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STELLAR SEISMOLOGY FROM PHOTOMETRIC MEASUREMENTS.

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RESUMEN. Presentamos observaciones de la estrella HD 213534 (GX Peg) efectuadas dentro de una campaña para determinar los límites de detección en tierra de oscilaciones de alta frecuencia y pequeña amplitud.

ABSTRACT. Observations of the star HD 213534 (GX Peg) made to determine the detection limits for high frequency and small amplitude star oscillations from earth are reported.

Key words: PHOTOMETRY — STARS-OSCILLATIONS

1.-INTRODUCTION.

The traditional methods used in photometry and spectroscopy, allow us to determine some of the properties of the photosphere and exterior layers of stars. Differential photometry is used to study the variable behaviour of them and its analysis suggest us the possibility to study its interior layers. The use of rapid 'continuous' photometry allows us to extend the range of detection and hence, to determine some of the possible oscillatory modes present on the interior of the stars.

This technique has beeing applied with considerable success in the detection of solar oscillations (see for example Woodard and Hudson, 1983, Jimenez et al, 1987, 1989), and has also been used for the analysis of Ap stars, where Kurtz, (1982), reports amplitudes of a few 10-4 mag. with periods in the range of 4 to 15 min. (from 4 to 1 mHz).

2.-OBSERVATIONS OF A δ-SCUTI STAR.

Using two identical 'three channel' photometers designed and built by one of us (M.Ch.), and working in a cooperative campaign between the observatories of San Pedro Mártir, Baja California, México and Pico de Teide, Canary Island, Spain, we obtained during the spring of 1987, some series of more than 12 hours of continuous observations of the δ-Scuti star HD 155514 (63 Her).

We observed seven oscillatory frequencies on this δ-Scuti star. Three of these frequencies are most probably non-radial modes of degree $l>0$ and low value of n. Four of these modes can probably be identified with g-modes (not to be present on these stars according to the actual stellar models). Since one of the main purposes of this campaign was to determine the detection limit of the variability on 'solar type' stars, we used the comparison star HD 155543 (an F2V star), as an additional test on the performance of the instrument. Within the limits of detection, this F2V star appeared constant. A description of the instrument and the results obtained on that campaign, has been given by Belmonte et al. (1989).

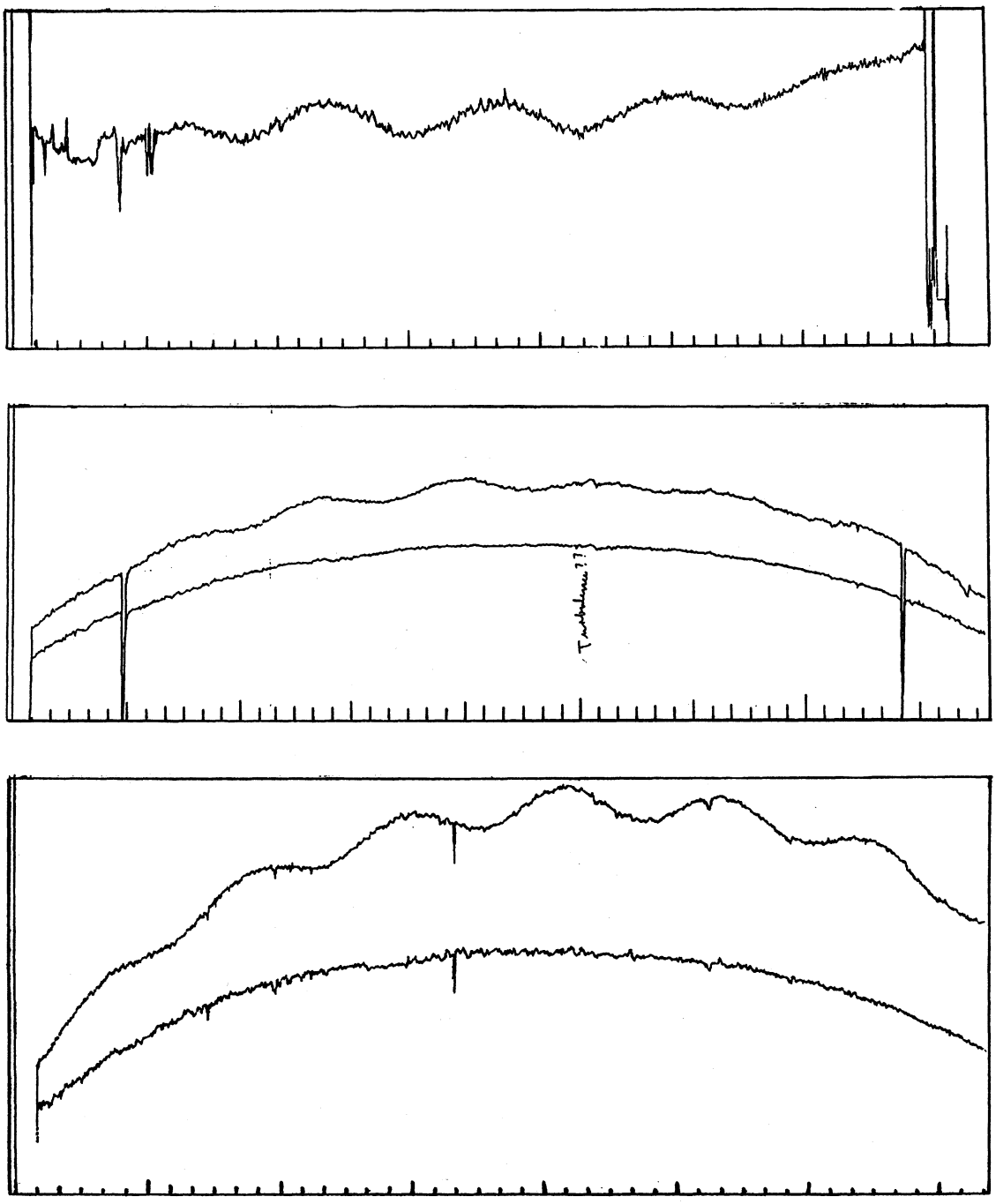

Figure 1.- TOP: Night of August 22/23, 1989. SPM. Tel 1.50 m. MEX02P.DAT The 1h. 20m. period is clearly seen. The short frequency (Apparent) is due to a telescope guiding problem, easily taken into consideration.
MEDIUM: August 29/30. 1989. SPM. Tel 2.12 m. MEX09.DAT The known period of the star is clearly seen. The scintillation noise is much smaller due mainly to the large aperture of the telescope.
BOTTOM: September 1, 1989. CANARIES. Tel 1.50 m. CAN08.DAT A 'Typical' good night of observations obtained at Canary Island, where the known period is well identified. The observed noise is due mostly to sky scintillation.

3.-NEW OBSERVATIONS.

The three channel photometer has a very small field of less than 15 arc min. and as a consequence, the choice of the observing targets is rather limited. As a continuation of this program, we have observed the star HD 213534 (GX Peg, A5V V=6.3), another δ-Scuti star with a period of 0.056 d. that has the star HD 213473 (K5 V=9.1) at 6.3 arc min. The magnitude difference requieres the use of a filter to have a similar response on both photomultipliers.

We observed from three observatories, Pico de Teide (OPT) in Canary Islands (28.2 N, 16.4 W.), San Pedro Mártir (SPM) in Baja California (31.0 N, 115.5 W.) and a chinesse observatory, near Peking, China (39.5 N, 116.2 E). We used a 1.5 m. telescope at OPT from August 23th. trough September 11th., with a total of 18 nights of observation. From SPM, we observed with a 1.5 m. telescope from August 22th. through the 27th. and with a 2.12 m. telescope from August 28th. through September 6th. having a total of 16 nights of observations. Our Chinese colleagues observed from August 21st. through September 12th. with a total of 10 observing nights.

The log of the observations is given in Table 1, for the three sites. We include the total observing time for each day and an 'average' of the quality of the night.

In figure 1, we present an example of the data obtained at Baja California and Canary Island, where the characteristic period of 1h.20min. is very clear. The analysis of this data is under way. Here we want to present the actual status of this experiment. We are planing another coordinated observing run between the three sites and we are also considering to join another observatory at the Soviet Union. Our aim is to be able to cover as long as possible the whole variable cycle of the target star in order to determine with very good precision and without the usual mathematical problems associated with the 'observing windows' very common in our photometric analysis.

4.-FUTURE WORK.

This program is part of an ambitious idea to measure stellar oscillations from the soviet satellite that will be launched to Mars. To insure the success of this experiment it is necessary to test the performance of the instrument and at the same time, we are obtaining new information about some 'well known' stars. We are planning to use this instrument with other 'solar type' stars in order to detect similar oscillatory modes to the ones observed on the Sun. We will use this same instrument to study also some B and Be stars, that seem to have periods of different time scales.

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TABLE 1.
HD 213534. LOG OF THE OBSERVATIONS.
August-September 1989.

V1= HD 213534 (GX PEG) A5 V. V=6.3 B-V= 0.2 Mv= 2.1 RV= +2 km.s-1
C1= HD 213473. K5. V=9.1 B-V= 1.0

Date	Pico de Teide Tenerife, Spain	San Pedro Martir Baja California,Mexico	Kun-Ming Peking,China.
August			(##)
21	---	Inst. Test.	Observations.
22	---	530 min. (1)	Observations.
23	147 min. (2)	410 min. (1)	---
24	259 min. (2)	370 min. (1)	---
25	119 min. (2,3)	480 min. (3)	---
26	36 min. (2)	480 min. (1)	---
27	---	164 min. (3,4)	---
28	---	280 min. (1) *	---
29	535 min. (0)	508 min. (0)	---
30	438 min. (0)	500 min. (0)	---
31	510 min. (0,1)	517 min. (0)	Observations.
September			
1	516 min. (0)	480 min. (0,2)	Observations.
2	517 min. (0)	500 min. (0)	Observations.
3	512 min. (0,2)	520 min. (0)	---
4	519 min. (0)	520 min. (0)	---
5	519 min. (0,2)	476 min. (0,2) ++	---
6	513 min. (0)	468 min. (0,2)	Observations.
7	525 min. (0,3)	---	---
8	520 min. (0,2)	---	---
9	288 min. (2)	---	---
10	487 min. (0)	---	Observations.
11	151 min. (2)	---	Observations.

Notes:
* SPM, start of observations with the 2.12 m. telescope.
++ SPM, change of filter to ND=1.0. The 'color' effect dissapears.
The chinese observations where secured by Dr. Jiang Shi Yang from Peking observatory.

(0) Good quality of observations.
(1) Minor telescope problems.
(2) Weather problems.
(3) Minor mechanical and/or electrical problems.
(4) Mechanical problem not solved during the night.

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