Radial Velocity Variability of K Giants

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Abstract: At McDonald Observatory we have been monitoring the relative radial velocities of a sample of K giants. The technique employed uses the telluric O_2 lines near 6300 Å as a reference for measuring the stellar line shifts. We demonstrate that precisions of 10 m s^{-1} are possible with this technique. We present radial velocity data covering a 2 year time span for α Boo, α Tau, and β Gem. All of these stars show both long term variations ($\sim$ several hundred days) with a peak-to-peak amplitude of about 400 m s^{-1} and short term variations ($\sim$ few days) with a peak-to-peak amplitude of about 100 m s^{-1}. The long term variations may be due to the rotational modulation of surface active regions whereas the short term variations may be indicative of pulsations.

1. Introduction

Recent advances in techniques for measuring relative radial velocities have produced an increase in the precision of these measurements from a few tenths of km s^{-1} to a few m s^{-1}. Not surprisingly this has opened new fields of study for stellar phenomena. Recently Arcturus was shown by Smith *et al.* (1987) to be a radial velocity variable with an amplitude of several hundred m s^{-1}. This result was later corroborated by Cochran (1988). Later, Walker *et al.* (1989) found that a small sample of K giants were low-level (30–300 m s^{-1}) variables. At McDonald we have been monitoring the radial velocity of a sample of K giants. Here we present preliminary results on three K giants: α Boo (Arcturus), α Tau (Aldebaran), and β Gem (Pollux).

2. Observations

We have been employing the Griffins' telluric line technique to measure relative radial velocities (Griffin and Griffin, 1973; Cochran, 1988). This technique uses the atmospheric absorption lines of O_2 at 6300 Å as a reference for measuring stellar Doppler shifts. Data were acquired using the coudé focus of the McDonald 2.7-m telescope. An echelle grating was used in 36th order along with a Texas Instruments 800×800 CCD. This resulted in a dispersion of 0.014 Å/pixel and a resolving power of about 170,000.

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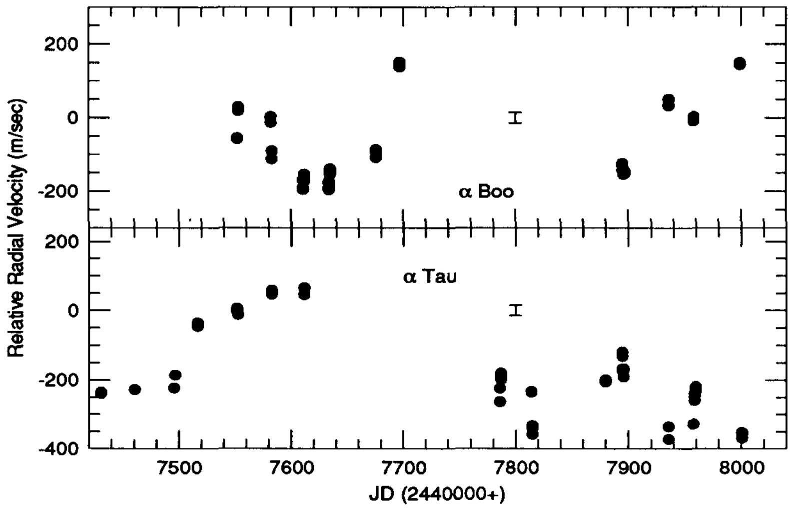

Fig. 1. Relative radial velocities for α Boo and α Tau.

3. Radial velocity measurements

The relative radial velocity measurements for α Boo, α Tau and β Gem are shown in Figs. 1 and 2. The radial velocity variations for the G8 dwarf τ Ceti are also shown in Fig. 2. The constant radial velocity of the G dwarf indicate that there are no large systematic errors in the radial velocity measurements. Typical errors for repeated measurements are about 10–15 m s^{-1} (shown as an errorbar) thus corroborating the Griffins' claim that the technique was capable of precisions near 10 m s^{-1}. All the K giants show both long term variations on timescales of hundreds of days as well as day-to-day and month-to-month variations that are larger than the estimated errors.

Arcturus exhibited long term variations in late 1988 and early 1989 (near JD 2447550) as well as in late 1989 and early 1990 (near JD 2447900). Assuming that the radial velocity curve has minima near JD 2447600 and 2447900 and maxima near JD 2447700 results in an upper limit of 250–300 days for the period of any long term variations.

Aldeberan also exhibited long term radial velocity variations in 1988/89 in the form of a steady increase of about 300 m s^{-1} within 100 days suggestive of a full period of order 200 days. This long term trend was completely absent in the measurements taken in the Fall/Winter of 1989/90.

In late 1988 and early 1989 Pollux displayed a steady increase in its relative radial velocity (amplitude $\sim$ 200 m s^{-1}). Again if this is part of harmonic variability then an upper limit of about 400 days results for the period. However, the following year such a large, long term variation in the relative radial velocity was absent from this star.

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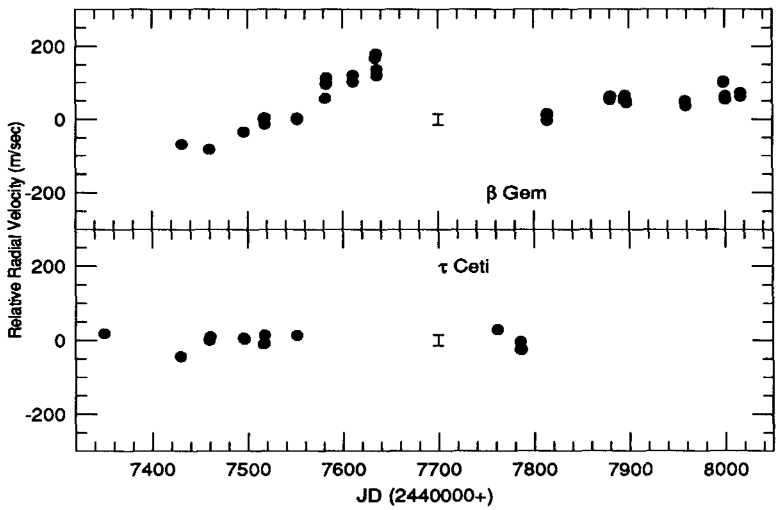

Fig. 2. Relative radial velocities for β Gem and τ Ceti (a G8 dwarf).

4. Discussion

More radial velocity data are needed before we can begin to speculate about the nature of these variations. But even with the small body of data presented here we can state with certainty that there are at least two timescales to the radial velocity variations ($\sim$ days and $\sim$ hundreds of days). It is possible that different mechanisms may be responsible for these two timescales. It is tempting to attribute the long term variations to a modulation by surface features such as active regions, plage, or spots. For instance, the measured $v \sin i$ for α Boo is about 2.7 km s^{-1}. Assuming a radius of 23 solar radii and an inclination of 90°, this yields a maximum rotation period of about 400 days, which is near the timescale of the long term radial velocity variations.

The radial velocity variations in K giants appear to be rather complicated and attributable to different pulsation modes or to a variety of mechanisms at work for producing the radial velocity variations. Clearly more data are needed before we can understand the nature of the mechanisms causing the radial velocity variations.

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