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PERIODICITIES IN THE FLARE STAR H II 2411

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RESUMEN

Hemos analizado las repeticiones de la estrella ráfaga H II 2411 para buscar periodicidad en el fenómeno ráfaga con el formalismo de Lomb-Scargle. Encontramos dos períodos de 3060.444 y 23.827 días.

ABSTRACT

We have analyzed the repetitions of the flare star H II 2411 to search for periodicities in the flare phenomenon with the Lomb-Scargle formalism. We find two periods of 3060.444 and 23.827 days.

Key words: **STARS-FLARE – STARS-VARIABLE**

I. INTRODUCTION

The flare stars are those that show very fast changes in their intrinsic brightness. A flare star is considered as such when it shows a brightness increment rate greater than 0.005 mag/sec and a fast return to the quiescent or non excited state (Gurzadian 1980). A great number of these stars show repetitions of the flare phenomenon. The flare stars have spectral type between K and M, and it is believed that they are relatively young. There are two classes of the so called flare stars: the *UV* Ceti (spectral type M) in the solar vicinity and the flare star of clusters and associations (spectral type K-M). Of all these characteristics it is important to know if this flaring activity shows some periodicity, since the existence of periodicity in these explosive events will give us some indication of the physical mechanism that could produce the flare phenomenon.

There have been some reports about the possibiliy of periodicities in some flare stars (Gurzadian, 1980; Parsamian and Pogosian 1986, and referencces therein). One of the principal difficulties to search for the existence of periodicities is that there are very few flare stars with a sufficient number of repetitions (there are three in the Pleiades with more than 30 flares) to carry out an analysis of their periodogram with confidence. In this work we will try to study the specific case of the flare star H II 2411 in the notation of Hertzsprung (1947), number 377 in the catalogue of Haro, Chavira and González (1982), because it has the highest number of observed repetitions. This star has 120 reported repetitions from 1963 to 1982 (Haro *et al.* 1982). The star H II 2411 in the direction of the Pleiades has coordinates $\alpha = 3^h 43^m\!.7$ and $\delta = 24° 01'$ (1950), and spectral type beween dM3e and dM4e. The minimum and maximum observed amplitudes are 0.4 and 4.5 magnitudes respectively. From proper motions, Jones (1973, 1981) has shown that this star is not a member of the Pleiades but of the Hyades. A group of flare stars has been studied by van Leeuwen, Alphenaar and Meys (1986), and

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among them H II 2411 in its quiescent phase, reporting a period of 6.051 days. Therefore, we want to know if the star H II 2411 shows some periodicity in the flaring activity. In what follows we present the observational material in §II, the analysis of these observations in §III, in §IV the results and in §V some conclusions.

II. OBSERVATIONAL MATERIAL

The dates of the observations of the 120 repetitions of the flare star H II 2411 were obtained from the catalogue of Haro *et al.* (1982). Of these observations 84 are from plates of Tonantzintla and the rest from Byurakan and Asiago. From the dates reported we examined the plates of Tonantzintla to find the time of maximum amplitude of the flare. For the other 36 we considered that the maximum occurred at zero hours UT, because we did not have the epoch of the maximum at hand. For both groups the Julian days were derived (see Table 1 and 2).

III. ANALYSIS OF THE OBSERVATIONS

The method that we considered convenient to analyze the observations in the search of periodicities is the Lomb-Scargle formalism (Lomb 1976; Scargle 1982) reported by Press and Teukolsky (1989), because it takes into account the non-uniformity of the spacing of the points and the noise of the observations. One should take the results of the false-alarm probability cautiously because it discards peaks that could be real (Koen 1990); although, the comparisons of Koen are for evenly spaced data. We made several tests to find out if the inclusion of the 36 points could change the results; first we analyzed the 84 points considering that the maximum occurred at zero hours UT of the date of the observation and then with the correct times to be able to make comparisons. Following that, we analyzed the other 36 points to see if they could give us some significant results. Lastly, we studied all the points together, taking into account the considerations mentioned above, that is, taking first all the observations at zero hours UT of the date and then with the times that appear in tables 1 and 2.

IV. RESULTS OF THE ANALYSIS

For the 36 observations we did not find peaks in the periodogram with false-alarm probabilities less than 0.5 which means that we cannot have

TABLE 1

OBSERVATIONS FROM TONANTZINTLA[a]

JD	Δm	JD	Δm	JD	Δm	JD	Δm
75.6326	1.5	1439.7451	0.5	2238.8021	0.6	3653.8750	0.4
86.7854	0.6	1439.8042	0.5	2241.7458	3.7	3657.7681	0.5
342.6806	0.8	1443.7680	0.5	2503.8493	0.4	3660.5882	0.6
343.7444	0.5	1444.7076	0.5	2538.8750	1.8	3663.7250	0.5
345.7410	0.5	1444.7671	0.5	2565.6785	0.4	3663.7736	0.5
354.6938	0.7	1444.8386	0.7	2565.7444	0.5	3687.5604	0.5
356.7847	3.0	1445.8150	0.6	2568.6421	0.5	3688.6056	0.6
689.8493	0.5	1467.8221	0.5	2593.5833	0.7	3688.6465	1.2
701.7806	0.8	1495.6833	0.6	2597.6313	0.5	3691.7153	0.6
727.6653	0.7	1801.7639	1.0	2615.6208	0.9	3719.7313	1.6
731.6576	0.8	1820.6944	1.5	3269.6736	0.5	4004.7826	0.5
1081.7194	0.5	1821.6670	2.5	3275.7813	0.9	4072.6042	1.0
1082.7340	0.5	1823.7215	0.6	3277.6910	0.4	4098.6889	1.0
1083.9792	0.6	1823.8222	0.5	3301.8243	0.4	4340.5035	2.6
1085.6319	0.6	2210.5785	0.6	3306.7104	0.5	4726.7972	1.0
1085.7292	0.5	2210.8340	1.5	3331.6882	3.0	5512.7951	4.5
1085.8285	1.6	2211.6660	1.4	3596.8042	0.5	5549.5701	3.0
1087.8132	0.5	2233.7993	0.8	3604.8771	0.6	6519.7171	1.0
1092.7861	0.5	2234.7590	0.8	3632.8319	0.4	6556.7437	0.7
1093.7271	0.5	2236.6833	0.6	3634.8000	0.6	6961.6792	1.5
1437.7271	1.5	2236.8167	0.6	3634.9118	0.5	....	

a. JD +2438000.0

TABLE 2

OBSERVATIONS FROM OTHER OBSERVATORIES[a]

JD	Δm	JD	Δm
738.4299	0.9	3324.6200	1.5
739.4542	2.5	3652.5000	1.0
2127.5000	3.0	3655.8750	2.7
2504.5000	2.4	4012.5000	1.5
2505.5000	1.5	4338.5000	1.2
2510.5000	2.0	4775.5000	2.0
2511.4778	2.9	4775.6200	0.9
2511.5000	1.7	4775.7400	0.7
2535.5000	1.7	5455.5000	1.8
2595.5000	1.7	5456.5000	0.8
2621.3514	2.0	5460.5000	1.0
2870.5000	1.6	5789.5000	0.8
3212.5000	1.7	5815.5000	1.8
3214.5000	1.7	5820.5000	1.9
3243.5000	1.7	5836.5000	1.2
3249.5000	3.0	5837.5000	3.2
3275.5000	1.9	6527.5000	2.4
3324.5000	1.6	6529.5000	2.0

a. JD +2438000.0

any confidence in the peaks; a small value for the false-alarm probability indicates a highly significant periodic signal (Press and Teukolsky 1988). For the 84 points with the true times of the maximum we found a peak at 197.03 days with false-alarm probability of 0.35 and a peak at 425.07 with false-alarm probability of 0.5. For the 84 points with the times at zero hours UT we found the same two peaks but with false-alarm probability of 0.84 and 0.68 respectively. When we analyzed the 120 points with the times of Table 1 and 2 we found a peak at 3060.444 days with false-alarm probability of 0.19 and other two less significant ones at 423.758 and 122.419 days. Therefore, we can say that the most significant peak is at 3060.444 days.

These results were obtained using an oversampling parameter OFAC = 4 and for the highest frequency parameter HIFAC = 2, two times the equivalent Nyquist frequency, i.e., the Nyquist frequency if the 120 data points were evenly spaced over the same time span of the observations. When we go to higher frequencies for the 120 points we start seeing more peaks corresponding to the periods shown in Table 3, for OFAC = 4.0 and HIFAC = 10.0. If we increase the highest frequency HIFAC to 40 and 58 we obtain a probability of 0.255 and 0.347 respectively for the period of 23.827 days. These results show that when you increase the frequencies searched the probabilities of the peaks diminish. Therefore, the only important peak that remains when we search up to HIFAC = 58 is 23.827 days. There are some very insignificant peaks around 6.051 days.

TABLE 3

PERIODS, AMPLITUDES OF PEAKS AND FALSE-ALARM PROBABILITES FOR OFAC = 4 AND HIFAC = 10

Period (Days)	Amplitude	Probability
3060.444	7.04	0.65
39.014	8.64	0.19
35.268	8.98	0.14
23.827	9.70	0.07
22.375	7.22	0.59

V. CONCLUSIONS

We found two periods, that we believe can be taken into consideration to try reobserve this star in order to have more time coverage and to test the results again. These two periods led us to suppose that the flare phenomenon in this star is similar to the flare phenomenon in the Sun.

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REFERENCES

Gurzadian, G.A. 1980, *Flare Stars*, (Oxford: Pregamon Press.)
Haro, G., Chavira, E. and González, G. 1982, *Bol. Inst. Tonantzintla*, **3**, p. 3.
Hertzsprung, E. 1947, *Ann. Sterrew*, Leiden XIX, IA.
Jones, B.F. 1973, *Astr. and Ap. Suppl.*, **9**, 313.
Jones, B.F. 1981, *A.J.*, **86**, 290.
Koen, C., 1990 *Ap. J.*, **348**, 700.
Lomb, N.H., 1976, *Ap. J.*, **39**, 447.
Parsamian, E.S. and Pogosian, G.A. 1986, *Astrophysics*, **21**, 138.
Press, W.H. and Teukolsky, S.A. 1988, *Comput. in Physics*, **2**, 77.
Scargle, J.D. 1982, *Ap. J.*, **263**, 835.
van Leeuwen, F., Alphenaar, P., and Meys, J.J.M. 1987, *Astr. and Ap. Suppl.*, **67**, 483.

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