ON THE POSSIBILITY OF THE USE OF OBSERVATIONS OF SOLAR DECIMETRE RADIOEMISSION FLUCTUATIONS FOR THE FORECAST OF SOLAR PROTON FLARES

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ABSTRACT. The results of analysis of solar decimetre preflare radioemission fluctuations observed with 10-m telescope on frequencies 755 and 612 MHz during 1979-1984 for 30 events (19 of them proton events) are considered. The possibility of using the obtained results for the forecast of solar proton events is discussed.

О ВОЗМОЖНОСТИ ИСПОЛЬЗОВАНИЯ НАБЛЮДЕНИЙ ФЛУКТУАЦИЙ ДЕЦИМЕТРОВОГО РАДИОИЗЛУЧЕНИЯ СОЛНЦА ДЛЯ ПРОГНОЗИРОВАНИЯ СОЛНЕЧНЫХ ПРОТОННЫХ ВСПЫШЕК: Приведены результаты анализа наблюдений предвспышечных флуктуаций дециметрового радиоизлучения Солнца, проводившихся на 10-м радиотелескопе на частотах 755 и 612 МГц с 1979 по 1984 гг. для 30 событий (из них 19 протонных). Обсуждается возможность использования полученных результатов для прогнозирования протонных вспышек.

O MOŽNOSTI VYUŽITIA POZOROVANÍ FLUKTUÁCIÍ DECIMETROVÉHO RÁDIOVÉHO ŽIARENIA SLNKA PRE PROGNÓZOVANIE SLNEČNÝCH PROTÓNOVÝCH ERUPCIÍ: V práci sú uvedené výsledky analýzy pozorovaní prederupčných fluktuácií decimetrového rádiového žiarenia Slnka. Pozorovania pre 30 erupcií (z toho bolo 19 protónových) boli uskutočnené od r. 1979 do r. 1984 na 10-m rádiovom ďalekohľade na frekvenciách 755 a 612 MHz. Uvažovaná je možnosť prognózy výskytu protónových erupcií zo získaných pozorovaní.

Table 1

Analysed events 1979 - 1984. The proton importance "p" means that the flux of protons with energy E >10 MeV is concluded in the interval 10^p - 10^{p+1} part/ /cm^2.s.sr

Date	Maximum of sm-bursts (UT)	Flare position	Import. X-rays/opt	Proton import. p
03.06.79	09^h36	N14E41	- /2N	-
04.06.79	04^h09	N20E34	X1/2B	3
05.06.79	05^h33	N17E14	X2/2B	2
13.08.79	10^h28	S28E90	M2/1N	2
14.08.79	12^h48	S27E76	M3/1N	2
18.08.79	14^h13	S25E17 N08E90	X1/SN X6/SB	2
20.08.79	09^h24	N05E77	X5/2B	2
23.08.79	12^h51	N05E29	- /1B	2
04.06.80	08^h37	S16E59	M4/1N	1
06.06.80	11^h40	S13E31	- /SF	-
08.06.80	10^h33	no relation with H_α -flare noticed		
21.06.80	01^h29	N13W91	X2.6/1B	0
23.06.80	10^h56	S24E02	- /SF	-
29.06.80	10^h41	S27W90	M4/1F	-
05.07.80	07^h42	N25W25	- /SB	-1
	11^h14	N27W23	- /SN	-
16.07.80	15^h11	no relation with H_α -flare noticed		
17.07.80	06^h05	S11E06	M3.3/3N	2
13.08.80	12^h54	S28E45	M4/1B	-1
17.08.80	13^h10	no relation with H_α -flare noticed		
20.07.81	13^h29	S26W75	M5.4/1B	2
25.07.81		the source is unknown		1
03.08.81	11^h19	S04W71	- /1F	-
07.08.81	19^h16	S10E24	M4/2B	1
12.06.83	-	S09W90	- / -	1
25.06.83 01.07.83	11^h20 13^h34	no relation with H_α -flares noticed		
05.05.84	12^h07	-	M7.1/-	0
21.05.84	-	-	M5.7/-	0
24.05.84	10^h13	S08E07	- /SB	-
31.05.84	11^h40	-	M1.7/-	1

Observations of fluctuations of solar radioemission on frequencies 755, 612 and 326 MHz are carried out annually from May to September, beginning from 1979 on 10 meter radiotelescope at the Radioastrophysical Observatory of the Latvian Academy of Sciences. We chose 30 records on frequencies 755 and

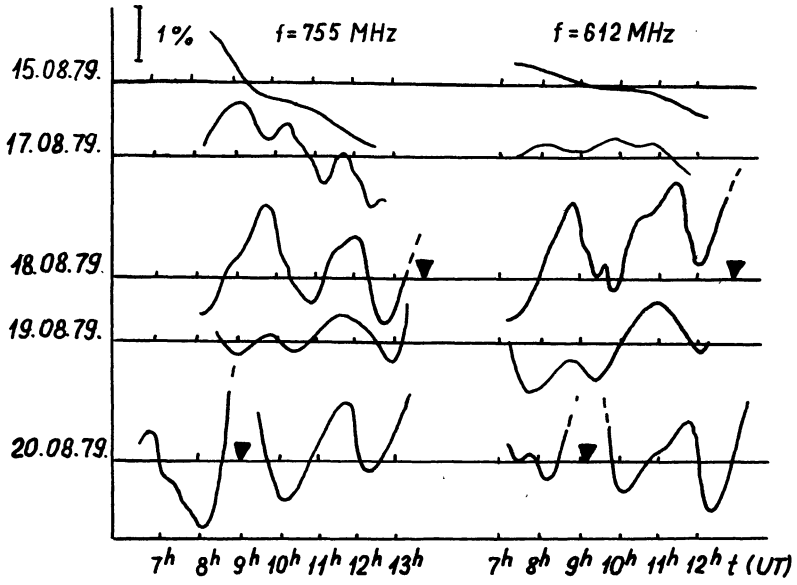

Fig. 1: Low frequency pulsations of solar radioemission on frequencies 755 and 612 MHz before proton flares of 18.08.79 in McM 16224 (X1/SB) and McM 16239 (X6/1B) and before the proton flare 20.08.79 in McM 16239 (X5/2B). The beginning of the radioburst is shown by the triangle

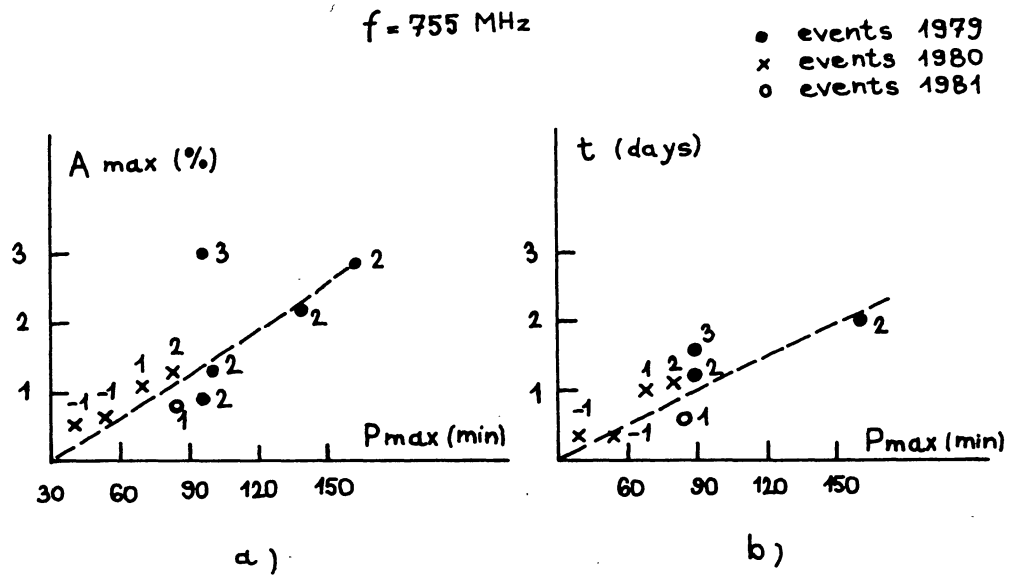

Fig. 2: The comparison of maximum obtainable amplitudes A_{max} and moments of appearance t of LFP with the periods P_{max} of pulsations for proton flares

612 MHz with radiobursts of various intensity and duration (from several minutes and more) for the analysis of preflare changes of fluctuations of decimetre radioemission. 19 of them are connected with proton flares. We considered weak proton events with the threshold level $J(E>10) \geq 0.1$ part/cm^2.s.sr (5 events) too. A list of events is given in Table 1.

1. LOW FREQUENCY PULSATIONS (LFP)

Let us begin with the LFP as the very first precursor of the flares. LFP with periods from 40 to 160 minutes and amplitudes from 0.5 to 3% of the level of quiet Sun /1,2/ (Fig. 1) are observed in time from several hours to 3 days before 14 from 19 proton events. Periods and amplitudes of LFP are not constant and changes within the day at most occurances. The comparison of maximally obtainable amplitudes and periods just as moments of appearing pilsations tions with proton flux at the Earth's orbit and the optical magnitude of the flare /3,4,5,6/ indicated that before flares with $J(E>10$ MeV$) \geq 10^2$ part/ cm^2.s.sr LFP appeared there with $A \geq 1\%$ and $P > 80$ min within the time from one to several days, but before flares with $J(E>10$ MeV$) < 10^2$ part/cm^2.s.sr LFP appeared there with $A < 1\%$ and $P \leq 80$ min within the time from several hours to one day (Fig. 2). No connection with the optical magnitude was obtained.

For 5 proton events no LFP with $P > 40$ min are ascertained on June 5, 1979; August 13, 1980; May 21, 1984 and May 31, 1984. There are no observations during 19 hrs before the flare for the first event on June 5, 1979. For the next three events $J(E>10) < 7$ part/cm^2.s.sr, but the flare on May 31, 1984 ($Jp \approx 15$ part/cm^2.s.sr) occured beyond the limb abd there are no bursts on our frequencies.

Before non-proton events no LFP with $P > 40$ minutes are ascertained.

LFP with $P < 40$ minutes are observed before proton as well as non-proton flares (15 events). They appeared from 40 to 90 minutes before the flare on the growing phase before the radioburst. The number of such pulsations varies from 1 to 3. It is just possible that these pulsations are responses of a new outgoing magnetic flux before the flare, which, as it is known, may be accompanied by a chain of fast changing LFP with characteristic duration of about 30 minutes /7/.

2. PREFLARE SHORT-PERIOD FLUCTUATIONS

During analysis of short-period fluctuations ($P < 20$ min) of decimetre radioemission we separated the observed preflare changes according to /8/ on evolutional and true (precursors) ones.

Evolutional changes of short-period fluctuations

After eliminating of all trends LFP and other non-stationary effects, it

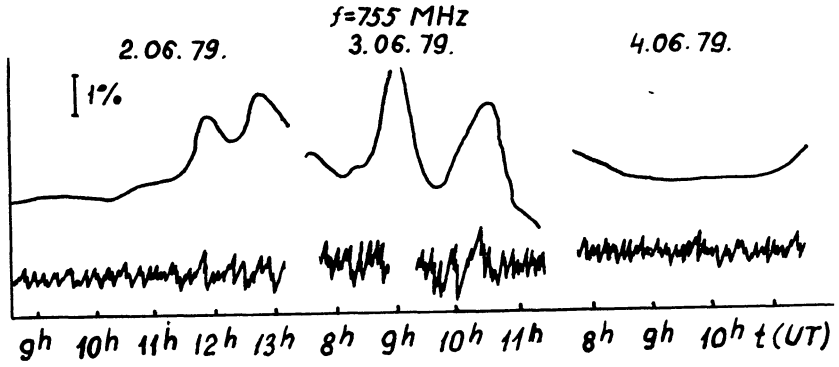

Fig. 3: Low frequency pulsations and short-period fluctuations (5 min P 20 min) of solar radioemission on 755 MHz before the proton flare 4.06.79 (X1/2B) in AR 1781 at 4^h09 UT.

is obvious that for the time from one hour and more before the radioburst (for proton as well as non-proton flares) the amplitudes of preflare fluctuations with periods from 5 to 20 minutes are exceeding the amplitudes of fluctuations of quiet Sun by 2 to 4 times. Gradual as well as abrupt increasing of amplitudes of fluctuations are observed /9/. After an isolated during the time radioburst the value of amplitude, as a rule diminished to the level of quiet Sun.

In some there is a connection between the appearing of LFP and the increasing of amplitudes of short period fluctuations (Fig. 3).

Precursors

During one hour before almost all the analysed radiobursts such or other precursors are presented (Fig. 4).

Main characteristics of them are as follows:

1/ on the phase of growing intensivity of decimetre radioemission in the time from 10 to 20 minutes before the radioburst pikes with duration of 1 to 3 minutes occured, frequently with amplitudes 1 to 3% of the level of qiet Sun on the given frequency and sequency interval from 3 to 7 minutes (Fig. 4a);

2/ on the LFP, observed before some of the radiobursts, appeared packets of 1 to 3 minutes pikes with duration from 2 to 10 minutes and amplitudes from 1 to 5%. There is an example of such precursors in Fig. 4b. It is interesting to mention that before the radioburst the duration of pulsations diminishes, but the amplitude of the pikes as well as the length of the packets increases;

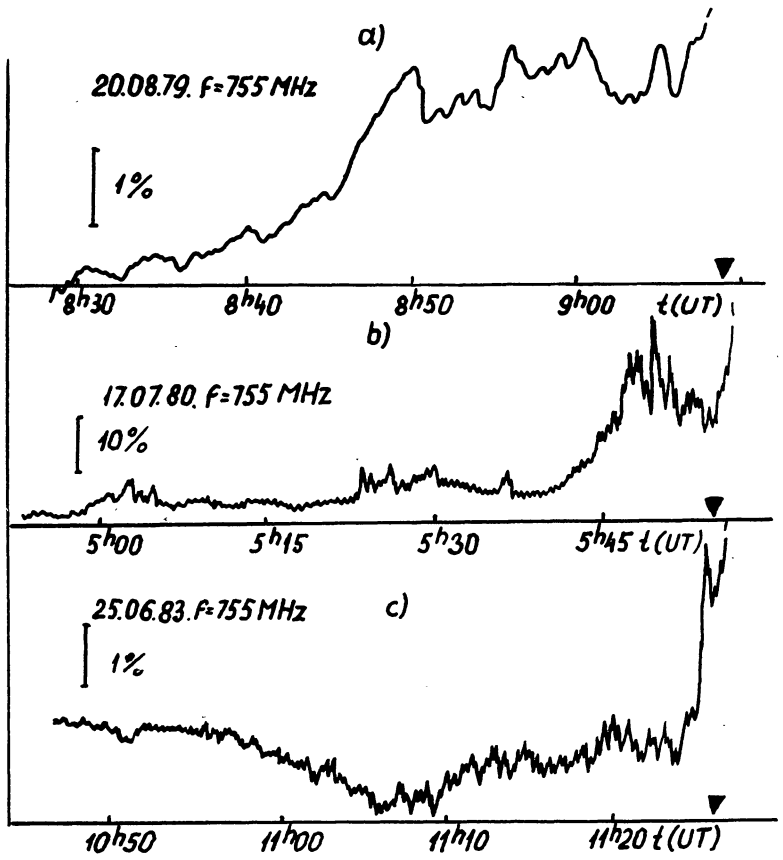

Fig. 4: Precursors obtained in fluctuations of solar radioemission on 755 MHz:
a/ before the flare of 20.08.79 (X5/2B) in McM 16239;
b/ before the flare of 17.07.80 (M3/1B) in AR 2562;
c/ before the burst of 25.06.83. The beginning of the radioburst is shown by the triangle.

3/ during the time 10 to 30 minutes before the radioburst some increase in amplitudes of fluctuations with $P < 1$ min is noted. At that, such an increase of amplitudes is occuring simultaneously with decrease in mean level of radioemission before the radioburst at 1-4% (with so called "depression effect" /7/) (Fig. 4c).

Combinations of various types of precursors are observed frequently. But, certainly, not all precursors follow mentioned lay-out.

There is no clear, obvious connection between the value of amplitudes of short-period fluctuations and their periods at evolutional changes as well as of various characteristics of precursors (duration, amplitudes, number of pi-

kes, packets of pikes, etc.) with the parameters of the flare in H_α rays, X-rays, proton flux and characteristics of radiobursts on explored frequencies. Obviously, it is determined by insufficient quantity of analysed events.

3. DISCUSSION

The preliminary analysis shows that only distinction between proton and non-proton events in the presence of LFP with periods more than 40 minutes in preflare solar decimetre radioemission. Using of this fact and also the obtained connection between the parameters of LFP and the flux of protons (see Fig. 2) for quantitative forecast it seems to be impossible at present because:

1/ there are no continuous observations for most events and therefore we have no data of moments of appearance of LFP and do not know the rule of change of the LFP's parameters with the time. Up to now it is not clear, for example, whether they are continuous processes or abrupt packet processes. From 14 proton events, before which LFP are observed, only before 8 of them this connection appeared directly before the beginning of the flare. For all the rest 6 events we had no observations directly before the flare, therefore we used data of LFP of the preceeding day;

2/ the analysis was carried out using integral solar observations and therefore our observations of LFP are not exactly related to determined active regions and so we have the connection between LFP and the flare only with some probability;

3/ the statistics of powerfull non-proton flare which is necessary for comparison is insufficient.

The appearance of LFP with $P > 40$ min in fluctuations of solar decimetre radioemission may be used only as a qualitative criterion for forecasting proton flares at this time.

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