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# KIC 7582608: a new *Kepler* roAp star with frequency variability

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**Abstract.** We analyse the fifth roAp star reported in the Kepler field, KIC 7582608, discovered with the SuperWASP project. The object shows a high frequency pulsation at 181.7324 $d^{-1}$ ($P = 7.9$ min) with an amplitude of 1.45 mmag, and low frequency rotational modulation corresponding to a period of 20.4339 d. Spectral analysis confirms the Ap nature of the target, with characteristic lines of rare earth elements present. From our spectral observations we derive a lower limit on the mean magnetic field modulus of $\langle B \rangle = 3.05 \pm 0.23$ kG. Long Cadence Kepler observations show a frequency quintuplet split by the rotational period of the star, typical for an oblique pulsator. We suggest the star is a quadrupole pulsator with a geometry such that $i \sim 66^\circ$ and $\beta \sim 33^\circ$. We detect frequency variations of the pulsation in both the WASP and Kepler data sets on many time scales. Linear, non-adiabatic stability modelling allows us to constrain a region on the HR diagram where the pulsations are unstable, an area consistent with observations.

## 1 Overview

KIC 7582608 was observed by the SuperWASP instrument during 5 seasons [1], and for the entire duration of the Kepler mission in LC mode [2]. The light curve shows clear rotational modulation due to surface brightness anomalies which have produced a double wave signature (Figure 1). From the light curve, we determine a rotation period of 20.4339 d. Spectral analysis of the star confirms the Ap nature of the pulsator. From the spectra we derive $T_{\rm eff} = 8700 \pm 100$ K from Fe I and Fe II lines, $\log g = 4.3 \pm 0.4$, and $v \sin i \leq 4\,{\rm km s^{-1}}$. Using the derived spectroscopic values, and those in the KIC, we are able to place KIC 7582608 on a theoretical HR diagram, amongst the hottest roAp stars known. We have conducted linear, non-adiabatic stability modelling of KIC 7582608 over the theoretical instability strip for roAp stars. Further details of the modelling are presented in [2].

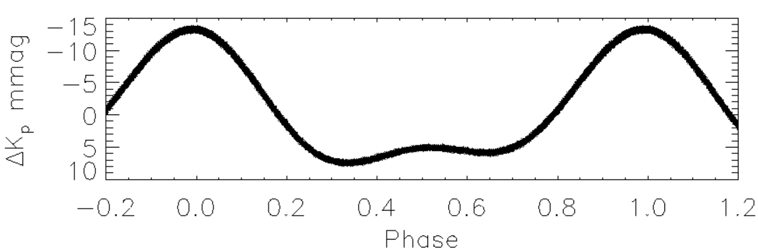


**Fig. 1.** Phase folded light curve of Q10 *Kepler* data showing the double wave nature of the variations.

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## 2 Pulsation Analysis

The pulsation was initially detected in SuperWASP data at a frequency of 181.7324 $d^{-1}$ ($P$ = 7.9 min) with an amplitude of 1.45 mmag in the broad-band filter (400 − 700 nm) [1]. Although above the 'classical' Nyquist of Kepler LC data, we are able to detect and analyse the true frequency as a result of timing variations[3]. Detailed frequency analysis of the entire Kepler data set revealed a 'ragged' pulsation quadruplet split by the rotational period. This raggedness indicates that the pulsation frequency is unstable, similar to [4,5]. To analyse the frequency variability, we split the data into sections of 0.55 d (or 100 pulsations) and fit the data with a constant frequency. This results in phase variation over the entire data set. Interpreting the phase variation as frequency variation we see frequency variations on many time scales. It is unclear whether the variations are due to pulsational cavity changes or binary motion. Taking the view that the large scale variations are due to binarity, we split the data in to 20 d sections and, including WASP observations, apply a binary fitting code to photometric RVs. We derive an eccentric fit of $e$ = 0.4 with a period of 1203 d. A full discussion of the frequency variations is available in [2].

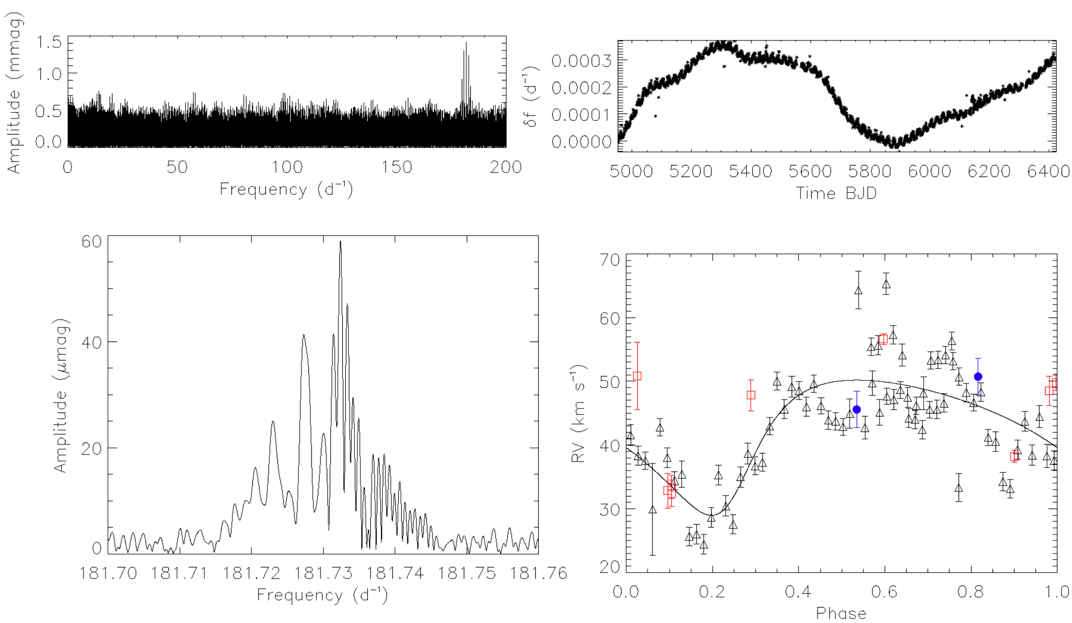


**Fig. 2.** Top left: WASP discovery periodogram. Bottom left: High resolution look at the Q00-17 LC pulsation peak. Top right: Frequency variability over the 1400 d observations. Bottom right: RV curve from photometric data. The black triangles are derived from *Kepler* photometry, the red squares are from WASP photometry, and the solid blue dots are from the spectra.

## References

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