Radial velocity studies of roAp stars

A.P. Hatzes[1] **and A. Kanaan**[2]

[1] *McDonald Observatory, University of Texas, USA*

[2] *Departamento de Matemática, UFSM, Brazil*

Abstract. We present recent results from our radial velocity (RV) studies of rapidly oscillating Ap (roAp) stars. Our measurements reveal that the pulsational amplitude of these stars depends on the spectral region that is examined. For one star, γ Equ, the pulsational RV amplitude depends on both line strength and atomic species. The elemental difference is most likely related to the abundance patches on the surface of these stars. The line strength difference is interpreted as arising form a height effect in the atmosphere. Ultimately, these measurements may provide valuable diagnostics of the atmospheres of these stars.

Key words: Stars: oscillations - Techniques: radial velocities

1. Introduction

The rapidly oscillating Ap stars (roAp) represent a class of stars pulsating in nonradial p-modes with periods of 4–15 min. We have begun a programme of using precise stellar radial velocity (RV) measurements to study these pulsations. Data were acquired using the F3 focus of the 2-d coudé spectrograph of McDonald Observatory's 2.7-m telescope ($R \approx 60{,}000$). RV measurements were made using an iodine gas absorption cell placed in the optical path of the spectrograph (Cochran & Hatzes 1994). Exposures of 45-60 secs duration were made in rapid succession over ~ 4 hrs for each of the stars presented here.

2. Results

To date we have measured RVs in three roAp stars:

γ Equ: The photometric variability is dominated by 4 modes centered around 12 min (Martinez et al. 1996). The dominant photometric period has been detected in our RV measurements. A detailed analysis (Kanaan & Hatzes, 1998) reveals that the pulsational RV amplitude depended not only on atomic species, but also line strength. Figure 1 shows the measured pulsational amplitude as a function of equivalent width for neutral and once ionized Cr, Fe, and Ti.

HR 1217: There are at least 6 pulsation modes in this star with periods near 6.15 minutes. Matthews et al. (1988) found a peak-to-peak RV amplitude of 400 m s^{-1}. Our measurements show that the RV amplitude depends on the spectral region that is examined (Fig. 2).

Contrib. Astron. Obs. Skalnaté Pleso **27**, (1998), 347– 349.

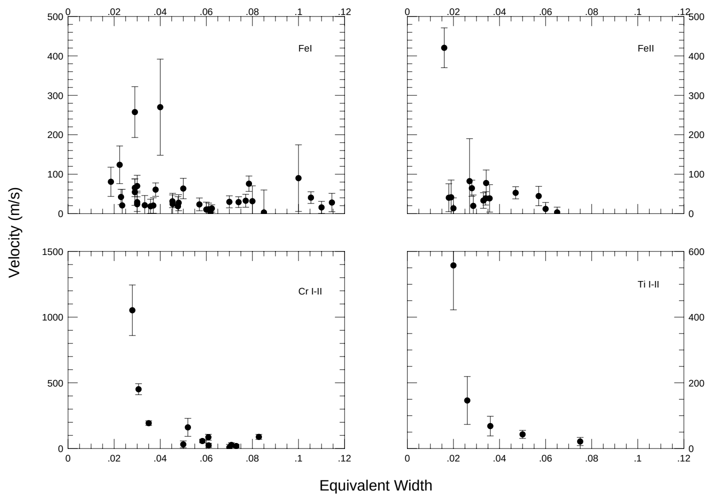

Figure 1. The amplitudes of all unblended lines of Cr I and II, Ti I and II, as well as Fe I and II. The RV semi-amplitude is shown as a function of equivalent width.

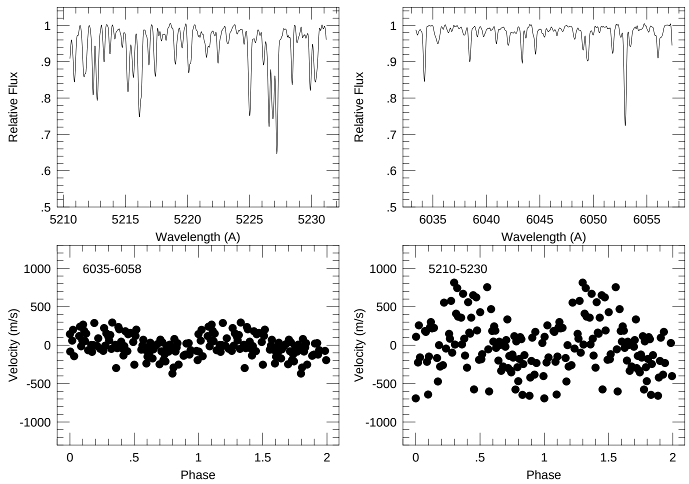

Figure 2. The top two panels show two spectral regions (orders) of HR 1217. Below each spectrum is the RV measurements from these spectral regions phased to the photometric period.

33 Lib: The single pulsation mode with period 8.27 min (Kurtz 1991) is clearly seen in the periodogram of the RV measurements (top panel of Fig. 3). The $2K$-amplitude of the variations is about 100 m s^{-1} (lower panel Fig. 3).

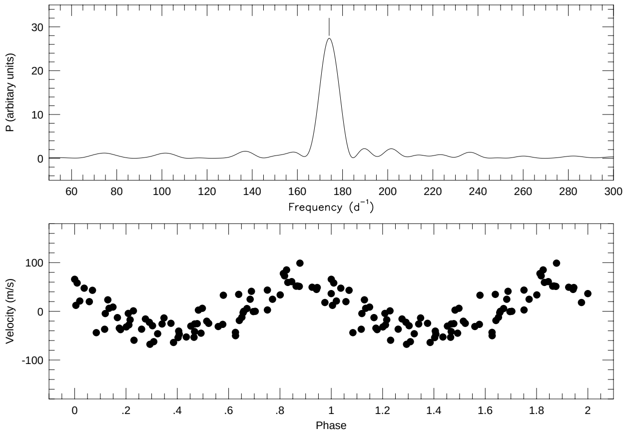

Figure 3. (Top) The Scargle-Lomb periodogram of the RV measurements derived from all spectral lines in the wavelength range 5500 – 5684 Å. The vertical line marks the frequency of the photometric period from Kurtz (1991). (Bottom) The RV measurements phased to the photometric period.

3. Discussion

Our RV measurements show that the pulsational amplitude for roAp stars depends 1) on atomic species (e.g. in γ Equ, Cr has a higher amplitude than Fe), and 2) line strengths (weaker lines have a higher RV amplitude than stronger lines). The former effect is interpreted as arising from the inhomgenous distribution of elements on the stellar surface (if Cr is concentrated at the magnetic poles then its vertical motion is unhindered by the field lines). The line strength effect most likely arises from vertical structure of the pulsations since weaker lines are formed, on average, deeper in the stellar atmosphere.

References

Cochran, W.D., Hatzes, A.P.: 1994, *Astrophys. Space Sci.*, **212**, 281
Kanaan, A., Hatzes, A., *Astrophys. J.*, in press
Kurtz, D.W.: 1991, *Mon. Not. R. Astron. Soc.*, **249**, 468
Martinez, *et al.*: 1996, *Mon. Not. R. Astron. Soc.*, **282**, 243
Matthews, J.M. *et al.*: 1988, *Astrophys. J.*, **324**, 1099