Bull. Astr. Soc. India (2003) **31**, 289–293

Study of Three Homologous Solar Flares Observed from Active Region NOAA 9033 on 12th June 2000

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Abstract. In the paper, we present a study of three homologous $H\alpha$ flares observed on 12th June 2000 in active region (AR) NOAA 9033. During the observation of AR NOAA 9033 on 12th June 2000, we observed 1st solar flare between 0135-0155 UT, 2nd flare between 0236-0253 UT and 3rd flare between 0259-0323 UT. The present study supports the quadrapolar reconnection scenario presented by Machado et al. (1983) and also shows the presence of 26.7 min periodicity in intensity data estimated from the site of the homologous flares.

Keywords : Sun - solar flares - homologous - periodcity

1. Introduction

Ellison, McKenna and Reid (1960) carried out a detailed study of recurring tendency of solar flare within an active region (AR) and coined the name 'homologous flares' for those events that appear twice or several times in the same location and with similar shape. Fokker (1967) extended the concept of flare homology to the radio observations, indicating that many radio bursts from consecutive flares have similar intensity in the time profile, while Stewart et al. (1974) also found similar evidence in the interferometric observations of moving type IV bursts. Machado et al. (1983), Strong et al. (1984), and Machado (1985), have carried out the study of flare homology to the keV to deca-keV energy regime, using X-ray imaging data provided by instruments aboard the Solar Maximum Mission (SMM) spacecraft. Furthermore, Machado (1983) noticed that the study of the conditions that lead to the break up of a series of homologous flares can contain important information on the processes of energy storage and release. In this paper we present

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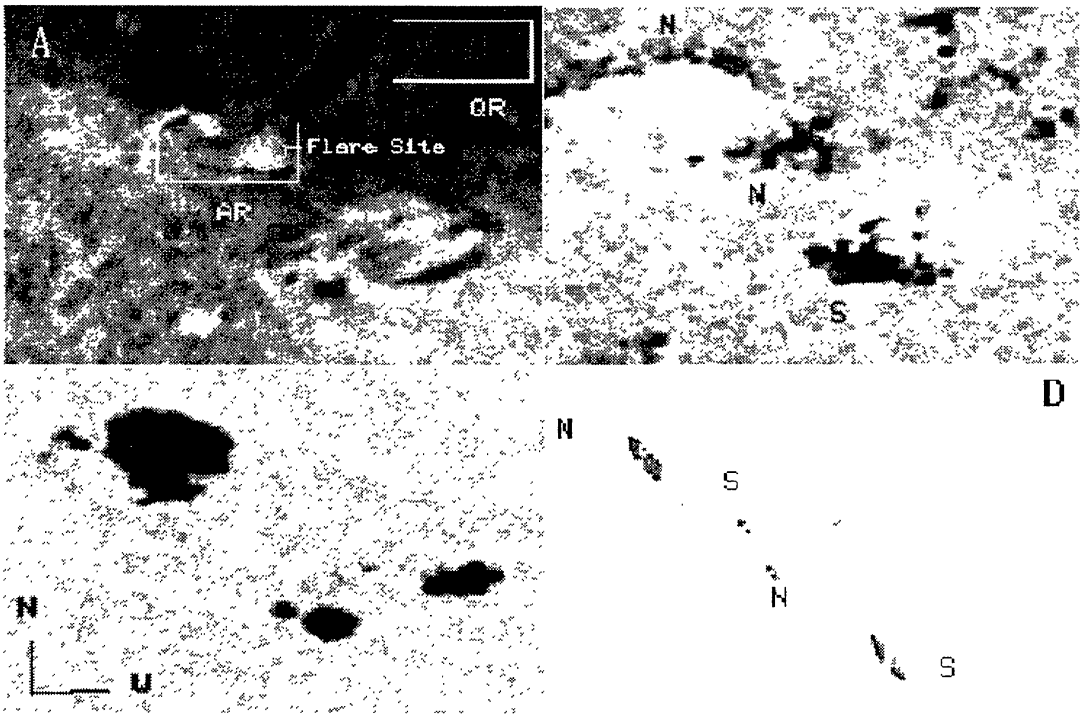

Figure 1. Figure 1A Shows the location of AR NOAA 9033 and Quiet Region (QR) used in the analysis, Figure 1B Shows SOHO/MDI magnetogram images of NOAA 9033 at 01:36 UT , Figure 1C shows SOHO/MDI continuum images of NOAA 9033 at 01:36 UT and Figure 1D Shows the quadrapolar reconnection scenario for the origin of homologous flares proposed by Machado et al.(1983).

CCD observations of AR NOAA 9033 on 12th June 2000 for four hours, starting from 0135 UT. During this period we recorded three solar flares between 0132-0155 (SF), 0236-0253 (SF) and 0259-0323 (1N) on about same location of the solar disc. In the present paper we report morphological studies, flare time-profile and periodicity of energy release from NOAA 9033.

2. Observations, Data Analysis and Results

On 2000, June 12 while monitoring the sun through a 15cm f/15 refractor equipped with 0.7 A passband Bernard Halle $H\alpha$ filter and Photometrics PXL CCD camera system (Verma, 1999), we first noticed a flare at 0135 UT. The observations comprised of 1600 images with exposure time 50ms and tuning $H\alpha$ filter to line centre with field of view (FOV) $5.5' \times 5.5'$ and time interval 2-20 sec. During the four hours of observation, three solar flares were observed within 41×73 arcsecond of the solar area in the AR NOAA 9033 of the Sun. In the Figure 1A we have shown an $H\alpha$ image which includes the active region(AR) NOAA 9033 as well as the quiet region (QR) shown by rectangular box. The disc area shown in Figure 1A covers area on the Sun as 247 by 195 arcseconds. The 1600 images are cleaned with flat and dark images. The images are finally aligned for the analysis. The reduction work is done using the IRAF software. For

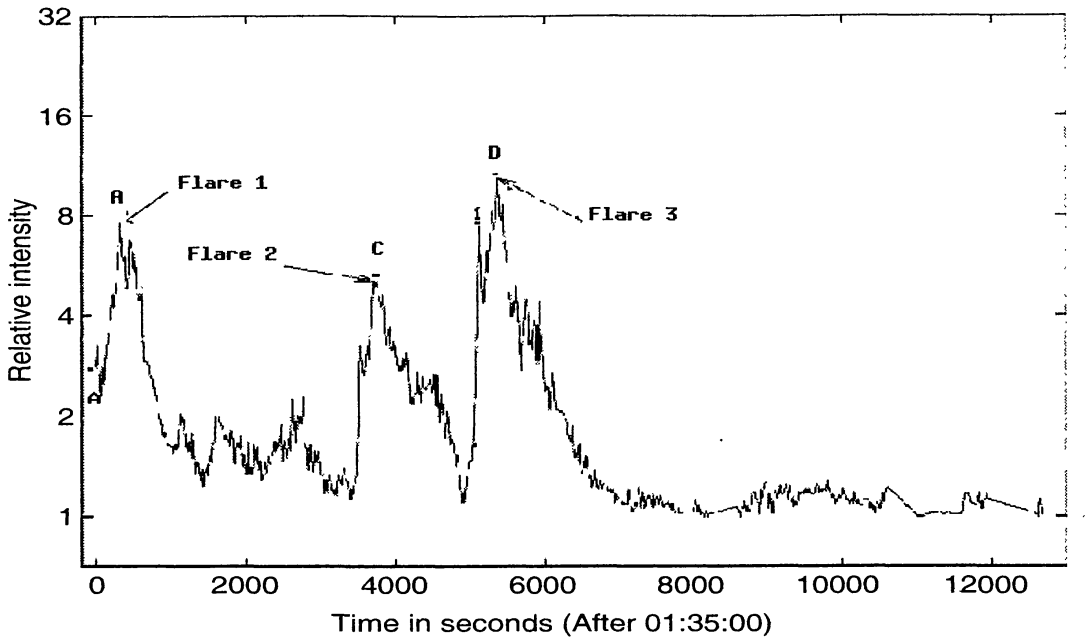

Figure 2. Plot of relative intensity versus time after 0135 UT of solar disk area

the analysis we have estimated maximum intensity of 41″×73″ of AR area which is a part of active region NOAA 9033 and also estimated maximum intensity of QR shown in Figure 1A. The Figure 1B Shows SOHO/MDI magnetogram images of NOAA 9033 at 01:36 UT and Figure 1C shows SOHO/MDI continuum images of NOAA 9033 at 01:36 UT. The Figure 1D Shows the quadrapolar reconnection scenario for the origin of homologous flares proposed by Machado et al. (1983). From Figure 1A and 1B it is clear that three solar flares occur in AR rectangular box area of Figure 1A and Figure 1B confirm that the flares occur in the area which is biploar or N-S polarity area, similar to as suggested by Machado et al. (1983). In the Figure 2 we have plotted relative intensity which is the ratio of maximum intensity of AR and maximum intensity of QR versus time. In Figure 2 the points A, B, C, and D are different moments of four hours observations during which the three solar flares were recorded and are shown in Figure 3. In table 1 we have shown the detailed parameters of the three solar flares.

Table 1. Details of three solar *Hα* flares observed on 12th June 2000 in AR NOAA 9033.

S.N.	Start in UT	Max. in UT	End in UT	Class of Flare
Flare 1	01:32	01:40	01:55	SF
Flare 2	02:36	02:39	02:53	SF
Flare 3	02:59	03:05	03:23	1N

We can see from Figures 3A1-3D1 that '<' shaped filament is present in AR and remains there, after the occurrence of 3 solar flares. It means that the filament did not play any role in the production of these solar flares. The subtracted images 3A2-3D2 from previous images

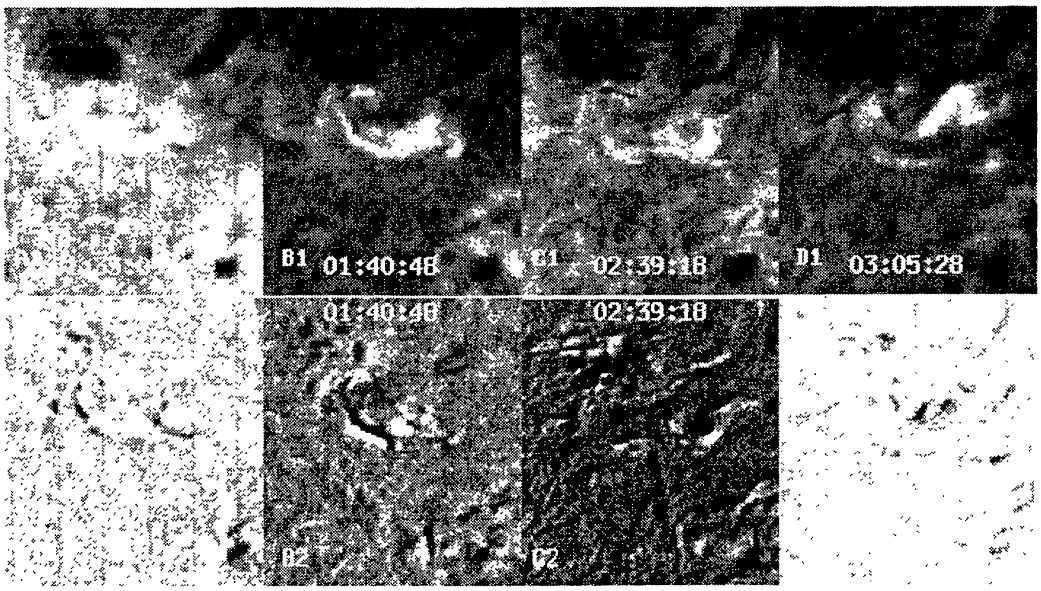

Figure 3. Shows the selected images at moments A,B,C and D which shows three homologous flares, occurred in solar disk area 41″ × 73″. The A2-D2 images are subtracted images of A1-D1 from previous images recorded during observations.

recorded during observations show that N-S polarity regions shown in Figure 1B show kernal like structures and may be clearly understood / explained by quadrapolar reconnection scenario described by Machado et al. (1983) and recently confirmed by Ranns et al. (2000).

To know the rate of occurrence of energy release processes in AR MOAA 9033 we have carried out power spectrum analysis of the relative intensity versus time (as shown in Figure 2) and the plot of normalized power and frequency is shown in Figure 5. To carry out the analysis we followed the methodlogy of Scargle (1982) and the program was downloded from http://star-www.rl.ac.uk/software/. From Figure 4 it is clear that periodicity of 26.7 min (±3 min) is present in the data of maximum intensity from solar disk area under consideration which produced the three solar flares. From the study we are of the view that 26.7 min is the period or time for the active region to store the magnetic energy which is released later in the form of solar flares as suggested by Machado et al. (1983).

3. Conclusions

In previous sections we have carried out study about the three solar flares. From the study we conclude followings:

(1) The present study of three homologous flares support quadrapolar reconnection scenario described by Machado et al. (1983) and Ranns et al. (2000).

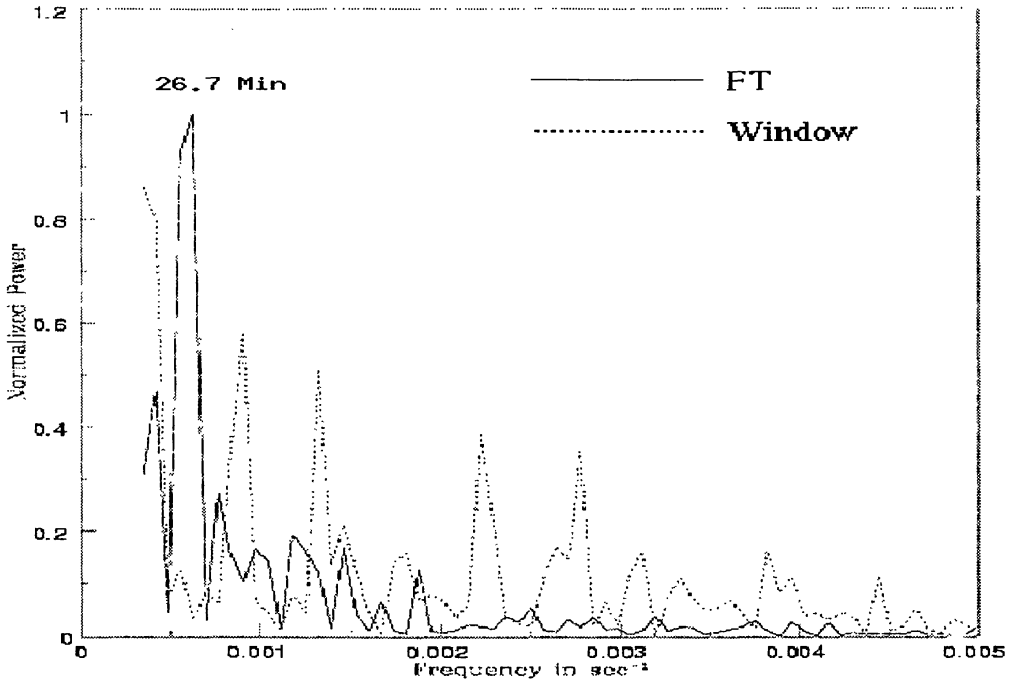

Figure 4. Plot of frequency of intensity of AR and normalized power.

(2) 26.7 min periodicity is present in the observed solar intensity data from solar disc area producing three homologues solar flares.

(3) The 26.7 min period may be the time for active region to store the magnetic energy which is released later in the form of solar flare.

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