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XCOV12: A REPORT ON THE L 19-2 CAMPAIGN

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Abstract. A preliminary report on the successful 1995 Whole Earth Telescope observations of the pulsating white dwarf L 19-2 is presented. Information on the campaign organization, observing logistics, quality of the data obtained and the likely scientific returns is provided.

Key words: stars: variables, white dwarfs – stars: individual: L 19-2

1. Introduction

The DA white dwarf L 19-2 (MY Aps) was identified as a pulsator by McGraw (1977). An extensive photometric study of this DAV object was subsequently undertaken by O'Donoghue and Warner (1982, 1987) (OW, hereon) during the period of 1979 and 1985 at the South African Astronomical Observatory (SAAO). Five coherent pulsations with periods near 350, 192, 143, 118 and 113 s were identified, along with strong evidence for the rotational frequency splitting of each one.

In spite of the extensive nature of this single-site data set (including data segments derived from 6 – 8 hour runs on 5 successive nights!), the forest of peaks in the power spectrum due to the one-day aliases made some of the OW conclusions tentative. In fact, a perusal of the OW papers will reveal, how hard they had to work to obtain evidence of power in their Discrete Fourier Transforms (DFT) at some frequencies (e.g. the power near 143 s). Removal of larger amplitude components using least squares fitting in the time domain (i.e. prewhitening), was an essential part of their analysis procedure. Use of this technique indicated that the largest amplitude pulsation near 192 s was, in fact, a triplet with unequal splitting. This asymmetry was interpreted by OW as a detection of the second-order rotational splitting effect (Chlebowski 1978). Furthermore, an investigation of the stability of this pulsation mode revealed no detectable change in the frequency over an eight-year base line. This makes L 19-2 one of the extremely stable white dwarf pulsators.

L 19-2 was selected as a southern hemisphere target for the 1995 WET campaign, XCOV12. Along with Chris Clemens, I acted as a PI. The scientific justification for this choice centered on the desirability of unambiguously identifying all the pulsation modes and associated rotational splitting effects in this interesting object. In addition, a quality WET data set on L 19-2 would enable a pulsation mode stability analysis to be extended back to the OW data were obtained. Ten years have elapsed since that data were obtained, and given that L 19-2 is one of the hottest DAV's (Bradley 1993), it is time to reexamine the possibility of detecting a period change resulting from the effects of evolutionary cooling. Only one DAV (G 117-B15A: Kepler et al. 1991) has revealed definite indications of a secular cooling change in the frequency of a pulsation mode.

The intention of this paper is to provide a brief preliminary report on the L 19-2 component of the XCOV12 campaign. A substantive paper authored by all the WET contributors is in preparation.

2. XCOV12 in the south

The 14th magnitude object L 19-2 (−81° declination) is visible only from southern hemisphere observatories and, since the other WET targets were only visible by northern observers, XCOV12 ended up causing a Whole Earth Telescope north/south divide!

Southern observing time for WET was obtained during the period 24 April – 8 May at SAAO near Sutherland, South Africa (14 nights, 0.75 m telescope), Pico dos Dias Observatory (PDDO) at Itajuba in Brazil (11 nights, 2.1 m telescope) and Mt. John University Observatory (MJUO) near Lake Tekapo in New Zealand (9 nights, 1 m telescope). Darragh O'Donoghue and David Buckley shared the observing at SAAO, Odilon Giovannini undertook the PDDO observing, while I was the MJUO observer. The "on-line" data reduction and monitoring function was carried out by the WET headquarters team, based at Iowa State University for this run and organized by Chris Clemens.

Fig. 1 displays the theoretical visibility of the target object from all three sites throughout the complete 24 hour cycle. (Note: I developed the program to display object visibility in this way as part of an introductory astronomy course and adapted it for WET work; I am currently in the process of making it more portable so that it can be conveniently used by other WET observers.)

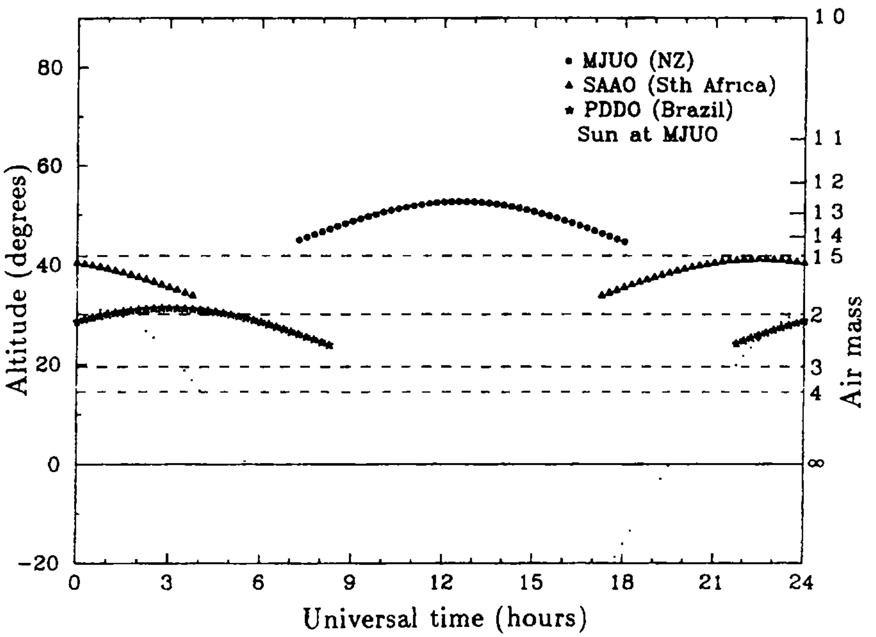

Fig. 1. The plot of visibility (altitude/airmass) versus universal time for the object L 19-2 at the three sites that were part of the southern hemisphere WET campaign. Points for each site are plotted every 15 min when the Sun is 15 or more degrees below the horizon. To aid interpretation, corresponding positions of the Sun are provided for the MJUO site.

It is clear from Fig. 1 that a combination of winter observing conditions, circumpolar target and a virtually optimum longitude distribution of observing sites meant that continuous coverage from just three sites was possible. However, there was no longitude redundancy – an important feature of previous WET campaigns that provides some insurance against the weather. I was initially very disappointed that an application for Chile observing time (CTIO) was unsuccessful, but the lack of CTIO time was largely academic, as this site was clouded out for the central period of the WET run (with the aid of a graduate student, observer at MJUO, I was also involved in another coordinated observing campaign that had obtained small aperture telescope CTIO time during the WET run).

3. L 19-2 observations

Fig. 2 displays in low time resolution all the data obtained on L 19-2 from the three sites during the WET campaign. The displayed data are the "quick-look" preliminary reductions that were carried out at the WET headquarters during the campaign.

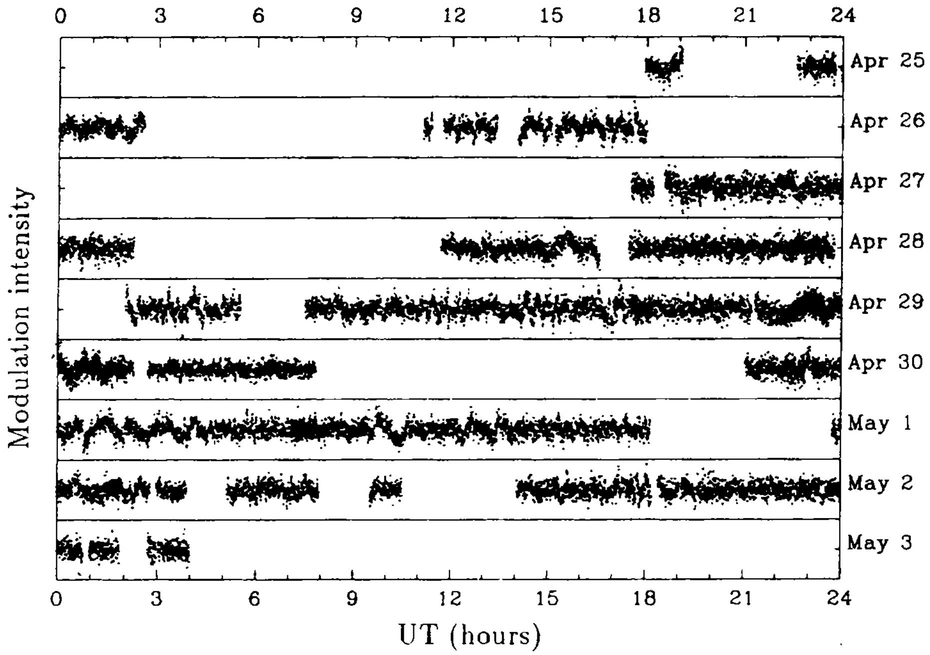

Fig. 2. The combined WET data set obtained on L 19-2 from all three sites. Each point is derived from an effective 20 s integration and the vertical axis is plotted in the WET standard modulation intensity units (1000 mi = 100 %), with each 24 h data segment displayed in the range ±40 mmi (= ±4 %). MJUO data cover the central time regions of the graph, while data from SAAO and PDDO share the end regions - see Fig. 1.

The compressed timescale disguises the intrinsic light variations that result from the pulsations (although the amplitudes of the variations are small, the dominant frequencies are detectable in the two-channel raw data when displayed in higher time resolution), and the variations of ~hour are the result of inadequate sky subtractions. None of the sites had access to a three channel photometer to provide a continuous monitor of sky transparency. Data obtained by me on L 19-2, in particular, has demonstrated the desirability of a continuous sky monitor, and I am currently in the process of modifying the VUW two-channel instrument to incorporate the three-channel improvements developed by Scot Kleinman and Ed Nather.

A glance at Fig. 2 shows that this three-site campaign was very successful. We were extremely fortunate with the weather: Table 1 summarizes some relevant observing statistics.

Table 1. Key L 19-2 observing statistics

Site	SAAO	PDDO	MJUO
Allocated nights	14	11	9
% useable	27 %	28 %	41 %
Hours clear	38.4	31.4	38.0
Observer(s)	O'Donoghue/ Buckley	Giovannini	Sullivan

During the 7.4 day period from April 25 (18 h) to May 3 (03 h) we achieved a duty cycle of 57 %, including some small amount of overlap. MJUO – a sometimes indifferent site – produced nearly as much good data from 9 nights as SAAO (one of the better sites in the world) did from 14 nights. This included two MJUO runs of nearly 11 hours. Even PDDO, which I understand is often hampered by poor weather, produced a ~30 % photometric-night return. The combined data set features two segments of essentially 24 hour continuous coverage, which significantly contributes to the suppression of the one-day aliases in the frequency spectrum of the data.

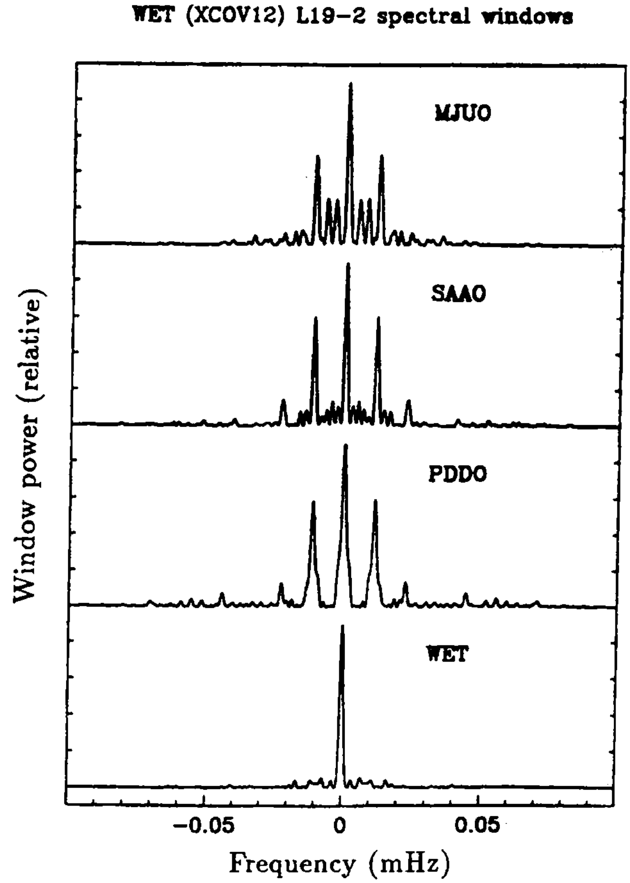

Fig. 3. The DFT spectral windows of the data obtained from the three individual sites together with that of the combined data set.

4. Preliminary results

The quality of the WET data set is clearly demonstrated in Figs. 3 and 4.

Fig. 3 illustrates the spectral window for the WET data set, along with the corresponding windows for the three individual sites. It is clear that the one-cycle-per-day aliases ($\delta f = 0.012$ mHz), that are strong features of the individual site data, are largely suppressed in the combined data. Of course, this is not really surprising, since this is what extended coverage is all about, but the results of this campaign dramatically show the advantages of this technique in a direct and obvious way.

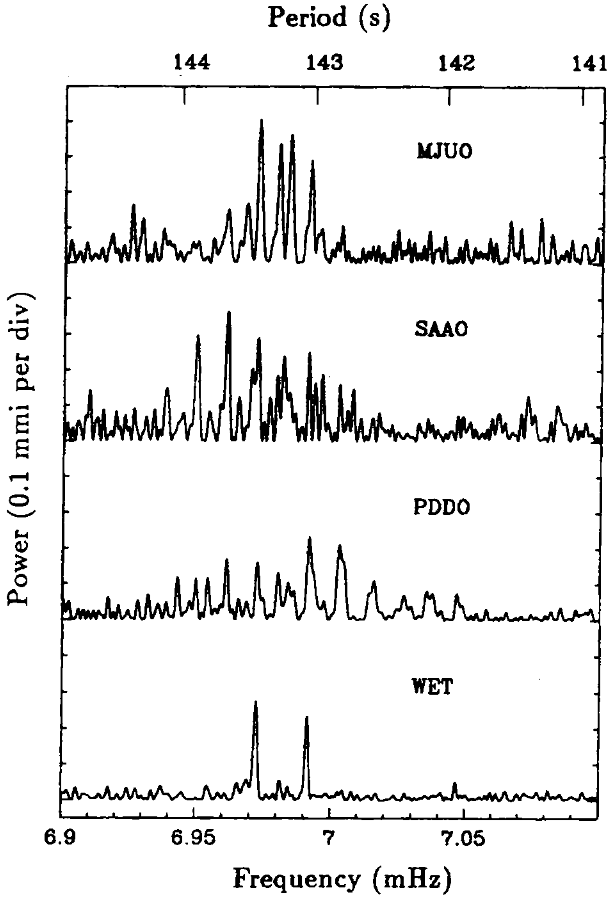

Fig. 4. The DFT of the WET L 19-2 data in the vicinity of 143 s (~7 mHz). The corresponding DFTs for the individual site data are provided for the purpose of comparison.

Fig. 4 displays both the DFT of the WET data and the single site data in the vicinity of 7 mHz (~143 s). This was the region for which OW detected the smallest amplitude power in their data. One could argue about the conclusions reached by OW in isolation, but one cannot argue with the WET DFT: there is unquestionably coherent power present, *and* it is split into two frequencies. The individual site DFTs illustrate the problems. Undoubtedly, prewhitening of the

MJUO data would reveal the two real frequencies, and presumably this approach would individually extract the frequencies from the other sites, but, in the case of the SAAO data, the largest peak is an alias. A quality of the WET data set makes detection of these coherent low-level signals believable.

The WET DFT in the other frequency regions, isolated by OW as containing real power, essentially confirms their (sometimes) tentative conclusions. For example, the power with a period near 118 s definitely has two components, and a comparison of the spacing between these components with the frequency spacing of the 143 s components strongly suggests, on theoretical grounds, that the latter frequency results from an $l = 2$ g-mode pulsation of the white dwarf (Bradley 1993, Clemens 1993). The dominant 192 s oscillation is clearly evident in even short data segments, but even the DFT of the combined WET data segment does not clearly reveal the rotational splitting of this mode. However, a preliminary prewhitening analysis of all the data reveals the unmistakable presence of two side peaks, in agreement with the OW analysis.

5. Conclusion

I would like to emphasize that this paper reports on a preliminary look at the excellent data set obtained on L 19-2 by the WET team during the 1995 XCOV12 campaign. DFTs and prewhitening calculations were carried out using the data reduced at WET headquarters during the run. The data are being re-reduced and a paper detailing the analysis and the results, authored by all WET contributors is in preparation.

Taking advantage of the convenient circumpolar position of L 19-2 at MJUO, I have obtained single site data both before and after the WET run, covering the period April to August 1995. These data combined with the WET run, should permit the determination of an unambiguous link back to the L 19-2 frequency determinations a decade ago.

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