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ASTEROSEISMOLOGY OF THE DELTA SCUTI STAR V650 TAURI

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RESUMEN

Presentamos los resultados preliminares de una campaña observacional multisitio sobre la estrella tipo δ Scuti V650 Tauri perteneciente al cúmulo de las Pléyades. La estrella fue observada durante 14 días en noviembre de 2008 desde tres observatorios distribuidos en longitud alrededor de la Tierra. Como resultado del análisis preliminar nueve frecuencias de oscilación han sido detectadas en V650 Tauri con un nivel de confianza superior al 99%.

ABSTRACT

The preliminary results of a multisite photometric campaign on the Pleiades Delta Scuti variable V650 Tauri are reported. The star was observed photometrically for 14 days during 2008 November from three observatories distributed in Longitude around the Earth. As a result of the preliminary analysis we have detected in V650 Tauri at least nine oscillation frequencies above a 99% confidence level.

Key Words: stars: early-type — stars: oscillations — stars: variables: delta Scuti

1. INTRODUCTION

Stellar oscillations provide a powerful tool for studying the interiors of the stars since the mode frequencies depend on the properties of the star and give strong constraints on stellar models and hence evolution theories. However, the observations of stellar pulsations require extensive data sets in order to achieve accurate frequencies and to avoid the sidelobes in the amplitude spectrum caused by the daily cycle. Long time series are usually obtained from the ground by means of multisite observations.

A good scenery to carry out seismic studies are short period pulsating stars in open clusters. Since the cluster members have been formed simultaneously in the past they share similar stellar properties in the present as age, chemical composition and distance. By means of isochrone fitting it is possible to fix the age and stellar masses. These constraints imposed by the cluster are very useful in computing seismic models (e.g., Fox Machado et al. 2001, 2006; Suárez et al. 2002). This has motivated, for instance, a number of observational studies on the Pleiades δ Scuti stars. In particular, six δ Scuti variables have been discovered in the Pleiades cluster until now and most of them have been intensively observed in recent years namely: V647 Tauri (Liu et al. 1999), HD 23628 (Li et al. 2002), V534 Tauri (Fox Machado et al. 2000; Li et al. 2004), V624 Tauri (Fox Machado et al. 2002, 2008), HD 23194 (Fox Machado et al. 2002, 2008) and V650 Tauri (Kim & Lee 1996).

The target star V650 Tau (HD 23643, $V = 7^{\mathrm{m}}.79$, A7) was identified as a short-period pulsating variable by Breger (1972). One-site CCD photometric observations carried out by Kim & Lee (1996) in November-December 1993, detected four frequencies. With the aim at detecting more pulsation frequencies that may be helpful in constructing new seismic model for the star (Fox Machado 2003) we have organized a multisite campaing on V650 Tauri.

2. OBSERVATIONS AND DATA REDUCTION

Three site observations were obtained with a 0.50 m telescope of Xing Long Station of National Astronomical Observatory of China, the 0.84 m telescope of Observatorio San Pedro Mártir in Mexico and the 0.80 m telescope IAC80 of Teide Observatory in Spain. For all these observations CCD cameras were used. The photometric data at Teide observatory and Xing Long Station were acquired through a Johnson V filter. In San Pedro Mártir a Strömgren y filter was used instead. More than 16000 frames on 21 nights were obtained. All data were reduced using standard IRAF routines. Aperture photometry was implemented to extract the instrumental magnitudes of the stars. The differential magnitudes were normalized by subtracting the mean of differential magnitudes for each night. An example of the differential light curves is shown in Figure 1a.

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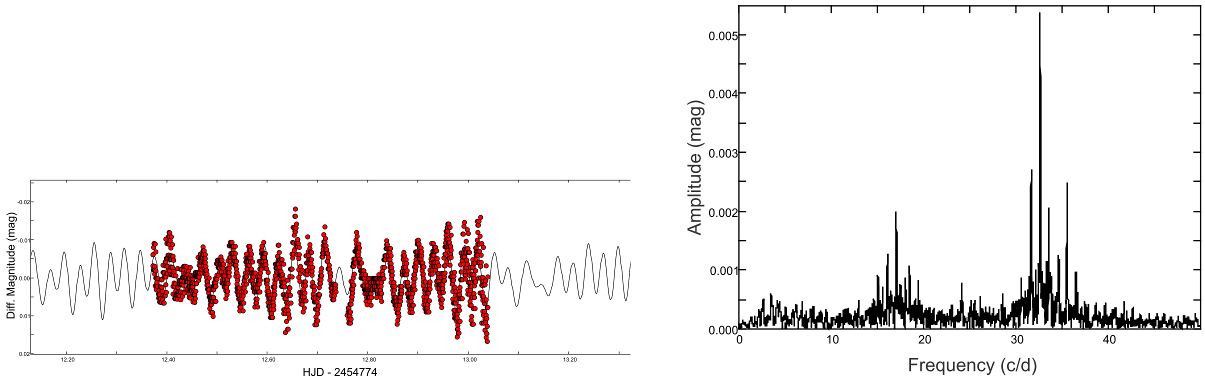

Fig. 1. (a) Example of the differential light curve V650 Tauri – Comparison. The solid line represents a fit to the observed data of the nine frequency detected in V650 Tauri. (b) Amplitude spectrum derived from the light curve V650 Tau – Comparison. The amplitude is in mag and the frequencies in c/d.

TABLE 1

FREQUENCY PEAKS DETECTED IN A PRELIMINARY ANALISYS OF THE LIGHT CURVE V650 TAURI – COMP. S/N IS THE SIGNAL-TO-NOISE RATIO IN AMPLITUDE AFTER THE PREWHITENING PROCESS

Freq. (c/d)	A (mag)	$\varphi/(2\pi)$	S/N
32.623471	0.005075	0.910606	34.3
35.565042	0.002194	0.777990	17.6
17.023812	0.002064	0.305423	8.9
18.460618	0.001216	0.659008	5.7
15.030028	0.000832	0.529173	4.2
32.705001	0.000761	0.605440	5.2
3.4312070	0.000646	0.249472	4.0
24.177849	0.000621	0.466309	4.6
32.862220	0.000672	0.144418	4.6
4.1768560	0.000598	0.383873	2.9

3. PERIOD ANALYSIS

The period analysis has been performed by means of standard Fourier analysis and least-squares fitting. In particular, the amplitude spectra of the differential time series were obtained by means of Period04 package (Lenz & Breger 2005), which considers Fourier as well as multiple least-squares algorithms. This computer package allows to fit all the frequencies simultaneously in the magnitude domain

The amplitude spectrum of the differential light curve V650 Tauri-Comparison is shown in Figure 1b. As can be seen, V650 Tauri presents high-amplitude peaks distributed between 12 c/d and 38 c/d.

The frequencies have been extracted by means of standard prewhitening method. In order to decide which of the detected peaks in the amplitude spectrum can be regarded as intrinsic to the star we follow Breger's criterion given by Breger et al. (1993), where it was shown that the signal-to-noise ratio (in amplitude) should be at least 4 in order to ensure that the extracted frequency is significant.

The frequencies, amplitudes and phases are listed in Table 1. Nine significant frequencies have been detected in V650 Tauri in this preliminary analysis. A detailed analysis of these observations will be given in a forthcoming paper.

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