

ON THE QUESTION OF LONG LASTING MICROWAVE EMISSION FAR FROM THE SOLAR LIMB

V.M. Bogod<sup>1</sup>, A.N. Korzhavin<sup>1</sup>, Sh.B. Akhmedov<sup>2</sup>,  
J. Hildebrandt<sup>3</sup>, A. Krüger<sup>3</sup>

<sup>1</sup>Acad. Sci. USSR, Special Astrophysical Observatory,  
196 140 Leningrad, USSR

<sup>2</sup>Acad. Sci. USSR, Main (Pulkovo) Astronomical Observatory,  
196 140 Leningrad, USSR

<sup>3</sup>AdW. d. DDR, Zentralinstitut für Astrophysik,  
DDR-1500 Potsdam, Telegrafenberg, GDR

**ABSTRACT:** Referring to the recently described phenomenon of long lasting mm-wave sources high in the solar corona, we considered the possibility of detecting a related emission by RATAN-600 observations in the short cm-wave range. Starting from a summary of the main properties of the coronal mm-emission, the specific facilities of single-dish and RATAN-observations were noted. The consideration of a particular behind-limb event on September 22, 1980 reported by Urpo et al. (1986) shows a related emission at 2 - 4 cm and 4.4 cm wavelength by the RATAN 600 and the large Pulkovo radiotelescopes, respectively. Phenomenologically, this event has the character of a prolonged gradual burst emission.

К ВОПРОСУ О ДОЛГО-ЖИВУЩЕЙ МИКРОВОЛНОВОЙ ЭМИССИИ ДАЛЕКО ЗА ЛИМБОМ СОЛНЦА:  
Обращая внимание на недавно описанное явление долго-живущих миллиметровых источников на больших высотах в солнечной короне, мы рассмотрели возможность обнаружения их эмиссии на коротких сантиметровых волнах на РАТАНе-600. Исходя из основных характеристик источников мм-диапазона, были выяснены специфические особенности их наблюдений на отдельных зеркалах и на РАТАНе-600. Рассмотрение одного конкретного залимбового явления из 22-ого сентября 1980г. (опубликованного Урпом, 1986) показывает заметное излучение в диапазоне 2 - 4 см по записям на РАТАНе-600 и также на 4.4 см на больших Пулковских радиотелескопах. Это явление имеет характер длительной эмиссии похожей на всплески большой длительности.

K OTÁZKE DLHOTRVAJÚCEJ MIKROVLNNEJ EMISIE ĎALEKO OD OKRAJA SLNEČNÉHO DISKU: Vychádzajúc z nedávno opísaného dlhotrvajúceho zdroja v milimetrovej oblasti, ktorý sa nachádzal vysoko v slnečnej koróne, bola uvažovaná možnosť zaregistrovania odpovedajúcej emisie RATAN-om 600 v oblasti krátkych cm vln. Vychádzajúc zo základných charakteristík koronálnej mm-emisie, boli diskutované špecifické požiadavky na ich pozorovanie na jednotlivých zrkadlách a na RATAN-e 600. Analýza javu z 22. septembra 1980, ktorý sa nachádzal za okrajom slnečného disku a ktorý popísal Urpo (1986) viedla k identifikácii zreteľného žiarenia v oblasti 2 - 4 cm podľa pozorovania na RATAN-e a taktiež na vlne 4,4 cm na veľkých Pulkovských rádioteleskopoch. Tento jav má charakter dlhotrvajúcej emisie a ponáša sa na dlhotrvajúce rádiové záblesky s postupným vzrastom intenzity.

Observations of solar off-limb sources at mm-waves were reported by Urpo et al. (1986). The present contribution presents a brief discussion of that phenomenon under the view point of its recognition facilities by RATAN-600 observations. According to Urpo et al. some main features are as Follows:

- (1) The detectable source heights range between about  $5 \cdot 10^4$  and  $10^5$  km above the photosphere which are significantly different from those of the S-component and of the quiet Sun originating at heights of no more than a few thousand km.
- (2) mm-off-limb sources are rather rare (25 cases have been selected from more than 1500 solar maps obtained during five years).
- (3) Most off-limb sources appear to be related to near-limb flares and X-ray/microwave bursts starting some hours earlier and last therefore essentially longer than the main phase of the burst events.
- (4) Optically thick bremsstrahlung with an average temperature of the order  $10^4$  K appears consistent with the observed mm-radiation.
- (5) There is indicated an association with H alpha loop systems displayed by ground based coronagraph observations (cf. Urpo et al. (1983)).
- (6) A minor contribution of optically thin bremsstrahlung to the mm-emission is more difficult to detect but is anticipated from hot post-flare plasmas which can be also observed as long enduring events (LDEs) in soft X-rays. Recently Moiseev and Nesterov (1984, 1985) succeeded to discover such mm-radiation at a height of  $3 \cdot 10^5$  km (cf. also Urpo et al., 1985).

In comparison to the mm-observations which were achieved with parabolic antennas with diameters  $\leq 22$  m, the RATAN observations have the advantage of

- better angular resolution,
- simultaneous information at different wavelengths,
- including polarization measurements.

On the other hand, restrictions at RATAN observations in the present case result from

- the limitation of the observing time by transit observations,
- obtaining of only one-dimensional brightness distributions,

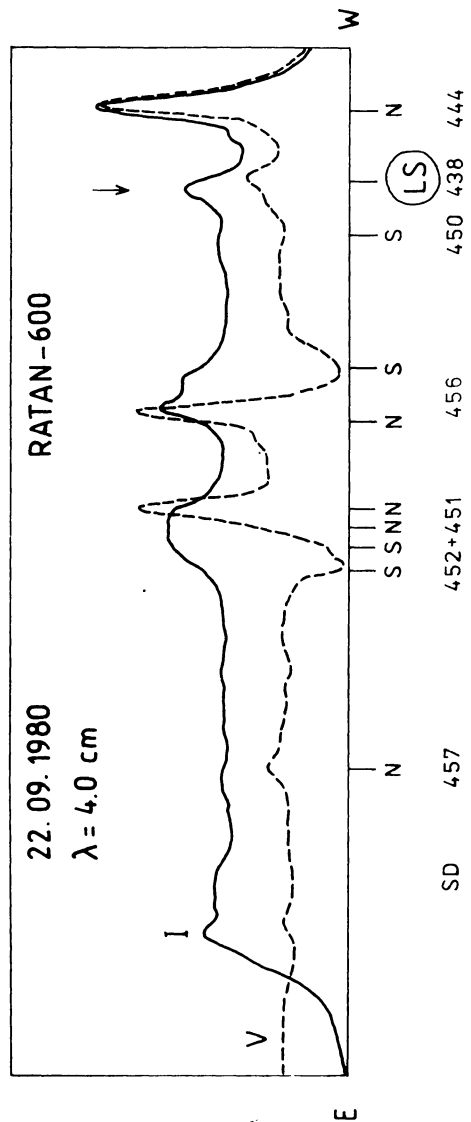


Fig. 1 RATAN-observation exhibiting the off-limb source (LS) at 7.5 GHz

- observations at longer wavelengths than mm- $\lambda$  (optically thick bremsstrahlung decreases as  $\lambda^{-2}$ )

A first checkong of the off-limb sources by Urpo et al. (1986) shows than the coverage with the RATAN observations is rather poor. Nevertheless, for a preliminary discussion observations of the event on September 22, 1980 are available.

According to Urpo (1985) this source was located at N15, W 90 and measured between 07 32 and 07 58 UT at 37 GHz ( $\lambda = 8.1$  mm). About 90 min later the source was recorded by RATAN 600 in the frequency range 15 - 7.5 GHz ( $\lambda = 2 - 4$  cm). At the RATAN records, because of the angle between the measuring profile and the solar equator, the off-limb source does not appear at the very edge, but more in the midth of the solar brightness pattern (cf. Figure 1). With high probability, the source belongs to a behind-limb event in AR SD 438 which disappeared just two days earlier at the west limb. Therefore, a lower limit of the source height of about 30 000 km above the photosphere can be assumed. There is a nctable contribution of right-handed circular polarization in the whole frequency range (15 - 7.5 GHz) which, contrary to the mm-emission, favours gyromagnetic radiation as the responsible emission mechanism at cm-waves. A small local shift between the maxima of the RATAN- I and V records may indicate a loop-like source structure.

The source is also detectable at the observations of the large Pulkovo radia telescope at 4.4 cm wavelength on the same day, but, of source, it is totally missing on the preceding and the following days (Solnechnye Dannye 1980, 2). Weak microwave burst activity (GRF) was also reported by the stations Toyokawa at about 05 45 UT (Solar Geophysical Data, 1981), Crimea at 06 52 UT, and Gorky at 07 37 UT, and terminating at about 09 11 UT.

Phenomenologically the event appears as some kind of gradual burst radiation (GRF or PBI?). However, in contrast with the usual appearance at the whole-Sun flux density records, the duration on the events observed with more spatial resolution appears much longer. Concerning the source dimension a lateral loop extension of at least 1 arc min can be expected from the displacement of the peaks of the I and V records by RATAN 600. A more refined analysis of this and other events is recommended in order to get representative informations of solar off-limb microwave sources.

#### REFERENCES

- Solar Geophysical Data, NOAA Boulder, No. 439, Part II, 1981.  
Solnechnye Dannye, Leningrad, 1980, No.2.  
Urpo, S.: 1985, private communication.  
Urpo, S., Krüger, A., Hildebrandt, J.: 1986, Astronomy and Astrophysics, submitted.