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PHOTOMETRIC OBSERVATIONS OF SHORT PERIOD VARIABLE STARS

Salvador González Bedolla

Instituto de Astronomía
Universidad Nacional Autónoma de México

RESUMEN. Se presentan observaciones fotoeléctricas de cuatro estrellas variables de corto período; se muestran las curvas de luz de estas observaciones, un análisis preliminar de estas observaciones es efectuado.

ABSTRACT. Photoelectric observations of four short period variable stars are presented, and their light curves are shown. Also a preliminary analysis of these observations is presented.

Key words: PHOTOMETRY — STARS-LIGHT CURVE — STARS-VARIABLE

I. INTRODUCTION

It is known that Delta Scuti stars constitute the second most numerous group of pulsators in the galaxy (after the pulsating white dwarfs); they are situated in the Cepheid instability strip or in its extension, they have a pulsation period less that one day, are variable stars of spectral type A or F with amplitudes in V,ranging from a few hundredths of magnitude to 0.8 magnitude. The origin of this phenomenon could be found in the He II and H ionization zones as well as another driving zone caused by the coincidence of maximum flux with the frequency of the second helium ionization front, however this scheme depends in some measure on a good period-luminosity-color relation (PLCR). The understanding of this phenomenon is actually more complicated due to the presence of multiperiodic radial and non radial pulsators, in this sense a good calibration PLCR is important. Various forms of the PLCR can be found in the literature, however many of the periods utilized for these relations regretably are extremely uncertain, hence, it is important to obtain better periods of Delta Scuti stars. In this sense we shown here some observations of the Delta Scuti stars, HR 401, HR 8006 and HD 106384 that are observed poorly, with the aim to improve the present knowledge of these particular stars.

On the other hand, other short period variable stars are the Be stars, that are usually early B stars rapidly rotating non supergiants whose spectra have or had at one time, one or more Balmer lines in emission. There are a subgroup of the Be stars known as shell stars, and these can be considered like stars which have shown strong absorption cores well down in the Balmer lines at least some time in their life. The Be and/or shell phenomena seem to depend on stellar rotation, but this may vary markedly with time. There are considerable evidences that shell stars are Be stars seen equatorially or nearly equatorially.

Three models for Be stars have been mainly proposed; historically the first is the rotating elliptical ring model, in which the line of apsides of a thin elliptical ring of gas, has a radius 3 to 4 stellar radii and eccentricity of 0.2 to 0.3, rotating with a period of 5 to 15 yr. A second model is the binary model; mass transfer in a binary system produces a gaseous disk around the hotter component and may also produce the rapid rotation of the hotter component. The third model is the stellar wind model, where the combined effect of rapid rotation and a radiation-driven stellar wind produces an expanding equatorial disk with a characteristic radius of 30 stellar radii and a characteristic outward velocity of 10 to 50 km/s.

The most pronunced variations in these stars occur on a time scale of months or years. The total strength of the emission or shell absorption may vary and in some cases the variations are cyclic with periods of years, but the variations may cease or reappear abruptly. In addition, short period photometric variations less that 1 day are frequently reported in these stars; continuous photometric observations could show correlations between these facts, hence, with this intention, we show some photoelectric observations in the Be star Omicron Andromedae.

II. OBSERVATIONS

H R 401:

This star (m_v = 6.01, Sp: F0V) was reported as a short period variable star by Jorgensen, Johansen and Olsen in 1971, who, with only three short nights, of photoelectric observations, detected a clear variation with an amplitude of 0.02 mag. In V and a period aproximately of 0.07 day. The Stromgren and Crawford photometry placed this star in the instability strip; it appears that no further photometry was made for HR 401.

With the 83 cm. telescope of San Pedro Mártir (OAN, México) we performed photoelectric differential photometry of this star with Johnson's V filter in September 23, 24, 28 and 29 of 1984. Figure 1 shows some light curves obtained, and their variation confirmes the Delta Scuti behavior of this star. A preliminary Fourier analysis with the data was made, and a fundamental frequency 14.5935 day^{-1} was detected thus a period of 0.0685 day in is of better precision than that reported by Jorgensen. With this value we can calculate the Q of the pulsation with the classical Stellingwerf formula:

$$Log\ Q = -6.454 + Log\ p + 0.5\ Log\ G + 0.1\ M_{bol} + Log\ Te$$

and with the values known for this star:

$$Log\ P = -1.1643,\quad Log\ G = 4.059,\quad M_{bol} = 2.09,\quad Log\ Te = 3.894$$

we obtain: $Log\ Q = -1.4858$, thus, $Q = 0.0327$.

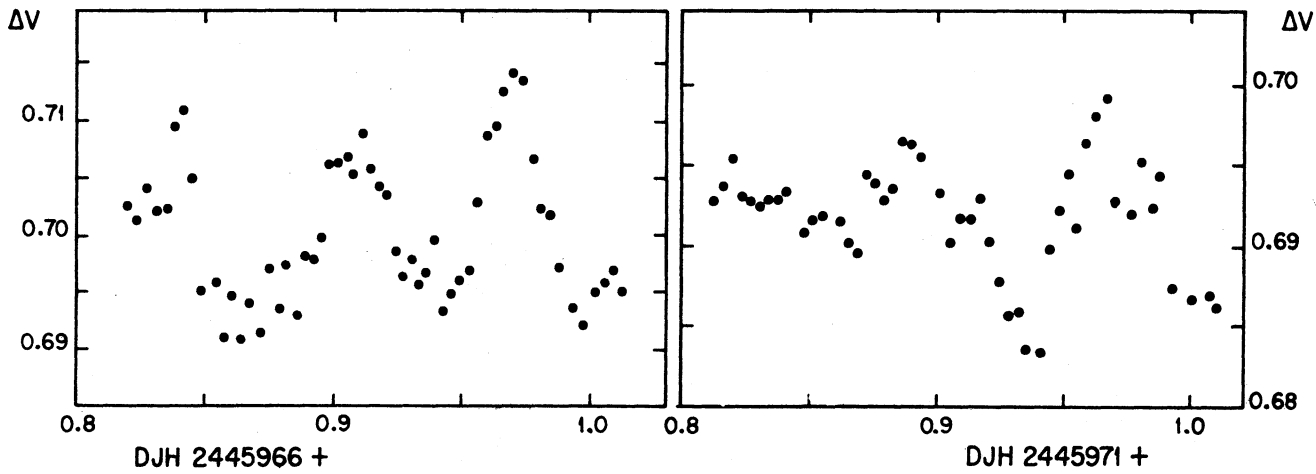

Fig. 1. Differential photometry for HR 401

This is a clear indication that HR 401 is pulsating in the fundamental mode. It is probable that a second frequency with less potency may exist; more observations are needed for this star in order to detect this possibility.

ℜ 8006

HR 8006 ($m_v = 6.6$, S_p: F0V) was first pointed out as a Delta Scuti star by Breger in 1969. He reported approximate period of 0.095 day and a mean amplitude of 0.07 mag. in V; later (1974) more photometric and ectroscopic observations were reported in this star by Le Contel *et al.*, the light curves obtained displayed wide anges in shape and amplitude and the values obtained for the period showed a great scatter from night to night, after 74. Apparently, there are no more published observations for this star.

In collaboration with the Instituto de Astrofísica de Andalucía we observed this star in 1980 with the lescopes of 83 cm. of San Pedro Mártir (OAN, México) and 40 cm. of Mojon del Trigo (Spain) obtainig 10 nights of otoelectric observations. Some light curves obtained for this star are shown in Fig. 2.

Also (like the observations of Le Contel *et al.*,) the light curves obtained show wide changes in shape and mplitude, however, the Fourier analysis made with these data clearly show a fundamental frecuency in 11.08628 day^{-1} hus, a period of 0.0902 day) in accordance with the period suggested by Breger. With this value and $Log\ P = -1.0448$, $\log G = 4.059$, $Log\ Te = 3.894$ and $M_{bol} = 2.09$ for this star, we can calculate the Q of pulsation with the Stellingwerf rmula above mentioned, obtaining $Q = -0.0279$. At first glance, this is an indication that HR 8006 is pulsating in e first overtone, altohugh possibly other frequency with less potency is present in the data. We are working on this well as in the matching of these results with other observations.

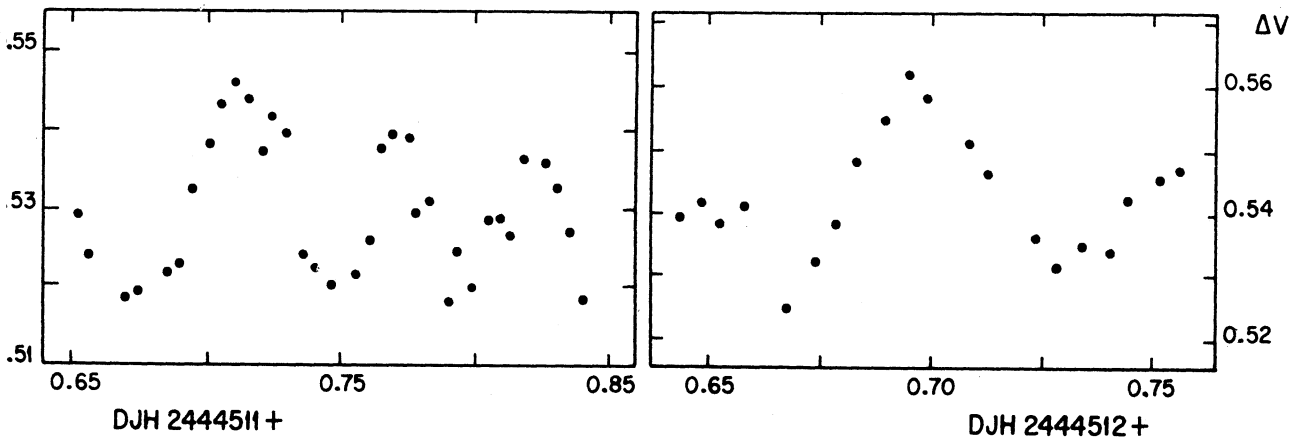

Fig. 2. Differential photometry for HR 8006

D 106384

In a study of Blue Straggler stars of old disk population, Eggen (1971) detected four additional variables th behavior like Delta Scuti stars, one of them was HD 106384 where, with one night of observation, Eggen proposed period of 0.07d and an amplitude of 0.05 mag. in V. Later on, López de Coca *et al.*, (1984) confirmed the pulsational aracter of this star like Delta Scuti with three nights of observation. In the Fourier analysis they found that there is least one period of about 0.079d that lead M_v of 1.73 mag. approximately (via P-L-C of Breger's relation); however, ey pointed out that more observations are needed, in order to find the whole period content of the star, hence, with is intention, we present here additional photoelectric observations for this Delta Scuti star.

HD 106384 was observed on March 28, 1986 in the Johnson's V filter with the 84 cm. telescope of San dro Mártir, (OAN, México), Figure 3 shows the light curve obtained; we can see that the amplitude is approximately e same as that reported by Eggen. A preliminary Fourier analysis of these data, together with the data of López de oca *et al.* (1984) give a fundamental frequency of 12.667 c/d, thus, a period of 0.0789/day (in agreement with the

periods reported by Eggen 1971 and López de Coca *et al.* (1984)) with this value and the values of *Log* $P = -1.1029$, *Log* $P = 4.017$, *Log* $Te = 3.885$ and $M_{bol} = 1.77$ known for this star, we calculate (with the Stellingwerf relation) the Q of the pulsation, obtaining $Q = 0.0326$, which is an indication that the star is pulsating in the fundamental mode. However, it is clear that more observations are needed in order to obtain the complete periodic content of this star.

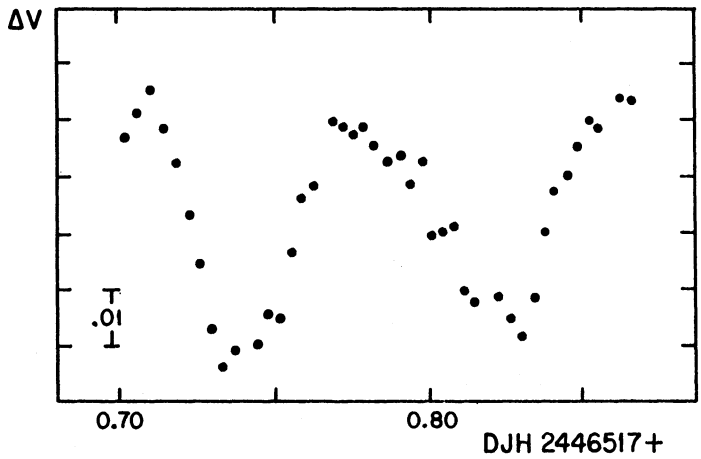

Fig. 3. Differential photometry for HD 106384

Chevalier (1971) has shown that δ Scuti stars can be considered as main sequence or post-main sequence stars of 1.6 to 2 $M_{\odot}$ pulsating in the fundamental radial mode or the first overtone and that a pulsational instability is present due to the second helium ionization zone. A good statistical agreement is obtained between the observed and the theoretical periods. In the case of the Delta Scuti stars here presented, we can conclude that their values agree with the expected periods of the models having the same position in the HR diagram.

OMICRON ANDROMEDAE

It is known that the rapid variations in the Be stars usually have small amplitudes (less than 0.1 mag.), therefore, these are not easily detectable. However, they seem to be potentially very important to understand the nature of Be stars. In this sense, O And. is a classical example where the problem of the light variations remains as a puzzle. At this moment, the only clear fact about this star is the suspicion about of a possible correlation where the rapid photometric variations could be due to the presence of a shell. Horn (1982) clearly showed, too, that together with occasional rapid photometric variations Omicron Andromedae also exhibts long term light changes at much larger amplitude.

O And. (HR 8762, B6IIIpe) has been the object of detailed spectroscopic and photometric observations through out this century, a summary of this was given by Harmanec (1983), collecting and analyzing all historical photoelectric observations. Harmanec (1984) concluded that the light variations of this star can be understood as a superposition of a long-term cyclic (8.5 years) variation with an amplitude over 0.1 mag. and a rapid periodic variation with a period of 1.571272 days; connected with this, there is a possible time scale for reappearance of a shell may be a 8.5 years. It is suspected that during the maximum of the 8.5 years ligth curve, the amplitude of the 1.57-day light curve is almost zero, while during the minima of the 8.5 years light curve the amplitude of the 1.57-day light curve reaches its maximum (0.1 mag), hence, it is understandable the importance to photoelectrically follow this star along all these years to check these possible correlations.

In coordination with the observatories of Meudon and Nice (France) we made photoelectric and spectroscopic observations of O And. in ten nights of September of 1988, using the telescope of 1.5 m. of San Pedro Mártir (OAN, México), Nice used the 60 cm. telescope installed in Sierra Nevada (Spain), in both sites, filters of the Stromgren system were used, Meudon made the spectroscopic observations in Haut Provence (France). The detailed results of these observations will be published later on. Here, we show in figure 4 the preliminary results of the photometry.

We can see in figure 4 that the observations lie in a band of 0.02 mag. approximately, thus, the photometry has high precision and that the star was almost stable during these nights. We are looking for the real possibility of short photometric variations below of 0.02 mag. (we note the high compression of the horizontal scale of figure 4). If these are true, the amplitude of the variations go up when the light of the star goes down, we are working in this now. These results indicate, at first glance, that apparently the period of 8.5 years suggested for this star is close to the maximum.

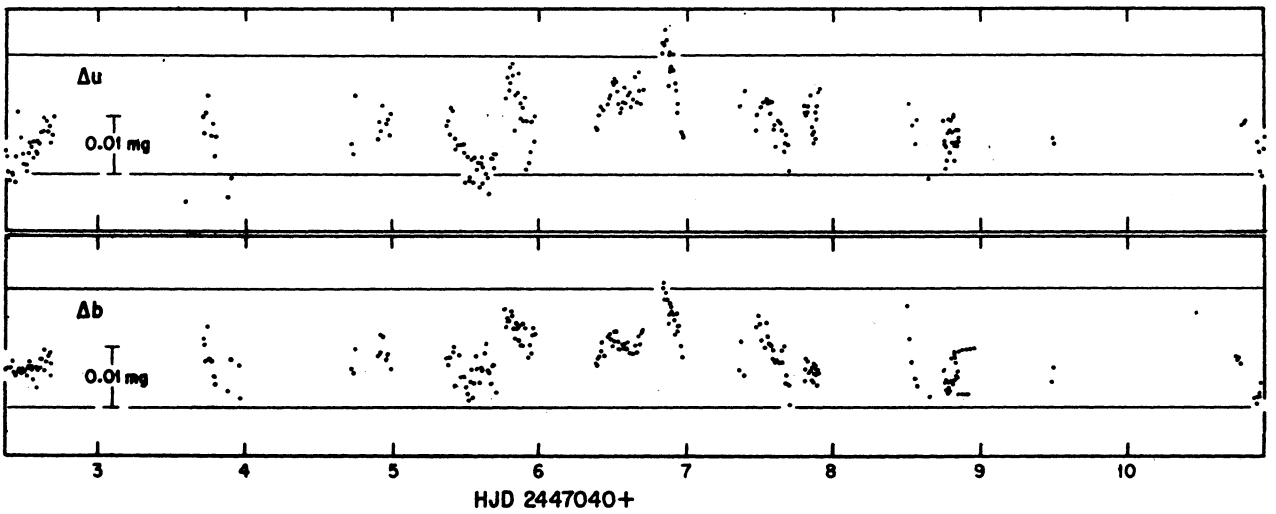

Fig. 4. Differential photometry for Omicron Andromedae

O And. is interesting too in the normal phase, therefore extensive and continuous spectroscopic and photometric observations are highly recommendables, these can define with precision the type of variability of this interesting object.

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Salvador González Bedolla: Instituto de Astronomía, UNAM, Apartado Postal 70-264, CP 04510, México, D.F.