A SURVEY FOR DOPPLER-SHIFT OSCILLATIONS IN K GIANTS

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ABSTRACT. A survey of K giants is being conducted to search for both short- and long-term oscillations. Our radial velocity spectrometer has a short-term precision on bright stars of ± 4 m/s after an exposure of 3 minutes on the CCD detector. Extensive sets of observations have been reduced for Arcturus, Pollux, and Aldebaran. Power spectra show no apparent oscillations within these data sets for frequencies between 0.15 and 2.0 mHz. However, the nightly averages over a 4 month time base show a three-fold increase in variance for Arcturus when compared to Pollux. A periodogram reveals a period of 1.844 ± 0.005 days (or its alias of 2.174 days).

1. INTRODUCTION

Small changes in the Doppler shifts of late-type stars are being monitored by a precise radial velocity spectrometer. The instrument is an interferometrically (Fabry-Perot) calibrated echelle spectrometer coupled to a 0.9-meter telescope by a single optical fiber. We monitor 300-500 transmission orders in the stellar spectrum over the range 4300-4600 A (McMillan *et al*. 1985,1986). The ultimate purpose for this instrument is a long term search for extrasolar planetary systems; however, during the first year of observations it was tested on K giant stars by searching for stellar oscillations of small amplitude and periods between a few minutes and several months. Extensive data sets exist for Arcturus, Pollux, and Aldebaran. Although preliminary, several interesting results already can be presented.

2. SHORT-PERIOD OSCILLATIONS (MINUTES TO HOURS)

Using exposure times of a few minutes, we have made series of observations equally spaced in time and spanning up to 8 hours. A typical run of 3.8 hours is shown in Fig. 1 for Arcturus. The velocity data are analyzed by fitting with the known Earth velocity curve and allowing small perturbations in the offset to obtain a

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minimum chi-square fit. The standard deviation of the points is ± 4 m/s, a good indication of the short-term internal consistency (precision). The power spectrum of these data is shown in Fig. 2 and has no significant peaks. These procedures were used to reduce data for Pollux and Aldebaran (not shown) and also yielded a null result.

3. NIGHT-TO-NIGHT VARIATIONS

The object stars are observed nightly during our two week observing runs each month; the data for four runs on Pollux and Arcturus have been analyzed and are shown in Fig. 3. For Pollux, 1986 DOY (day-of-year) 58 is used as the reference observation and the Fabry-Perot etalon is tilt-tuned to remove the intervening Earth motions; we track the same spectral features throughout the observing season. For each night the velocity differences from the reference observation are plotted (see Fig. 1); instrumental offsets are calculated from our nightly calibrations. For Pollux the deviation of the measurements is ± 18 m/s over three months, indicative of the long-term calibration errors. Arcturus (reference on DOY 85) shows a daily alternation with an amplitude between 60 and 100 m/s. On DOY 30 and 89 the alternation skips a step and shows a velocity offset of about twice the other days. A periodogram of these data is shown in Fig. 4; the two highest peaks (one is the alias of the other) are flanked by sidelobes which are a result of our two-week observing schedule. The peaks are significant at the 99% confidence level.

This is thought to be the first report of periodic behavior in Arcturus. However, because of the way our instrument samples the spectral profile, we cannot distinguish between a global oscillation and a periodic change of the asymmetries of the line profiles. If a global oscillation is responsible, the second harmonic (2H) of the fundamental radial resonance seems to be the mode with the appropriate period (Cox et al. 1972).

4. REFERENCES

Cox, J. P., King, D. S., and Stellingwerf, R. F. 1972, Ap. J., 171, 93.

Horne, J. H., and Baliunas, S. L. 1986, Ap. J., **302**, 757.

McMillan, R. S., Smith, P. H., Frecker, J. E., Merline, W. J., and Perry, M. L. 1985, in Proc. of IAU Colloq. No. 88, Stellar Radial Velocities, A. G. Davis Philip and D. W. Latham, eds. (Schenectady: L. Davis Press), p. 63.

McMillan, R. S., Smith, P. H., Frecker, J. E., Merline, W. J., and Perry, M. L. 1986, Proc. S. P. I. E., **627**, (Instrumentation in Astronomy - VI), ed. D. L. Crawford, in press.

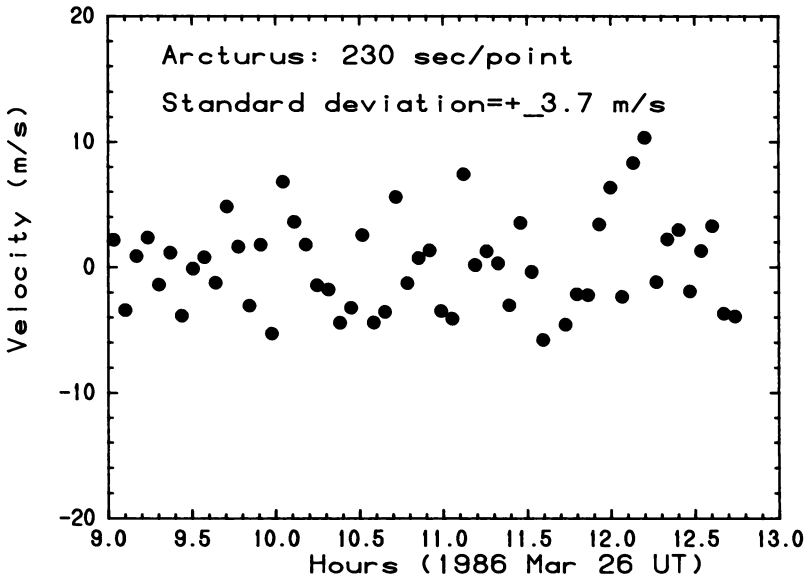

Figure 1. Relative line-of-sight velocity of the K1 IIIb star Arcturus observed during the night of 1986 March 26. Earth motions have been subtracted. Exposure times for each measurement were 230 s with our 0.91-meter telescope. The standard deviation per point is +_ 4 m/s.

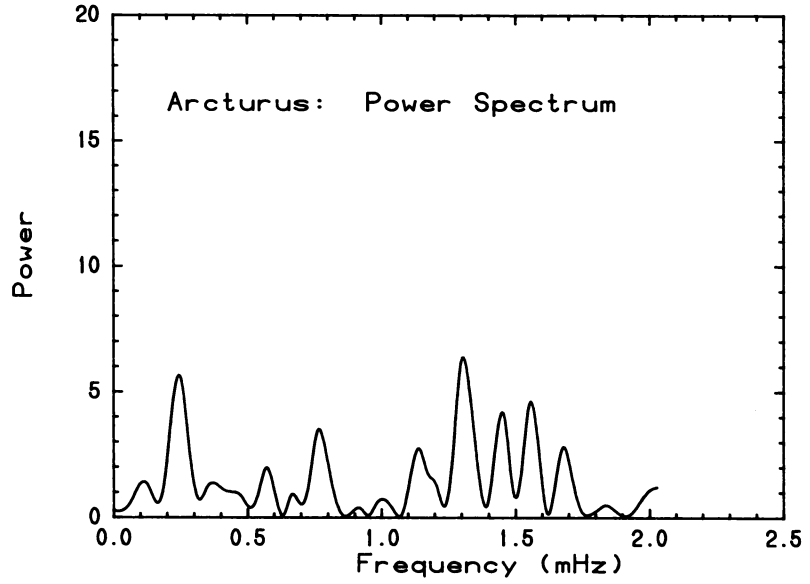

Figure 2. Power spectrum derived by Fast Fourier Transform of the data in Figure 1, which were taken at equal intervals of time. The ordinate is an arbitrary scale of power.

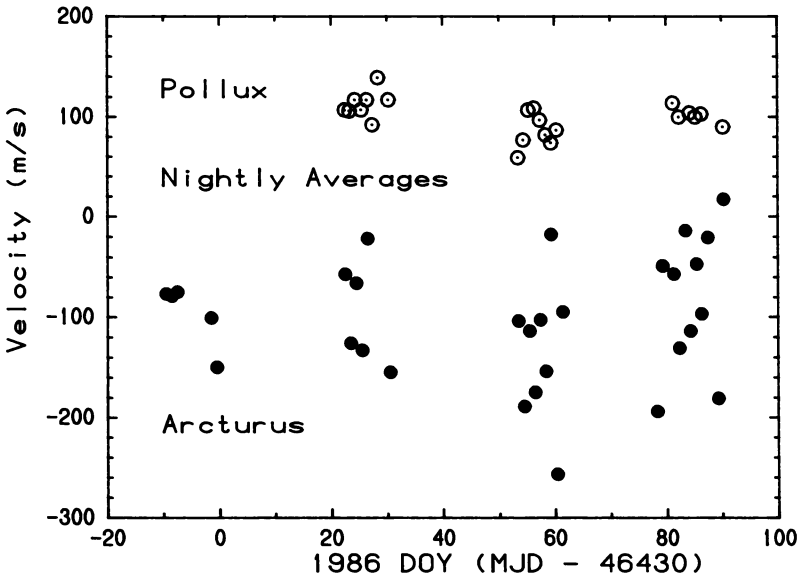

Figure 3. Doppler velocities of Arcturus (filled circles) and Pollux (open circles) referred to separate and arbitrary zero points, as functions of day of year (DOY) in 1986.

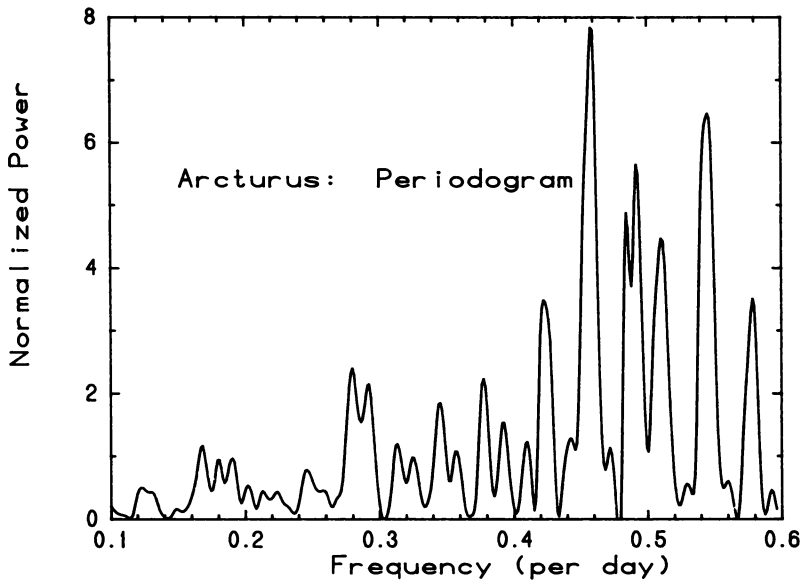

Figure 4. A periodogram of the Arcturus data in Figure 3. Because the data are sampled nightly, the Nyquist frequency is at 0.5 per day.