Astron. Astrophys. 103, L17–L19 (1981)

ASTRONOMY AND ASTROPHYSICS

Letter to the Editor

G 255-2: A New ZZ Ceti Variable Star*

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Received September 3, accepted September 18, 1981

ABSTRACT.

We report the discovery of a new ZZceti variable selected from its G-R color. G255-2 has been found to vary with two main periods : 830s and 685s of similar amplitude of about 4% of star luminosity. Two more periods at 450s and 380s of smaller amplitude may be present. Both periods and amplitudes seem to have remained stable during the six months interval between the two observing runs.

Key words : ZZceti stars, fast photometry, white dwarfs.

I - INTRODUCTION.

Observational properties of ZZceti stars have been recently reviewed by Robinson (1979) and McGraw (1980). These variable white dwarfs of DA type are clustered in a small range of effective temperature defining an instability strip. The exact range is still controversial. Comparison of Strömgren colors (McGraw, 1979) with model atmospheres (Wickramasinghe, Strittmatter 1972) lead to a range in effective temperature from 10500K to 13500K. Only about one fourth of the white dwarfs selected from UBV photometry and falling in this temperature interval are variable. Using his multichannel spectrophotometry (MCSP) together with recent model atmospheres (Shipman 1977), Greenstein (1981) finds a somewhat narrower instability strip (∿ 10700K-12000K), where almost all DAs are ZZceti stars.

Analysis of non-radial modes propagation in stratified white dwarf atmospheres have been recently undertaken after gravitational settling was recognized as strongly affecting the envelope structure (Koester 1976, Vauclair and Reisse 1977). Winget et al. (1981) showed how a few selected modes may be trapped in the hydrogen outer layers when their k radial wave number is such that the the corresponding kinetic energy is minimum. Stability analysis of such stratified envelopes has been carried out by Dziembowski and Koester (1981) who suggest that the helium partial ionization zone lying below the outer pure hydrogen triggers the pulsation by kappa-mechanisms, in the temperature range predicted by Strömgren photometry (10500K-13500K), provided the outer hydrogen envelope is small enough. Dolez and Vauclair (1981) confirm their results for models hotter than 11500K but also find a large excitation in the hydrogen partial ionization zone in the temperature interval 10000K-11500K, in better agreement with Greenstein's estimate of the instability strip.

It is clear that a better knowledge of the exact position in temperature of the instability strip should lead to an unambiguous interpretation of the pulsation mechanism. It is therefore quite important to improve the statistics on the number of ZZceti in the instability strip and the position of its blue edge.

Recent observational programs based on Greenstein's multichannel colors (Greenstein 1976) have largely increased the probability of detecting new ZZceti stars. Among the most recent discoveries of ZZceti variables, GD 385 (Fontaine et al. 1980, Vauclair and Bonazzola 1981), G191-16 and G185-32 (McGraw et al. 1981), G226-29 (Fontaine et al. 1981) had been selected for their (G-R) colors. With a (G-R) color of -.40, G255-2 (WD1159+80 in McCook and Sion (1977) catalogue) is lying in the instability strip and is thus a good ZZceti candidate.

In this paper, we report on the observation of G255-2 which reveals to be a ZZceti variable with two main periods around 830s and 685s.

II - OBSERVATIONS AND ANALYSIS.

The photometer we used has been described by Vauclair and Bonazzola (1981). It is a two channel photon counting photometer, allowing simultaneous observation of a comparison star. Observations were obtained at the 1.93m telescope at Haute Provence Observatory. Since the observations reported in Vauclair and Bonazzola (1981) large improvements have been made in the instrumentation : an offset guiding has been added at the Cassegrain focus, which allows no interruption during the data acquisition ; the data are stored on a HP21MX computer for Fast Fourier analysis ; the data stored on magnetic tapes may be analysed more carefully on the PDP1134 in Meudon Observatory. The photometer is equipped with two Rubidium 9989QB photomultipliers. Integration time is 0.1s.

G255-2 was observed on January 13th 1981 and on July 29th 1981. To the data is substracted a quadratic polynomials to minimize the very low frequencies due to the sky transparency variations. Apodisation according to classical methods is applied to the resultant data before calculating the Fourier transform (Hesser, Ostriker, Lawrence 1969). Figure 1 is the light curve of G255-2 obtained on January 13 and Figure 2 is the modulus of its Fourier transform. The observing run lasted 137 min. ; the Fourier transform exhibits two excited modes at 1.22mHz (± 0.06 mHz) and 1.46 mHz (± 0.06 mHz) with an amplitude of about 4.5% (note that the peak at 4.5 mHz represents a sinusoid of amplitude equal to 3% of the star total intensity, added to the data for calibration). Reductions have been performed on the PDP1134 at Meudon Observatory. The second observation of G255-2 on July 29 confirms the variabi-

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* Based on observations made at the Observatoire de Haute Provence

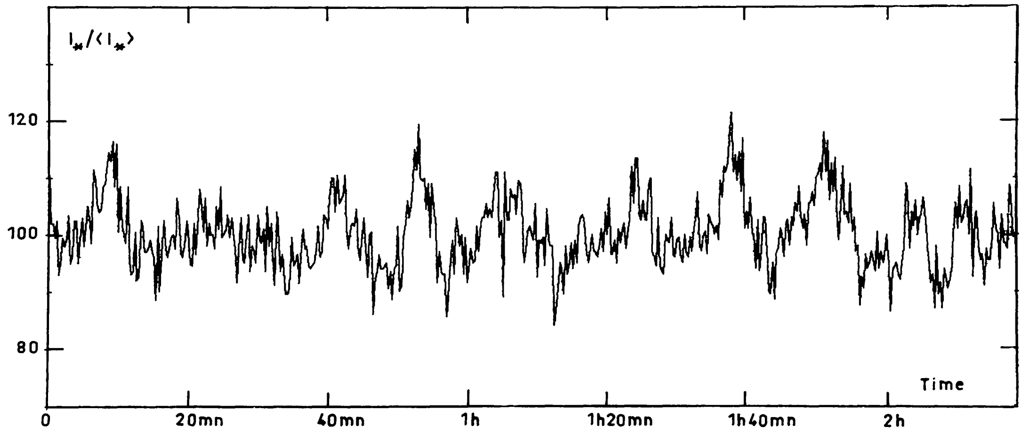

Figure 1

Light curve of G255-2, run of January 13th, 1981, Haute Provence Observatory.

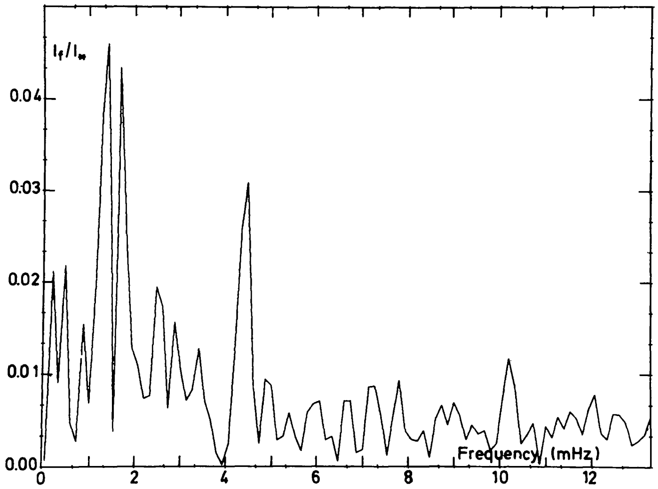

Figure 2

Fourier transform modulus of the light curve shown in Fig. 1. The peak at 4.5 mHz is a 3% amplitude tracer added to the data. The spectra exhibits two major frequencies at 1.22 mHz and 1.46 mHz.

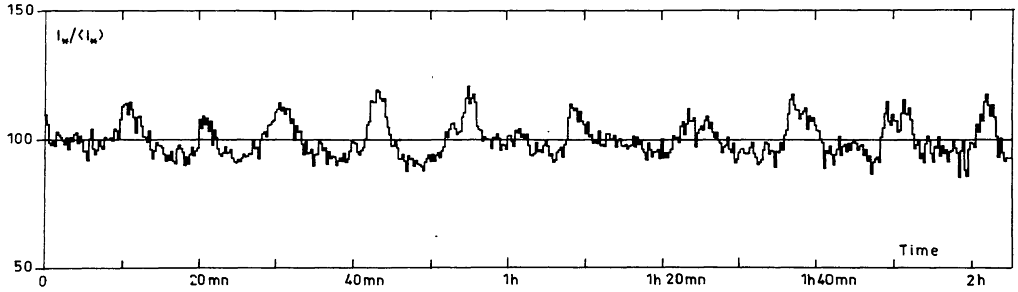

Figure 3

Light curve of G255-2, run of July 29th, 1981.

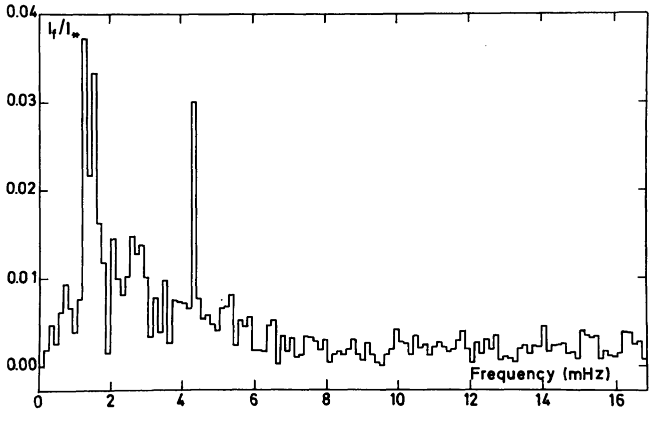

Figure 4

Fourier transform modulus of the light curve shown in Fig. 3. The two peaks at 1.19 and 1.46 mHz confirm the result obtained on January. Two frequencies around 2.1 and 2.6 mHz are possibly present in the spectra. The 4.2 mHz peak is again a 3% amplitude tracer.

lity. Figures 3 and 4 show the light curve and the Fourier transform obtained that night. Reductions of the data have been performed on the Haute Provence Observatory HP21MX computer. The observing run lasted 126 min. ; the Fourier transform shows two peaks at 1.19 mHz (± 0.07 mHz) and 1.45 mHz (± 0.07 mHz), with an amplitude of about 3.6% of the star total intensity. The peak at 4.2 mHz is again a 3% calibration sinusoïd. Within the resoluution the periods observed on July 29 are identical to those observed on January 13. By comparing the TF of the two runs, we suspect two more possible frequencies to be present in the Fourier spectrum with a much lower amplitude at 2.6 mHz, and at 2.1 mHz. However their amplitude is just slightly above noise level and we cannot be quite conclusive on their reality.

A statistical analysis of the significance of our observed peaks is made using the same method as in Vauclair and Bonazzola (1981). The probability that a peak due to noise exceeds a certain value I_0 in one frequency interval is $q = \exp(-I_0^2/\sigma^2)$. Then the probability for a peak exceeding I_0 to be due to noise, on a frequency domain containing N intervals of the Fourier spectrum is : $p = 1 - \exp(-qN)$. The value of σ is slightly different whether one considers all the frequency spectrum, or only the low frequency part of it, the low frequency noise being approximately twice the noise averaged on the entire Fourier spectrum. Here we consider the low frequency part of the Fourier spectrum (1 mHz - 10 mHz) relevant for non-radial modes. The two peaks at 820s and 680s have then a probability $p \simeq 5 \times 10^{-3}$ to be due to noise. For the two peaks at 2.6 mHz and 2.1 mHz, we find a very low probability of significance. It is only the existence of these peaks on the July observations also that makes them possibly real.

III - CONCLUSIONS.

We have discovered G255-2 to be a new ZZceti star in January 1981 and got confirmation of its variability in July 1981. The star exhibits mainly two excited modes of nearly equal amplitudes, of periods 820s and 685s, and possibly two more of smallest amplitude at about 450s and 380s to be confirmed. G255-2 has been selected from a list of white dwarfs with multichannel spectrophotometry by Greenstein (1976). After GD385, G226-29, G191-16 and G185-32, it is the fifth ZZceti variable discovered from this list. As Greenstein stressed recently, the temperature of the instability strip defined by his MCSP observations (10700K-12000K) fits well with the temperature where partial ionization in the hydrogen layer occurs in these stars (maximum of Balmer jump and Balmer lines equivalent widths). It is likely that the driving mechanism of pulsation is the kappa-mechanism in hydrogen ionization zone as predicted also by pulsation theory (Dolez and Vauclair 1981).

ACKNOWLEDGEMENTS.

The authors are undebted to Mr. Valliere and the technical staff of the Haute-Provence Observatory for their assistance.
We want also to thank Mr. Dagostinoz for his help in data reductions on PDP 1134 at the Meudon Observatory.

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