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A five-month multitechnique, multisite campaign on the β Cephei star ν Eridani

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Abstract

We have organised the largest ever observing campaign for a β Cephei star. Its target star is ν Eridani. We briefly discuss the prospects and problems for asteroseismology of B-type main sequence pulsators and we describe the layout of the campaign based on our scientific goals. Finally, we invite all interested colleagues who have not already done so to join our team.

Introduction

There is no doubt that the advent of multisite campaigns has improved our understanding of the pulsational behaviour of δ Scuti and γ Doradus stars enormously. Not only can pulsational mode frequencies be determined unambiguously because of the elimination of the aliasing problem, but the large amounts of data – sometimes even more than 1000 hr of observation (Breger et al. 2002) – also allow the detection of signals of very low amplitude. Such projects have led to determinations of up to 22 independent mode frequencies (Handler et al. 2000) for individual stars plus a number of combination signals.

Consequently, it is expected that asteroseismology of massive stars, such as β Cephei stars and SPB stars, will also benefit from large multisite campaigns. The prospects and problems these stars pose are somewhat different from those for δ Scuti stars.

Probably the greatest advantage for studying B-type pulsators is that the complicating effects of a surface convection zone as present in A/F stars do not exist, which should ease the tasks of mode identification and seismological modelling considerably. On the other hand, the beat periods of the multiple modes in these stars can be very long which requires measurements over a long time base to be resolved. This difficulty effectively eliminates the SPB stars (where beat periods can be of the order of years) as prime asteroseismological targets, at least for the time being.

This leaves the β Cephei stars as the objects of prime interest for multisite campaigns on massive pulsators. They have multiple pulsation periods of the order of a few hours, large light amplitudes, readily detectable line-profile variations and comparatively simple theoretically predicted pulsational mode spectra. In addition, many of these stars are quite bright, making them ideally suited for high-resolution spectroscopic studies. Consequently, we have organised for the first time an extensive multisite campaign on a β Cephei star, using both spectroscopic and photometric observing methods.

The target star

We have carefully selected the most promising β Cephei star for our campaign from the literature, ν Eri (RA (2000): 04:36:19, Dec (2000): $-$03:21:09, $V = 3.92$, B2 III). It has four well known pulsation frequencies (Cuypers & Goossens 1981), three of which have been claimed to form a triplet. Such a multiplet structure makes this star particularly interesting, as detecting several multiplets would allow us to derive the internal as well as external rotation rate with very high precision. In addition, the remaining mode is known to be radial which severely constrains the physical parameters of ν Eri. Clear pulsational line-profile variability, superposed to the moderate rotational broadening ($v \sin i < 25$ km/s) was already detected by Aerts et al. (1994). Therefore, being visible from both hemispheres (accessible to large numbers of telescopes), being a slow rotator, and being bright enough for effective acquisition of high-resolution spectra yet not being too bright for most photoelectric photometers, ν Eri is an ideal candidate of a massive pulsator to be studied with multisite asteroseismology techniques.

The only small difficulty for the organisation of our project was the close frequency splitting of the mode triplet, causing a beat period of 62 days that needs to be resolved with our measurements. It is important to note that the beat period of the outer two components of the triplet then has a beat period of about 31 days, which would interfere with a possible monthly alias if not being taken care of. It is, of course, impossible to get such long allocations on the large telescopes required for spectroscopy.

We have therefore applied for block allocations of the order of one week at many different sites, suitably spreading them over a three-month interval (photometry will even be obtained during at least five months) to resolve the triplet (and possible additional ones!) cleanly in the combined data set. We have also asked for dark time at some sites to suppress the monthly alias.

Consequently, we hope that we have fulfilled all the necessary conditions to acquire the observational material sufficient to perform for the first time a detailed asteroseismological analysis of a massive main-sequence star with a large convective core. An overview of present telescope allocations is listed in Table 1 and shown in Fig. 1.

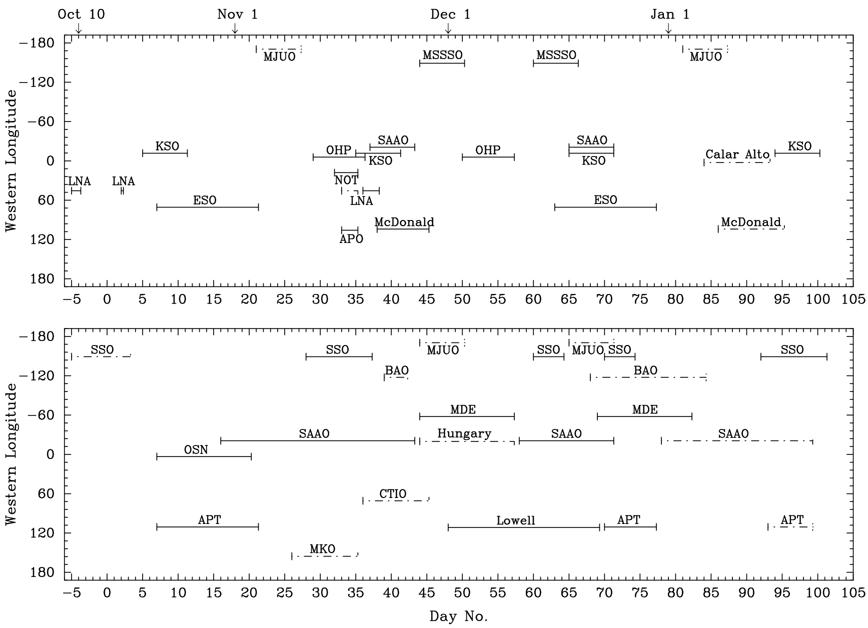

Figure 1: Graphical overview of telescope allocations. Upper panel: spectroscopy. Lower panel: photometry. The full lines are granted times of observation whereas the dashed-dotted lines are pending applications. Negative day numbers are due to a site starting earlier than planned.

So far, we have been allocated a total of 121 nights for spectroscopy at 10 telescopes up to 3.5 metres aperture on four continents spanning a total baseline of $\sim$ 105 days. We hope to obtain another $\sim$ 30 nights to extend our coverage. For the photometric measurements we have so far been awarded 166 nights with a time base of 94 days and we hope for $\gtrsim$ 80 nights more. However, measurements have already been obtained at Siding Spring Observatory from early September on, which means that our final time base is expected to be about 5 months.

Telescope	Contact or Observer	(desired) allocation	status
	Spectroscopy		
APO 3.5m	Krzesinski	3 nights	granted
NOT 2.6m	Uytterhoeven/Telting	4 nights	granted
McDonald 2.1m	Heiter	8 nights	granted
SAAO 1.9m	Balona/Romero	2×7 nights	granted
MSSSO 1.9m	James	2×7 nights	granted
OHP 1.9m	Mathias/Aerts	2×8 nights	granted
ESO Swiss 1.2m	Aerts/Maas/Groenewegen	2×14 nights	granted
Tautenburg 2.0m	Lehmann	4×7 nights	granted
LNA 1.6m	Bruch	2×3 nights	granted
Ondrejov 2.0m	Stefl et al.	whenever possible	granted
Mt. John 1.0m	Cottrell/Wright	2×7 nights	applied
Calar Alto 2.2m	Dreizler	10 half nights	applied
McDonald 2.1m	De Cat/Uytterhoeven	10 nights	applied
	Photometry		
SAAO 0.5m	Handler/Tshenye	3×14 nights	granted
SSO 0.6m	Shobbrook	30 nights	granted
Fairborn 0.75m	APT	31 nights	granted
OSN 0.9m	Rodriguez	14 nights	granted
Lowell 0.8m	Jerzykiewicz	21 nights	granted
MDE 0.8m	Dorokhova	2×14 nights	granted
SPM 1.5m	Arellano Ferro	14 nights	2 hr/night
Hungary 0.5m	Paparo	14 nights	applied
MJUO 0.6m	Cottrell/Wright	whenever possible	applied
SAAO 0.5m	Medupe/Ramokgali	21 half nights	applied
Leicester 0.4m	Burleigh		possible
CTIO 0.6m	Krisciunas	10 nights	possible
BAO 0.85m	Zhou	$4 + 16$ nights	possible
La Luz 0.6m	Eenens		possible
Mauna Kea 0.6m	Crowe		possible
Perth 0.6m	Birch		possible

Table 1: The participating sites.

Call for participation

Although the campaign is already running, it may not be too late for additional interested researchers to join in. As the outcome of this project will largely determine future strategies for asteroseismology of β Cephei stars and possibly of opacity-driven main sequence pulsators in general, we are interested to obtain the best results possible.

Observational requirements for spectroscopy is the ability to acquire high-resolution ($R > 30000$), high signal-to-noise ($S/N \gtrsim 200$) spectra of the stellar Si III absorption lines triplet near 4560 Å with a sampling interval no longer than 15 minutes. Photometric measurements are best acquired with photoelectric photometers and Strømgren uvy filters and a light neutral density filter, although Johnson (B)V photometry would also suffice. The photometric precision per differential target star measurement must be better than 5 mmag rms. CCD photometry would only be useful if heavy neutral density filters are available and if the field of view is larger than 20 arcminutes for acquisition of a sufficiently bright comparison star in the same field.

Interested colleagues are invited to contact the authors of this article for more information. The spectroscopic part of the campaign is led by CA who can be reached at `conny@ster.kuleuven.ac.be`, whereas photometrists are requested to email GH at `handler@astro.univie.ac.at`.

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