Testing the SALT High Resolution Spectrograph for pulsation studies of roAp stars

Daniel L. Holdsworth and Donald W. Kurtz

Jeremiah Horrocks Institute, University of Central Lancashire, UK; dlholdsworth@uclan.ac.uk

Abstract

We present the first time-resolved spectroscopic observations of a rapidly oscillating Ap star with the SALT HRS instrument. We used the instrument in the High Stability mode, with the fastest readout settings — a setup never used before. Over a 2.5-hr track length, we obtained 280 spectra at 8-second integration times and a cadence of 30 seconds. The target, α Circini, is the brightest of the roAp stars, and thus provides an excellent opportunity to test the instrument. Previous time-resolved spectroscopic studies of this star have been conducted with the VLT/UVES instrument (Kurtz et al. 2006) and with the HARPS instrument on the ESO's 3.6-m telescope (Mkrtichian & Hatzes, 2013). These two studies provide us with benchmarks to compare the performance of SALT/HRS for this type of study. With the upcoming TESS mission, the ability to perform high-precision, time-resolved spectroscopy of pulsating stars will be key in the scientific output of the Southern African Large Telescope.

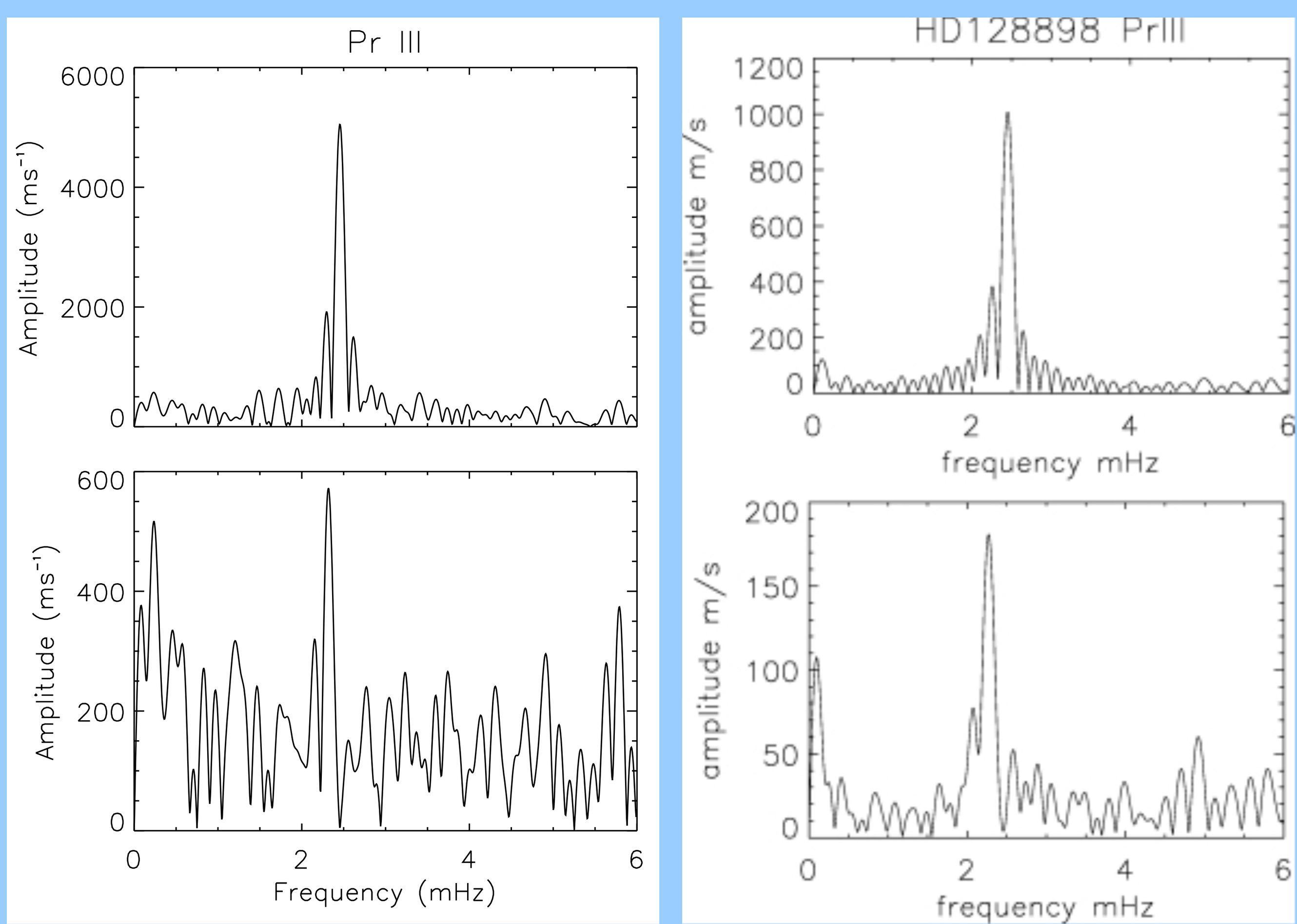
Observations

The observations of α Cir were made with HRS in the High Stability mode. Due to our high-cadence requirements, we used a previously untested readout mode: full amplifiers and 1000-kHz readout speed. 8-s exposures allowed for a cadence of 30 s and S/N ~100 for each spectrum.

Comparison Data

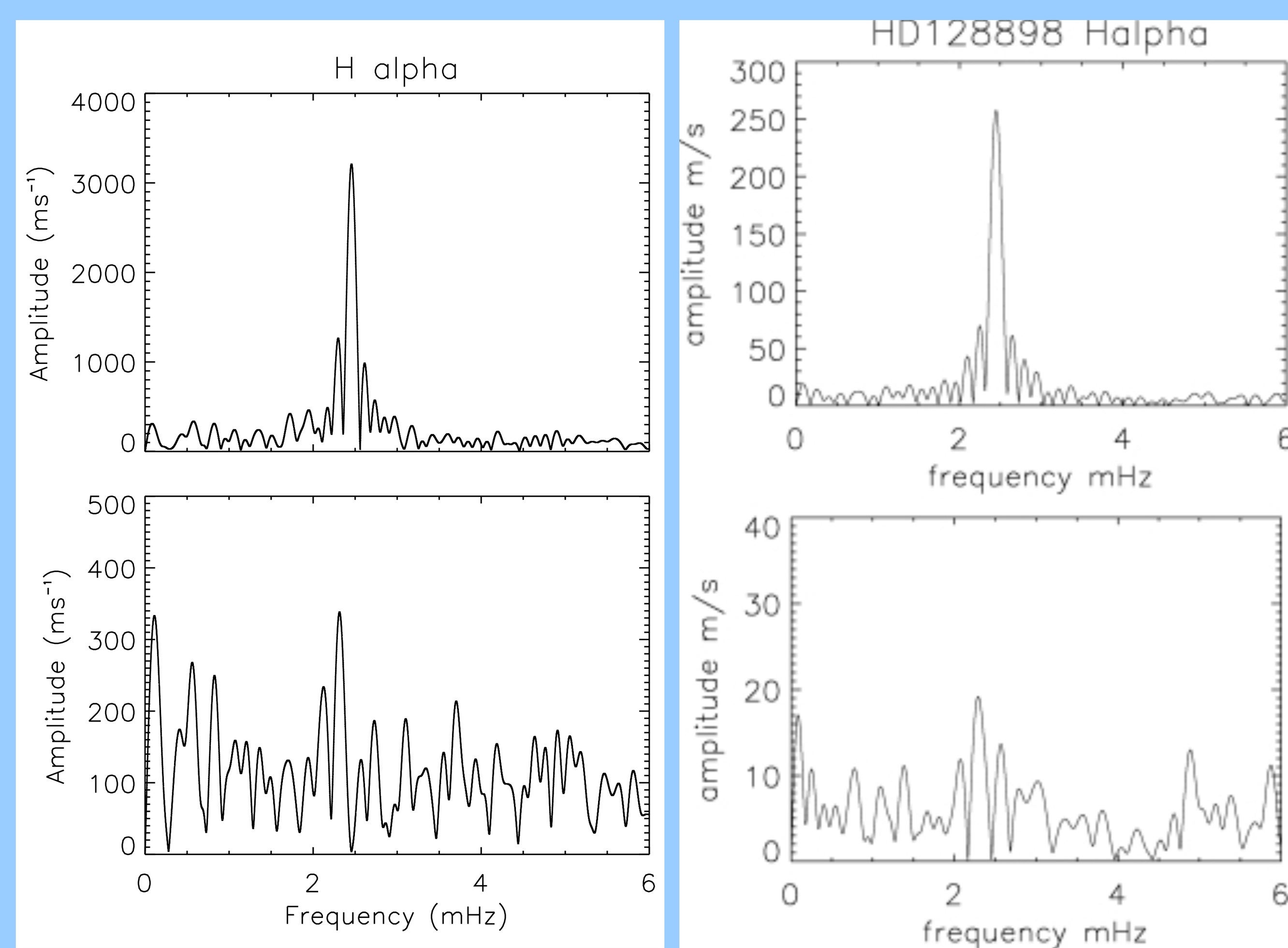
Our preliminary analysis makes a comparison with UVES results (Kurtz et al. 2006). Their data consisted of 1.5-s exposures and achieved a higher S/N ~175. Their time base and number of spectra are comparable to our dataset, making direct comparison possible.

Pulsation Analysis

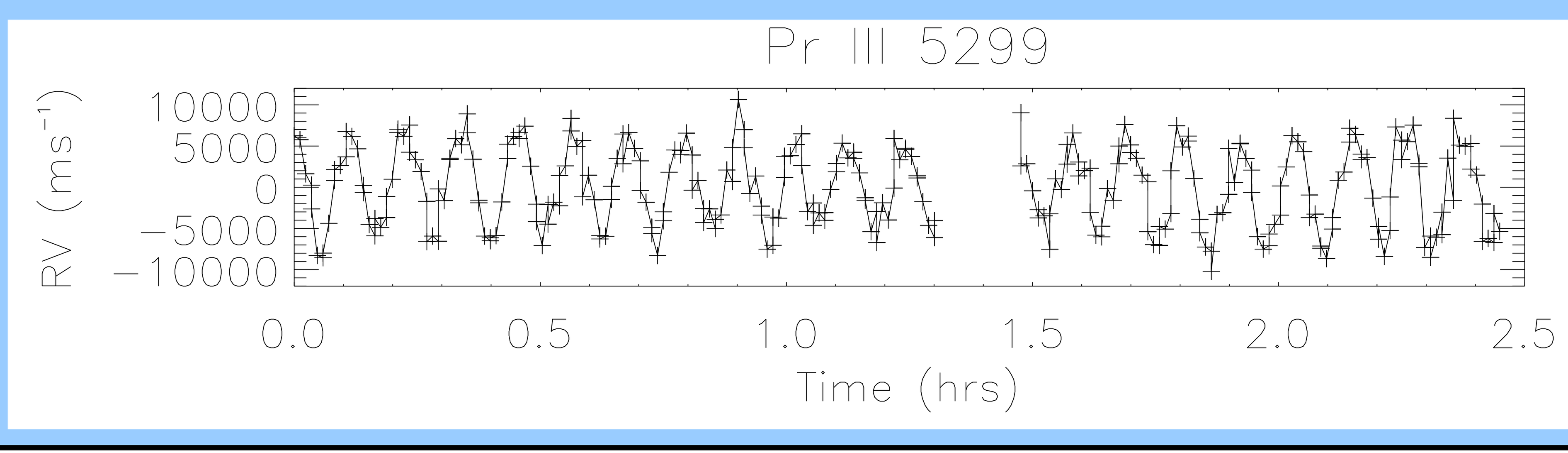


Comparison between the SALT/HRS results (left column) and published VLT/UVES data (right column). It is clear that the noise characteristics in the HRS data are worse than the UVES data – most likely a result of the lower S/N of the HRS data. However, our analysis uses the cross correlation method of individual spectra with the mean spectrum over the observations, whereas the published results use the center-of-gravity method. We will explore the difference between the two methods further. The lower panels of the plots show the amplitude spectra of the residuals after prewhitening the dominant peak.

The above plots show amplitude spectra of the radial velocities of a combination of four Pr III lines. The plots opposite show the analysis of the Hα core. These lines form high in the star's atmosphere and have been found to show some of the highest amplitude pulsations in spectroscopy.



Note the change in axis scale and amplitude between our results and the published figures. The amplitude of pulsations in roAp stars is dependent on the observers viewing aspect, which changes over the rotation cycle; the two data sets were taken 0.33 rotation periods apart.



Left: Example of the HRS RV curve for the Pr III line at 5299.993Å. There is a slight change in amplitude as a result of the second frequency.

Conclusions

This test was conducted to investigate the potential science outputs of SALT/HRS with respect to the pulsational analysis of roAp stars. Many new roAp stars will be discovered with the TESS mission, and the need for high precision spectroscopic observations will increase. Our test has shown that SALT/HRS is capable of providing the high quality data we require.

References

Kurtz et al., 2006, MNRAS, 370, 1274;
Mkrtichian & Hatzes, 2013, ASPC, 479, 115

We would like to thank the SALT/HRS team for agreeing to execute these proof-of-concept observations, and to Steve Crawford for his time spent on bespoke reductions.