of sizes 1-2.5m have been used for the WET. The main instruments during the first 10 years have been two channel (object and comparison star) and 3 channel photometers (object, comparison star and sky background). The experience has shown that the 3 ch photometer can get good data even through light cirrus clouds, and it has been able to extend the length of a nights run with at least one hour, by the continuous measurement of the sky brightness. To be accepted for the WET observers and instruments have to fill requirements given by the WET collaboration.

Now the WET instrumentation is in a transition state as more and more of the observers use CCDs specially programmed for continuous readouts. With such instruments it is possible to observe fainter stars, and also to correct for thin clouds.

Data are produced as standard ascii files and the WET collaboration has developed a set of PC programs (DOS) for the observations and the data reduction. In addition an interface card with a precise oscillator has been developed to collect the pulses from the photometer and send to the PC as numbers. A group in Lithuania has produced amplifiers, interface cards and complete photometers for the collaboration.

During a campaign a headquarters is organised with some experts that collect the data sent by e-mail from the observers as soon as they finish a night's observations. The headquarters people reduce data as soon as they get their hands on it, and post the results immediately on the internet pages of the WET (http://wet.iitap.iastate.edu), so that each observer in the field can follow his or hers contribution to the total light curve and also participate in the running discussion of the analysis of the data. Headquarters people are in daily contact with the observers, asking them about the weather prospects and tell them what to observe. A campaign has usually several targets, and if two observatories at the same longitude have clear weather, the headquarters can decide that one site observe the primary target and another one observe another target. The headquarters also give advice on the observing procedures and in particular check the timing, which has proved to be a problem at some observatories.

All the telescopes involved in WET work as a single instrument, as an orchestra - actually, to run an XCOV could be compared with a piece of music (Kleinman & O'Donoghue, 2000). At the moment Professor Steve Kawaler is the Director of WET, and Reed Riddle is his Deputy Director. They are located at the Iowa State University, Iowa, U.S.A.

Targets are traditionally chosen from the classes of pulsating white dwarfs (ZZ Ceti=DAV, DBV, DOV) and other rapidly (multiperiodic) variable stars, like IBWDs, interacting binaries, δ Scuti and roAp stars,

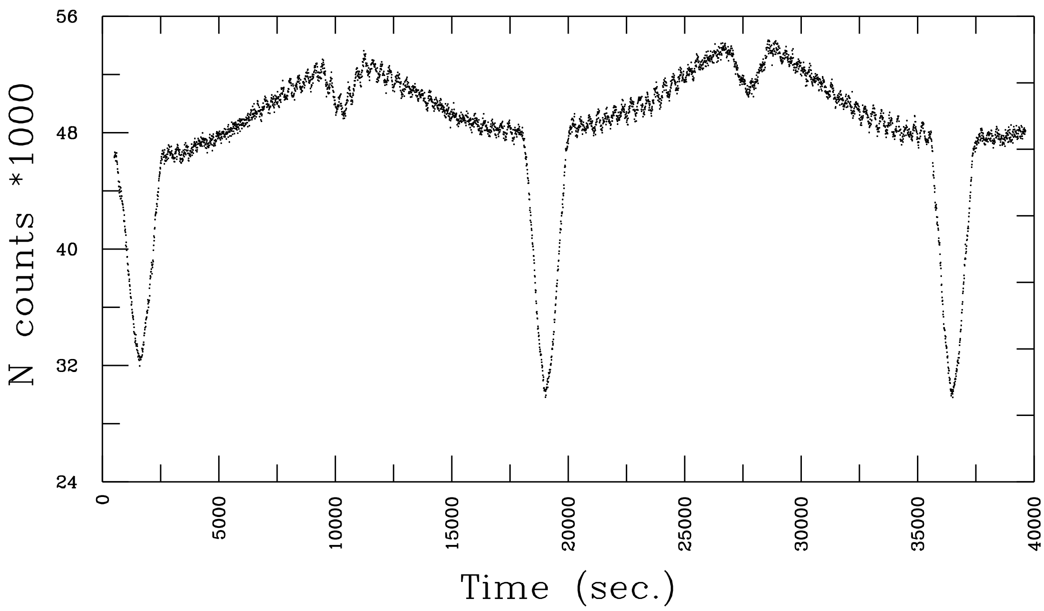

Figure 1: Light curve for PG 1336-018 observed at the Teide Observatory.

and the newly-discovered sdB pulsators.

2. The Target

The pulsating hot subdwarf PG 1336-018 (hereafter PG 1336) was the primary target of XCOV21 from April 15 to May 4 2001. 20 observatories from 16 countries around the globe aimed on this object during the run (Table 1). The list of observatories in Table 1 is sorted accordingly to their East longitudes which were extracted from Astronomical Almanac (2001).

The Principal Investigators for this run was Mike Reed from Iowa State University (USA), he observed in CTIO, and Dave Kilkenny from SAAO.

PG 1336 was also the target of XCOV17 in April, 1999, (Reed et al., 2000) and is really remarkable. It is a sdB star (V=13.4 mag) in a close binary system with P=2.4 hr. The name of the object is derived from Palomar-Green colorimetric survey. Recently some colorimetric surveys focus on the blue subluminous objects, above all quasars and hot stars different kinds.

Understanding the evolution of sdB stars, the so called prewhite dwarfs, is very important and can be a clue to understanding of many mysteries of the late history of massive stars and population synthesis.

When a group of astronomers from SAAO (Kilkenny et al., 1997) discovered the pulsating sdB stars, it has opened the prospect of using asteroseismology to examine the interiors of these stars. Kilkenny et al. (1997) refered these objects to the EC 14026 stars, because a prototype was discovered in the Edinburgh-Cape survey investigations. According to the 75th namelist of variable stars (Kazarovets, Samus & Durlevich, 2000) the class has been named RPHS – or "very rapidly pulsating hot (subdwarf B) stars", and the Prototype EC 14026 has been given the variable star designation V361 Hya. The pulsation periods of the EC 14026 stars range from 80 to 500 s and amplitudes are up to 30 mmag.

The 184 s and 141s pulsations of the sdB star, which is the primary of the partially eclipsing binary system PG 1336 were discovered by Kilkenny et al. (1998). As a result of the 17th run of WET Reed et al. (2000) found that the subdwarf pulsates in at least 15 modes - radial and non-radial. The companion is an M4-5 dwarf of approximately the same radius but considerably fainter and in the primary eclipse it covers roughly half of the pulsating star. The XCOV21 run of WET was optimised to search for the pulsations during the eclipses. The investigation of rotational splitting of the modes in eclipse and out of eclipse promises a real opportunity to identify radial and nonradial modes of the pulsations.

3. Some Results from XCOV21

Simulations done before the XCOV21 showed that some modes would be observable ***only outside*** the eclipses, some would be observable ***only during*** eclipses, and some both. This would help in classifying the modes. In the campaign it was expected to observe all eclipses during one week (Reed et al., 2001).

The coverage for PG 1336 in the XCOV21 became quite good. According to the WET internet pages (http://wet.iitap.iastate.edu) 268 hours were spent on

Table 1: WET XCOV21 observatories and telescopes.

Observatory	Abbr.	Country	Longitude	Tel. (m)
Mauna Kea		Hawaii, USA	-155° 28′	0.6
Southeastern Association	SARA	USA	-111° 36′	0.9
Mt.Lemmon		USA	-110° 48′	1.5
McDonald		USA	-104° 01′	2.1; 0.9
Hard Labor Creed Observatory	HLCO	USA	-83° 36′	0.4
Cierra-Tololo Interamerican Observatory	CTIO	Chile	-70° 49′	1.5
Pico dos Dias (Itajuba)		Brazil	-45° 35′	1.6
Nordic Optical Telescope	NOT	La Palma Spain	-17° 53′	2.6
Teide Observatory	OT	Tenerife, Spain	-16° 30′	0.8
Haute Provence Observatory	OHP	France	+5° 42′	1.93
Loiano		Italy	+11° 20′	1.5
South African Astronomical Observatory	SAAO	South Africa	+18° 28′	1.9; 1
Mt. Suhora		Poland	+20° 04′	0.6
Moletai		Lithuania	+25° 17′	1.65
Turkish Natl. Observatory		Turkey	+32° 47′	1.5
Crimean Astrophysical Observatory	CrAO	Ukraine	+34° 01′	1.25
Wise Observatory		Israel	+34° 46′	1
Uttar Pradesh (Naini Tal)		India	+79° 27′	1
Beijing Astronomical Observatory	BAO	China	+116° 22′	0.85
Mt.Stromlo		Australia	+149° 00′	1.9

PG 1336, and a total of 206 eclipses observed. Fig. 1 shows a long light curve from the Teide Observatory, Tenerife, where we can follow the pulsations into the eclipses which are only partial. The light curve from one of the primary eclipses is shown in more detail in Fig. 2.

However, the coverage in UT or longitude was quite uneven distributed in this campaign. From UT 21hr – to UT 09hr the object was observed 15-17 nights, while the coverage between 9 and 21 hr, corresponding to Asian longitudes, was an average 6 nights on the target, with a minimum of only one night between UT 18 and 19.

Fig. 3 shows the coverage hour by hour, and we note that there is considerable hole in the data set East of the Black Sea all the way to the Pacific Ocean. One could see also returning to Table 1 that from 20 observatories which participated in the run: 10 observatories were in the interval from -35° to +35°, 7 ones were in the interval from -35° to -180°, and 3 observatories only - from +35° to +180°, so we could make good use of more telescopes in this region.

At the same time on the location of the former Soviet Union stay large and equipped observatories, such as Mt.Dushak-Erekdag (λ = 57° 53′), Mt. Majdanak (λ=66° 53′), and Tien-Shan (λ=76° 57′) observatories. Their modern instrumentation is not in use and decay from the lack or complete absence of local financial support.

We applied for the participation in this run of WET with the 0.8 m telescope and two-star photometer of Odessa Observatory which are situated at the Mt.Dushak-Erekdag in Central Asia (Dorokhov et al., 1997). However, for financial reasons we could not go to the Mt.Dushak-Erekdag and applied instead for an observational time in the Crimean Observatory.

4. The Multi-Colour Observations

The time for the simultaneous UBVRI photometry has been given on 1.25 m AZT-11 telescope of the Crimean Observatory with the 5-channel photometer-polarimeter (Efimov et al., 1984). The multi-colour observations of PG 1336 prove useful to the mode identification and the eclipse modeling. Unfortunately the weather was not favourable in Crimea this spring, and only short series of observations could be obtained between the clouds. We selected a short interval of observations of 19 Apr with a bearable transparency and try to reveal the colour amplitudes in the region of principal frequency 5440 Hz, following to Kurtz (1998). The results are shown in Table 2:the filter, the effective length of band, the dominant frequency, the amplitude in mmag and the error of amplitude. Apparently, the results reflect the variability of atmospheric transparency in the Crimean Observatory on that time.

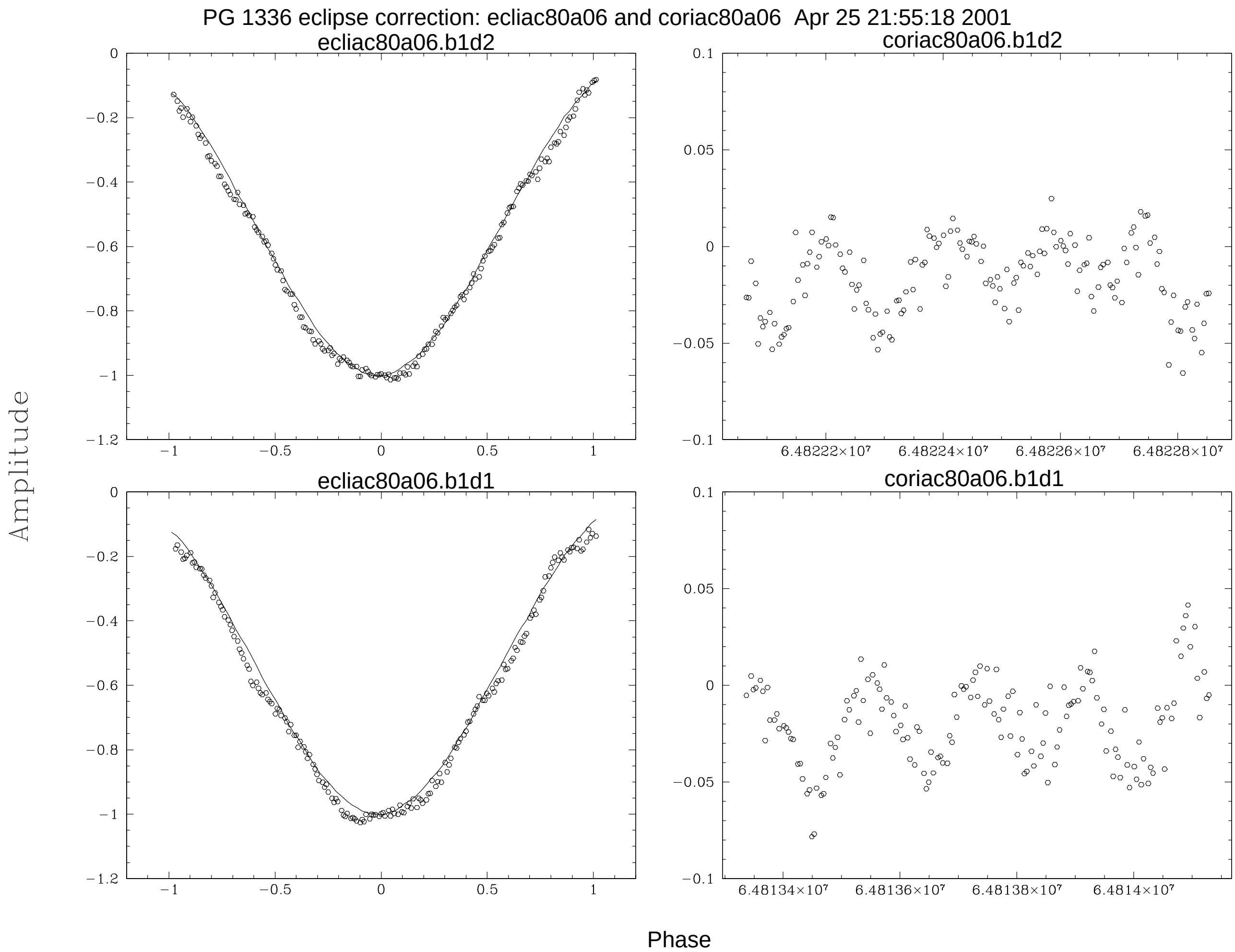

Figure 2: Details of the light curve for PG 1336-018 observed at the Teide Observatory. The curves show how the pulsations continue through two of the eclipses on April 24, 2001. (from wet.iitap.iastate.edu/xcov21/pg1336)

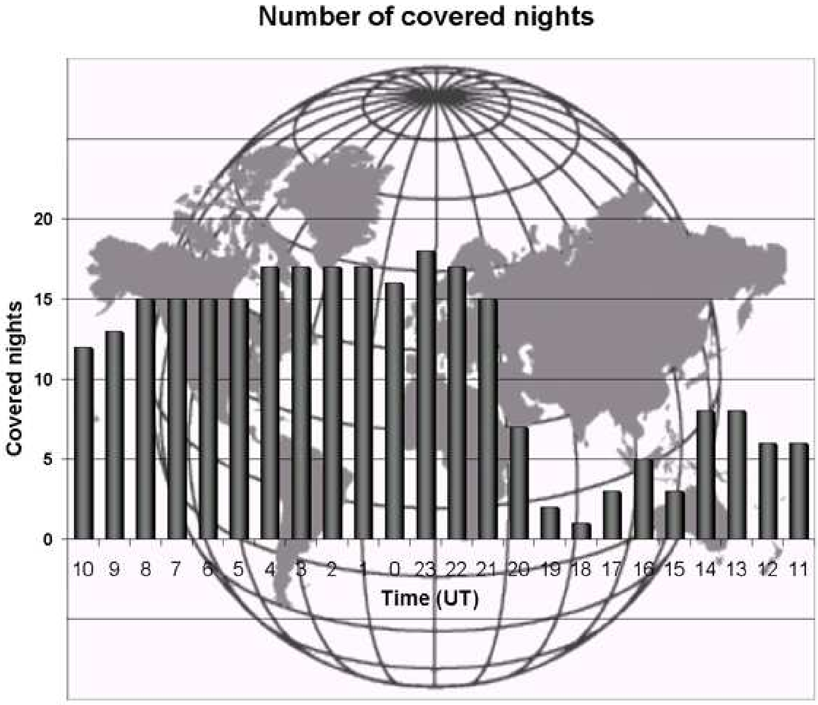

Figure 3: The distribution of the nights observed in particular intervals of UT, or the longitudes' distribution of the observatories. We see a substantial lack of coverage over the Asian continent.

Table 2: The colour semiamplitudes.

Filter	λ Å	Frequency μHz	Amplitude mmag
U	3670	5675	10 ± 7
B	4360	5710	12.5 ± 5
V	5450	5118	4.5 ± 7
R	6380	5662	6.6 ± 5
I	7970	5611	1.6 ± 10

5. The Future of the WET

The next campaign XCOV22 is planned for May 2002, and in the WET internet pages it will be possible to follow this campaign as it happens (wet.iitap.iastate.edu). The targets selected are PG 1456+103 and PG 1159-035. For this campaign we hope there will be possible to fill the Asian gaps in the coverage we experienced in XCOV21.

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