COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS
Number 3506

Konkoly Observatory
Budapest
21 August 1990

HU ISSN 0374 - 0676

HD196470 - A new equatorial rapidly oscillating Ap star

The rapidly oscillating Ap stars are cool magnetic Ap stars which exhibit low degree ($\ell \leq 3$), high overtone ($n \approx 30$) pulsations with peak-to-peak B amplitudes <16 millimagnitudes (mmag) and periods in the range of 4-15 minutes. Including HD196470, there are now 15 of these variable stars known. The amplitude of the oscillations in the roAp stars is modulated on a time-scale of days. The canonical model which explains this modulation is Kurtz's *oblique pulsator* model. In this model, a roAp star is simply a pulsating *oblique rotator* (Wolff 1983) in which the magnetic and pulsation axes coincide. Refer to the recent review by Kurtz (1990) for further details.

HD 196470 is a tenth magnitude equatorial ($\delta = -18$) star classified as Ap SrEu(Cr) by Houk (1988). As part of an ongoing search for new rapidly oscillating Ap stars, we obtained high-speed photometry of HD 196470 on the night 30 June/1 July 1990 (JD2448073). We used the University of Cape Town Photometer attached to the 1.0-m Elizabeth telescope of the South African Astronomical Observatory. All the data presented in this paper comprise continuous 10-s integrations through a Johnson B filter. A 30-arcsec diaphragm was used for all of the observations.

The data were prepared for frequency analyses in the following way: Firstly, we corrected the observations for coincidence counting losses. Next we subtracted the sky background contribution and then we removed the mean extinction. Finally, we binned the data to 40-s integrations by taking non-overlapping 4-point averages. Data reduced in this manner will always contain residual long-term trends which arise from gradual changes in sky transparency. On good nights, such sky transparency variations will be of sufficiently low amplitude and will also be slow enough to not interfere with our search for rapid oscillations. We do not use comparison stars and thus we do not transform our data to the standard system.

A visual inspection of the real-time display of the observations of HD 196470 on the night JD2448073 suggested the presence of oscillations with a period of 10.8 min. and an amplitude of around 0.8 mmag. However, as it was not an excellent night, we could not exclude the possibility that this was just an effect of sky transparency variations. We present in Fig. 1 (top panel) an amplitude spectrum of these data out to the Nyquist frequency of 12.5 mHz for 40-s integrations. The amplitude spectra presented in this paper were computed using Kurtz's (1985) faster implementation of Deeming's (1975) Discrete Fourier Transform algorithm for unequally spaced data. The peak marked

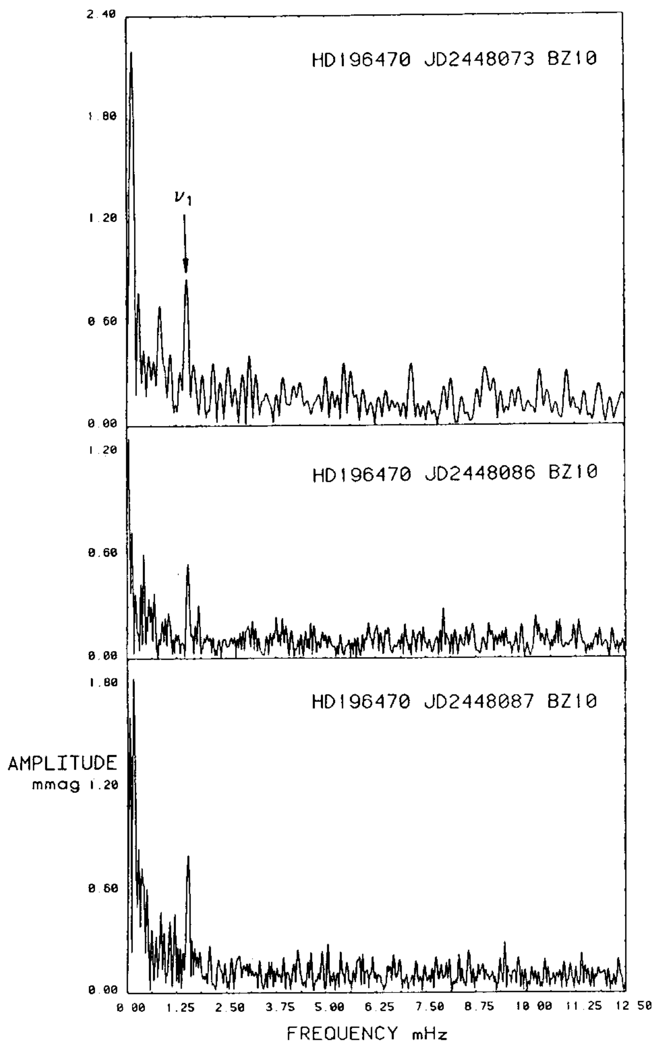

Figure 1

ν_1 at 1.54 mHz is hardly convincing in the presence of the sky transparency variations on that night, so we elected to confirm the reality of these oscillations by observing HD 196470 again on the nights 13/14 and 14/15 July 1990 (JD2448086-8087). The amplitude spectra for these two nights are presented in the middle and lower panels of Fig. 1, respectively. These amplitude spectra reveal that the sky transparency variations were less of a problem on the last two nights and ν_1 can be seen clearly.

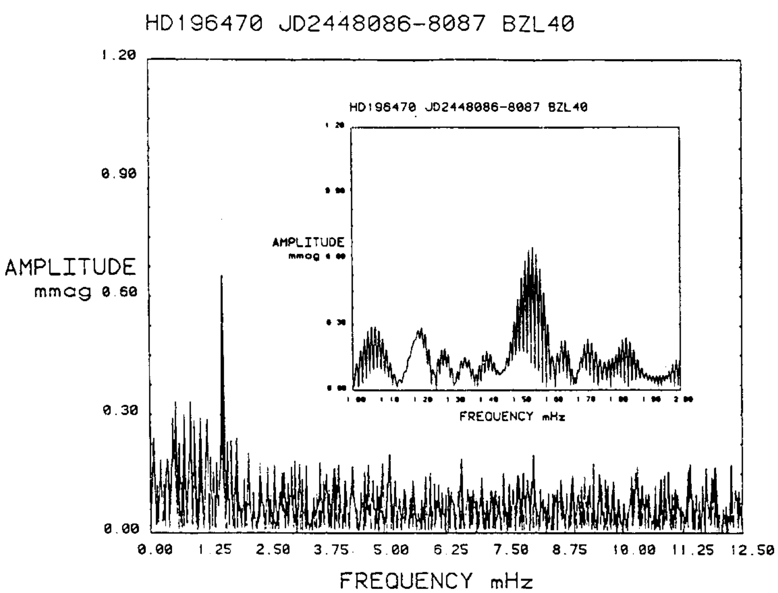

Figure 2

For an oblique pulsator, rotational amplitude modulation gives rise to a $(2\ell+1)$ multiplet in the amplitude spectrum with a spacing equal to the rotation frequency of the star. Thus the discovery of such rotational sidelobes would reveal the rotation period of HD196470 and would also allow us to constrain the magnetic obliquity and rotational inclination of this star. There is an indication of modulation in the amplitude of ν_1 in Fig. 1, but the reader should exercise caution here because the difference in amplitude from night to night could easily arise from the interaction of ν_1 with noise peaks suitably related in phase to ν_1 or with other unresolved oscillation modes in the star.

In Fig. 2 we present an amplitude spectrum for the nights JD 2448086-8087. The prominent peak is at $\nu_1 = 1.544$ mHz. In this amplitude spectrum we have removed the peaks at low frequency which we attribute to sky transparency variations. The inset shows the same spectrum in the frequency range 1 - 2 mHz; the severe 1 day^{-1} alias problem evident in the inset is not surprising. We also analyzed all three nights together. In both cases, we selected the tallest peak in the vicinity of ν_1 and optimized its amplitude and phase by fitting it to the data with a least squares algorithm. We then removed sinusoids from the data with these optimized amplitudes and phases and found no convincing evidence for further frequencies.

For completeness, we present in Fig. 3 a sample lightcurve of observations obtained on the night JD2448087. The sky transparency variations have been removed from these data. The solid line

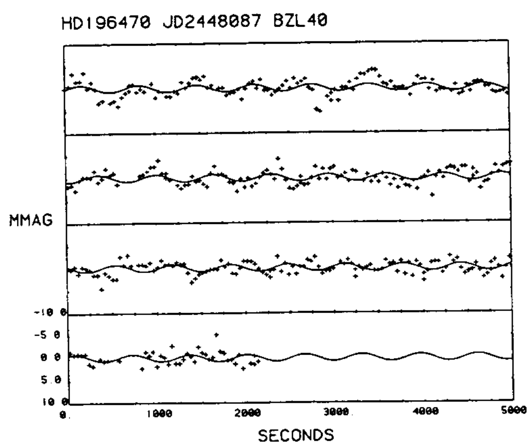

Figure 3

is a fit of a sinusoid of frequency $\nu_1 = 1.544$ mHz with its amplitude and phase determined by least squares. The fit to the observations is reasonably good.

As Fig. 1 shows, the noise at ν_1 is not always scintillation limited. This, plus the fact that the oscillations are of low amplitude, means that this star will be difficult to study; observations with large aperture telescopes on excellent nights will be required in order to reduce the scintillation noise to allow the search for secondary frequencies and rotational sidelobes.

PETER MARTINEZ, D.W. KURTZ, G. KAUFFMANN, A.C. JONSON

Dept. of Astronomy

University of Cape Town

Rondebosch, 7700

South Africa

References

Deeming, T.J., 1975. *Astrophys. Space Sci.*, **36**, 137.

Houk, N & Smith-Moore, M., 1988. Michigan Spectral Catalogue of Two-Dimensional Spectral Types for the HD Stars Volume 4, Dept of Astronomy, University of Michigan.

Kurtz, D.W., 1985. *Mon. Not. R. astr. Soc.*, **213**, 773.

Kurtz, D.W., 1990. *Annual Reviews of Astronomy & Astrophysics*, **28**, 607.

Wolff, S.C., 1983. *The A-Type Stars: Problems and Perspectives*, NASA Special Publication 463.