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Towards Asteroseismology of Long-Period Variable Subdwarf B Stars

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Abstract

Given the recent successes in the asteroseismological study of short-period variable subdwarf B stars, we investigate the asteroseismic potential of their long-period pulsating counterparts on the basis of both ground- and space-based photometry. We find the interpretation of the slow oscillators to be more challenging than that of the fast pulsators for a variety of reasons, however the first results obtained are encouraging and should pave the way for future observational efforts.

Introduction

During the last few years, we carried out an extensive observational campaign aimed at quantifying and interpreting the period spectra exhibited by members of the recently discovered class of slowly pulsating subdwarf B stars (Green et al. 2003). Generally cooler than their rapidly oscillating counterparts, these are thought to excite high radial order gravity modes with periods of the order of an hour through the action of a classical kappa mechanism associated with a local overabundance of heavy elements (Fontaine et al. 2003). We obtained an average 300+ hours of time-series photometry for each of three representative targets - PG 1627+017, PG 1338+481, PG 0101+039 - in the course of two dedicated multi-site campaigns on 1 to 2 m-class telescopes as well as an exploratory run on the 15 cm MOST space telescope. In what follows, we present a brief overview of the period spectra extracted for all three stars and their potential for asteroseismology; for more details please see Randall et al. (2006).

Campaign Results

From the periodicities extracted from the Fourier transforms of the combined light curves for the three long-period variables monitored we notice that

1. The periods and amplitudes of the pulsations seem to decrease the hotter and more compact the target. While the first effect is in line with current non-adiabatic theory, the second cannot be explained by linear pulsation calculations.

2. The distribution of the period spectra is non-uniform, with a central agglomeration of dominant peaks apparently separated from higher and lower frequency clusters of lower excess power, and closely spaced periodicities occurring within the clusters. One possible explanation is the preferential channelling of energy into certain frequency bands by an unknown mode selection mechanism, as has also been suggested for other types of variable stars.

3. In the case of PG 1338+481, we see a relatively uniform period spacing of around 275 s between six of the high-amplitude oscillations. This corresponds to the near-asymptotic behaviour predicted for $\ell = 1$ modes with consecutive radial orders from appropriate stellar models, an interpretation which is also supported by the exploitation of multi-colour photometry. Assuming this mode identification as well as the values of $\log g$ and $T_{\rm eff}$ inferred from spectroscopy, we were able to narrow down the other fundamental parameters for this target, but failed to find a unique and well-constrained family of optimal models.

Conclusions

1. Asteroseismology of long-period variables is more challenging than that of their short-period counterparts due to difficulties in extracting the much slower pulsations observationally, probable deficiencies in the models, and the weak dependence on the internal stellar parameters of the high-order g modes themselves.

2. In order for asteroseismology to be viable, assumptions regarding the mode identification and the spectroscopic parameters have to be made from the outset. This requires knowledge of the degree indices using an independent means (such as multi-colour photometry, line profile variations or rotational splitting) as well as tightly constrained values of $\log g$ and $T_{\rm eff}$.

3. The future of these stars' study clearly lies in space-based observations with satellites such as MOST or COROT, which can monitor targets for several weeks without significant gaps and enable the extraction of more periodicities.

References

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