SUPER ACTIVE REGIONS AND PRODUCTION OF MAJOR SOLAR FLARES

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The success of imaging detectors with small fields of view such as HXIS or P/OF (Pinhole/ Occulter Facility) depends heavily on pointing to the right place at the right time. During the solar maximum years many active regions coexist on the solar disk. Therefore, in order to point the imaging detector to the right place, it is important to know which active region is most likely to produce major flares. This knowledge is also important for flare prediction.

As a first step toward this goal, I have identified active regions which produced major flares observed by HXRBS (Hard X-Ray Burst Spectrometer) on SMM during February 1980 through December 1983. For this study I have used the HXRBS Event List (Dennis et al., 1983), an updated flare list compiled by the HXRBS group, and the Comprehensive Reports of the Solar Geophysical Data. During this period, HXRBS detected hard X rays from ~7000 solar flares, out of which only 441 flares produced X rays with peak count rates exceeding 1000 counts/s. I call flares with such high peak count rates major flares. During the same time period about 2100 active regions passed across the solar disk, out of which only 153 active regions were observed to produce major flares. (Some active regions are known to persist for several solar rotations, but at each passage new active region numbers are assigned and my estimate is based on active region numbers.) Out of these 153 active regions, 25 were observed to produce 5 or more major flares. Considering their high productivity of major flares, we may call these active regions "super active regions." These 25 super active regions produced 209 major flares, accounting for 51% of all the major flares with identified active regions.

In Table 1 I have listed number of active regions as a function of observed major flares. One finds that 82 active regions produced only one major flare each during SMM observation periods, and several active regions were found to produce more than 10 major flares. Because SMM is in the Earth's shadow ~50% of time, the actual rates should be regarded about double the rate in this table. In Table 2 super active regions are listed chronologically, with some pertinent information. Active region 18405 (NOAA region number 3763) produced the largest number (18) of major flares, making June 1982 the most active month in terms of major flare production. During the same month active region 18422 (NOAA region number 3776) produced 15 major flares, and it was still very active during its next passage across the disk (active region number 18474; NOAA region number 3804), producing 13 major flares. One could learn a great deal about solar flares by studying such super active regions in detail with use of magnetograms and optical observations. If we can find some common properties of the super active regions in Table 2, it would also help understand flare production.

TABLE 1. NUMBER OF MAJOR FLARES PER ACTIVE REGIONS

Number of Major Flares from Single Active Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Number of Active Regions	82	29	11	6	7	3	3	3	1	1	1	1	1	1	1	1	0	1

TABLE 2. CHARACTERISTICS OF SUPER ACTIVE REGIONS

ORDER	HALE (NOAA) REGION NUMBER	NO. OF MAJOR FLARES*	NORTH OR SOUTH	CMP DATE	CMP DAYS AFTER 00 UT 80.1.1	ROTATION	CARRINGTON LONGITUDE
1	16747 (2372)	8 (0)	N	80 APR 7.3	97.3	New	103
2	16923 (2522)	5 (0)	S	JUN 23.3	174.3	1,2; 16864	166
3	16978 (2562)	6 (1)	S	JUL 17.3	198.3	New	207
4	17244 (2776)	11 (3)	N	NOV 6.6	310.6	2nd: 17181	165
5	17255 (2779)	16 (2)	S	NOV 11.6	315.6	2nd; 17188	100
6	17491 (2958)	6 (2)	S	81 MAR 2.8	426.8	New at 17436 & 17438	74
7	17590 (3049)	7 (2)	N	APR 20.7	475.7	2nd; 17535	150
8	17751 (3221)	5 (1)	S	JUL 24.2	570.1	3rd; 17709 - 17667	340
9	17760 (3234)	9 (2)	S	JUL 28.3	574.3	2nd; 17713	290
10	17777 (3257)	7 (2)	S	AUG 10.0	587.0	1,2; 17737	118
11	17824 (3310)	5 (0)	S	SEP 4.9	612.9	2nd; 17777	133
12	17830 (3317)	10 (3)	N	SEP 10.6	618.6	New	59
13	17906 (3390)	12 (3)	S	OCT 14.3	652.3	New	334
14	17969 (3432)	5 (0)	S	NOV 4.9	673.9	New at 17890	50
15	18176 (3576)	5 (1)	S	82 FEB 1.4	762.4	New	323
16	18201 (3594)	5 (0)	S	FEB 10.7	771.7	2nd; 18142	202
17	18280 (3659)	8 (1)	N	MAR 29.0	818.0	New	309
18	18405 (3763)	18 (6)	S	JUN 8.5	889.5	New	85
19	18422 (3776)	14 (3)	N	JUN 18.8	899.8	New at 18382 & 18383	310
20	18430 (3781)	8 (1)	N	JUN 21.5	902.5	New	276
21	18474 (3804)	13 (4)	N	JUL 15.0	926.0	2nd; 18422	320
22	18473 (3814)	8 (0)	N	JUL 15.5	926.5	4,5; 18421	314
23	(3994)	7 (1)	S	NOV 20.0	1054.0		72
24	(4026)	5 (3)	S	DEC 16.9	1080.9	2nd; 3994	80
25	(4171)	6 (2)	S	83 MAY 13.0	1228.0		298

* Numbers in this column represent numbers of flares with HXRBS peak rates > 10,000 counts/s.

Inspecting Carrington longitudes of the super active regions in Table 2, one can find that the super active regions are clustered in the 60 to 120 degree and 300 to 360 degree intervals, and that no super active regions are found in the 0 to 30 degree and 210 to 270 degree intervals. It has been suggested that there exist active longitudes where the occurrence probability of active regions producing interplanetary protons is much higher than other areas (Svestka, 1970; for a review see Svestka, 1976). The present study confirms the existence of active longitudes. Recently Gaizauskas et al. (1983) have shown that many active regions frequently occur in "complexes of activity," which rotates near the Carrington rate. According to Svestka's (1970) study, there was only one sector of active longitudes during 1963 through 1967. However, in the present study we can find two sectors of active longitudes whose medians are separated by about 120 degrees. The existence of active longitudes may be due to giant convection cells (McIntosh and Wilson, 1985).

Because the Carrington rotation period is not *the* rotation period of the Sun, one can determine the mean rotation rate of the sectors of active longitudes by the following procedure: Adopt a system rotating rigidly at an assumed rate, count the number of major flares occurring in 20 degree longitude bins in this system, and calculate the rms flare numbers. Then by changing the rotation rate around the Carrington rate, find the rotation rate which maximizes the rms value. By this procedure I found that the rotation period 27.34 days (synodic) maximizes the rms value. The number of major flares in 20 degree longitude bins in the system rotating with the 27.34 day period is given in Table 3. Here I have adopted the Eastern limb at 00 UT on 1 January 1980 as 0 degree. We can see that a large number of major flares occurred in the 120 to 140 degree and 240 to 260 degree bins.

In the following I summarize the highlights of the present study which are pertinent to future P/OF observations of solar flares:

(1) All active regions are not created equal, but a small number of "super active regions" produce the majority of major flares. Therefore, it is very important to find out the properties of such super active regions. When we can recognize super active regions with the aid of such properties (yet to be found), we would have better chance of detecting major flares by pointing imaging detectors to such active regions.

(2) There exist sectors of active longitudes, where large fractions of major solar flares are produced. Active regions appearing in active longitudes are good candidates to point imaging detectors to.

TABLE 3. NUMBER OF MAJOR FLARES PER LONGITUDE BIN

Longitude Bin	0 20	20 40	40 60	60 80	80 100	100 120	120 140	140 160	160 180	180 200	200 220	220 240	240 260	260 280	280 300	300 320	320 340	340 360
Number of Flares	20	10	5	9	34	17	77	18	12	7	5	39	60	20	19	19	22	9

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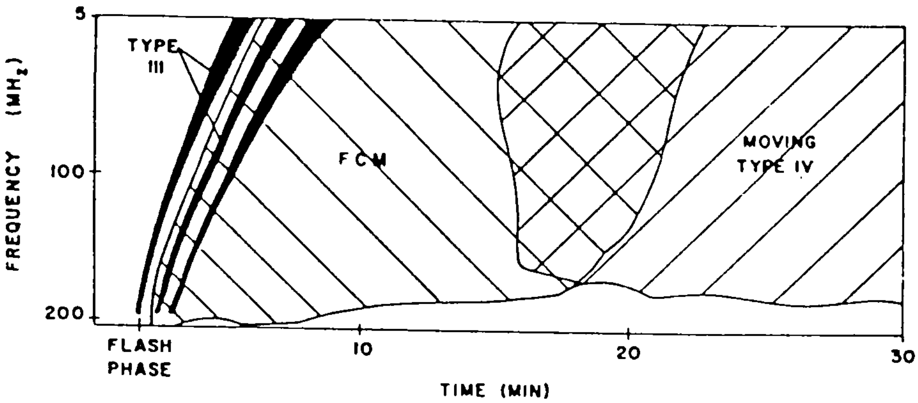
SOLAR RADIO PHYSICS



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