

# $\delta$ Scuti Paper

Authors:TBD

April 10, 2017

## Abstract

The seventh newly discovered triple-mode high-amplitude  $\delta$  Scuti in the Galaxy along with two other  $\delta$  Scuti variables are presented. Ground-based photometric data from the Robotic Optical Transient Search Experiment telescope was used for the initial detection of the three variables. An extensive frequency analysis using the Period04 software was carried out for each variable. The fourier analysis was performed on each archived public survey data available as well as on a global set created from the combination of all data. In addition, selected physical parameters and a new ephemeris formula were calculated. Three independent and six combination frequencies were found for the triple-mode high-amplitude  $\delta$  Scuti. The independent modes are radial with the first overtone being the dominate oscillation. Of the six other triple-mode  $\delta$  Scuti known, only one other has a dominate first overtone. The two remaining  $\delta$  Scuti variables were found to be mono-periodic.

## 1 Introduction

Study of multiperiodic variables leads to a better understanding of the stellar structure and evolution of these stars. The stellar interior can be modeled with the identification of radial and non-radial modes of oscillation within the star. The  $\delta$  Scuti type variables are a class of pulsators located in the instability strip near the zero-age main sequence (Breger, 2000).  $\delta$  Scuti variables have a fundamental period less than 0.2 days with masses ranging from 1.5-2.5 solar masses (Aerts et al., 2010). Extragalactic distances can be determined by using the  $\delta$  Scuti as a standard candle. These short period variables are capable of complex periodicity, exhibiting numerous radial and non-radial pulsations simultaneously, and are ideal for monitoring and subsequent asteroseismological studies.

High-amplitude  $\delta$  Scuti (HADS) variables are a subgroup of the  $\delta$  Scuti whose light amplitude exceeds

0.15 magnitude. Unlike the  $\delta$  Scuti type, lower HADS pulsations are generally radial with multiple being uncommon. When two radial pulsation modes are present, the variable is designated a HADS(B). Currently, only 6 HADS in the Galaxy are known to have 3 simultaneously excited radial modes. These objects do not yet have a unique designation. With the discovery of more triple-mode pulsators of this type, the origin criteria of multiple radial modes within the HADS group can be better understood.

The Variable Star Project (VSP) is an initiative associated with the Robotic Optical Transient Search Experiment (ROTSE). The pulsating variables examined here were discovered using cataloged ROTSE-I data. At the time of discovery, only a basic period analysis was done for identification purposes. The results were published in the International Variable Star Index (VSX).

## 2 Hardware

ROTSE-I

The Wide Angle Search for Planets (SuperWASP) first public data release was used in conjunction with ROTSE-I data (Butters et al., 2010). With the primary objective of discovering exoplanets, SuperWASP achieved first light in 2004. SuperWASP has cameras in two locations. La Palma in the Canary islands, Spain; and Sutherland, South Africa. Both instruments are identically built. Eight *Canon* 200mm f/1.8 lenses each with a 2048x2048 pixel *Andor* CCD are fixed in an array on a *Torus* fork mount (Pollacco et al., 2006). No filter is used on either instrument to maximize throughput. All magnitudes discussed in this paper are of the WASP-band unless otherwise defined. The instruments provide a field of view of approximately 64 deg<sup>2</sup>.

## 3 Observations

SuperWASP-N in La Palma covers the region of declinations from  $+20^\circ < \beta < +66^\circ$ . To monitor the

southern hemisphere sky, WASP-South in Sutherland patrols declinations from  $-90^\circ < \beta < -20^\circ$ . For each night of observations, a single declination is swept multiple times. Every declination strip contains a dozen fields the camera slews to and momentarily stops at to take a pair of 30s exposures (Smith & WASP Consortium, 2014). Data collected by both instruments using this observational method from 2004 – 2008 comprises the first SuperWASP public data release used in this study.

## References

- Aerts, C., Christensen-Dalsgaard, J., & Kurtz, D. W. 2010, *Asteroseismology*
- Breger, M. 2000, in *Astronomical Society of the Pacific Conference Series*, Vol. 210, *Delta Scuti and Related Stars*, ed. M. Breger & M. Montgomery, 3
- Butters, O. W., West, R. G., Anderson, D. R., et al. 2010, *Astronomy and Astrophysics*, 520, L10
- Pollacco, D. L., Skillen, I., Collier Cameron, A., et al. 2006, *Publications of the ASP*, 118, 1407
- Smith, A. M. S. & WASP Consortium. 2014, *Contributions of the Astronomical Observatory Skalnaté Pleso*, 43, 500