NEUTRON INCREASE AT LOMNICKÝ ŠTÍT (JUNE 3, 1982) AND CHARACTER OF SOURCE FLARE

L. Křivský, M. Karlický
Astronomical Institute, Czechoslovak Academy of Sciences,
251 65 Ondřejov, Czechoslovakia

K. Kudela
Institute of Experimental Physics, Slovak Academy of Sciences,
040 01 Košice, Czechoslovakia

ABSTRACT. The source flare with neutrons and its activity region was studied.

ДЕТЕКТИРОВАНИЕ НЕЙТРОНОВ 3 ИЮНЯ 82 Г. НА ЛОМНИЦКОМ ПИКЕ И СВОЙСТВА ОБЛАСТИ ВСПЫШЕЧНОГО ИСТОЧНИКА. Был изучен вспышечный источник солнечных нейтронов.

DETEKCE NEUTRONŮ NA LOMNICKÉM ŠTÍTU (3.VI.1982) A CHARAKTER ERUPČNÍHO ZDROJE. Je studována zdrojová erupce s neutrony a její aktivní oblast.

As early as in 1951 (Biermann et al.) it was assumed that some flares are sources of high-energy protons and neutrons which signal accelerating proceses with energies of 10^8-10^9 eV, i.e. one order higher than necessary to generate gamma line emissions. The effect of the increase can only be recorded by ground based neutron monitors, designed for recording cosmic rays, in exceptional cases when their flux is extraordinarily large (Kudela et al. 1984).

During the mighty outburst of the gamma emission and neutrons on the SMM probe (Chupp et al. 1985), a 2.9 % increase, guaranteed statistically, was recorded by the supermonitor at Lomnický Štít ($20^{\circ}15'$E, $49^{\circ}12'$N; 747 g cm^{-2} of atmosphere), Fig.1. The effect was also recorded at other stations and there can be no doubt that it was real. The effect of flare neutron increase occurred between 11 45 and 11 50 UT. The main peak of radio emissions indicate that an explosive flare event had occurred at about 11 42 - 11 47 UT, i.e. roughly 8 minutes earlier on the Sun (correction for the speed of light) at 11 34.5 - 11 39 UT. The mean time of the explosion (and of the main acceleration), about 11 37 UT, is indicated on the Fig.1 by the bold arrow.

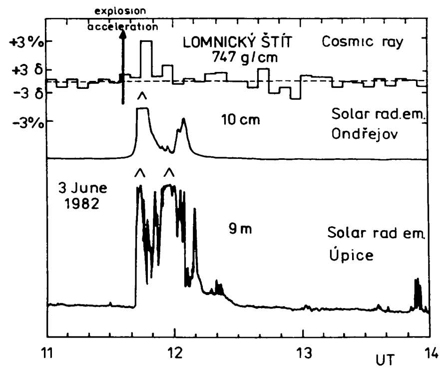

Fig. 1 : Lomnický Štít neutron monitor counts at five-minute intervals (June 3, 1982); the scale gives the range of ± 3 % and the statistical errors. Next curves: the radio emission of the flare on 10 cm (3 GHz), Ondřejov, and on 9 m (32.8 MHz) from Úpice; in the same minute, the starting process hit also the higher corona levels.

The flare of June 3,1982 occurred in a complex region Hale No 18405, in the position S 08°, E 72°. The Hα observations show the 2B flare that started at 11 42 UT, had its maximum at 11 45 and ended at 13 26. The Hα flare at 11 59 with well developed bright flare channel and light upwards prolonged flare loops was published by Křivský and Karlický (1985).

The γ-flash of this flare was observed by the SMM satellite at 11 43 25. The arrival of the most energetic neutrons (1187-790 MeV) was observed at 11 44 21.8 (Debrunner et al. 1983). About detection of protons, electrons and positrons from this flare after 11 40 on the Helios 1 (0.57 AU) see Kirsch et al. (1985).

The radio spectrum of this flare was published by Křivský and Karlický (1985). The radio flare started at 11 42.3 by a group of the type U-bursts in the band of 160-380 MHz. Then at 11 43 - 11 43.6 the broadband ($\Delta f > 160$-1000 MHz) impulsive burst followed. The impulsive character of this burst can be seen from very rapid formation of the type II burst at 11 44, in the band of 160-480 MHz. Furthermore the rapid positive frequency drift of this burst at 11 43.1 - 11 43.2 and 11 43.7 - 11 43.8 on the band of 640-1000 MHz is also probably connected with impulsive character of this flare. The following part of radio spectrum consist of many types of fine structure: narrowband dm-spikes at 11 46.1 - 11 46.5 in the band of 640-720 MHz, fiber bursts at 11 45.5 - 11 46.3 in the 860-1000 MHz band and the broadband pulsation (with period of 0.3 s) at 12 04 - 12 06 in the 480-800 MHz band.

All types of observations show that this flare is unusually fast process. The best evidence of this fact is the shortness of interval (35 s) between the impulsive phase and the beginning of the type II bursts. A typical interval for these phenomena is 5 min.

We assume that the flare is triggered in the loop configuration. By using the theory of type U burst (Wild et al. 1963) we can estimate the height of this flare loop and the electron density at the top of this flare loop as h = 90000 km and $n_e = 1.1 \times 10^{15}$ m^{-3}, respectively. In this flare loop the particles are accelerated, flare process propagates up and down along the loop, and the explosion of the loop leads to the generation of shock wave (type II radio burst). The high-frequency burst with positive frequency drift at 11 43.1 - 11 43.8 is interpreted as dissipation-spreading process propagating towards the ›topshere, to the place of the observed white-light emission. In such model the minimum frequency of type II burst and the maximum frequency of the ` positive drift) we can estimate the electron density in the region ›celeration as $n_e = 4.4 \times 10^{15}$ m^{-3}.
the fiber bursts (Kuipers 1975) we can determine the magnetic bottom parts of flare as $B = 12 \times 10^{-4}$ T.
stimated shock wave velocity, in the height of 10^5 km above the pho-, is $v_s = 1740$ km s^{-1}. Beacause the magnetic field decreases with, we assume that the magnetic field in the space of shock wave generation wer then 12×10^{-4} T. Thus we can estimate the magnetic Mach number of our ck as $M_A \geqslant 2.9$.

The output of flare energy in the course of days of development of an active region can be characterized, in the first approximation, by the trends in the summation curves of some flare parameters (Křivský 1969). More extensive data of these graphs has shown that certain flare trends, lasting several days, are related to some of the properties of the active region or to photospheric events in its neighbourhood.

The method of summation curves of the product of flare parameters I x t (I is the flare importance determined according to the old classification and t the duration of the flare) was used to process the active region S 10°, CMP June 8, 1982 (No. NOAA/USAF 3763, Hale 18405) in which the flare with neutrons was located on June 3, 1982, together with the proton flare of June 6, 1982, 16 37 UT. The summation curve constructed from all observed flares (SGD, Boulder) is shown in Fig.2. Three trends can be distinguished on the curve: I - the very steep trend from June 2 to June 11, reduced to 24 hrs F = 623; II - a relatively less steep trend, from 11 to June 13, F for 24 hrs amounts to 136; and III - again steeper, from June 13 to June 15, F reduced to 24 hrs amounts to 508. Figure 2 shows also the daily values of the sunspot areas S_A (in units of millionths of the solar hemisphere), and the number of sunspots S_n in this region (Solnechnye Dannye). The onset and duration of the slightly more gradual flare trend II is related to a distinct decrease in area S_A and number S_n on June 11 and 12. The revival of flare activity (trend III) is connected with the slight increase in the sunspot number S_n on June 13. The areas and sunspot numbers after June 13 are by the limb very inaccurate.

Throughout its passage over the disk the group was of type F and magnetic type δ or $\beta\gamma$ predominated (June 4-11); type δ in particular is evidence of the large accumulation of magnetic energy in relatively small spaces (June 5-10). The decrease in area and sunspot number, inclusive of the change to bipolar magnetic type β (June 12-13), created a physical situation in the area of the active region which was less favourable for the generation of plasma instabilities, i.e. flares of mighty importances (see the more gradual trend II on the summation curve).

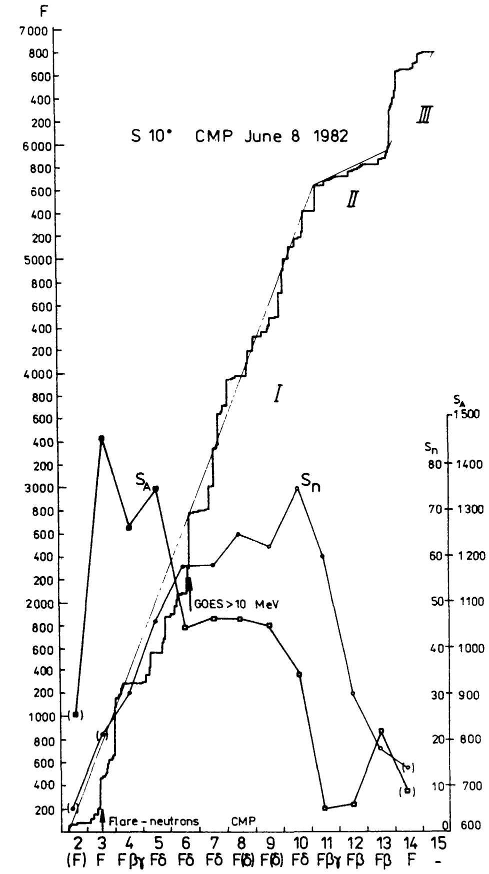

Fig. 2

REFERENCES

Biermann, L. et al.: 1951, Z.Naturforsch. 6a, 47.

Chupp, E.L. et al.: 1985, 19th Int.Cos.Ray Conf. (USA), SH-4, SH 1.4-1, 126.

Debrunner, H. et al.: 1983, Proc. 18th Int.Cos.Ray Conf. (India), 4, 75.

Kirsch, E. et al.: 1985, 19th Int.Cos.Ray Conf. (USA), SH-4, SH 1.4-10, 158.

Křivský, L., Karlický, M.: 1986, Sol.Max.An. Workshop Proc. (Irkutsk 1985), VNU Sci.Press Utrecht.

Kudela, K., Slivka, M., Stehlík, M., Janků, V.: 1984, Preprint. Inst.Exp.Phys. Slovak Ac.Sci., Košice.

Kuipers, J.: 1975, Sol.Phys. 44, 173.

Wild, J.P. et al.: 1963, Ann.Rev.Astron.Astrophys. 1, 291.

See comment on the page 152.