INVESTIGATION OF THE SPECTRUM OF GRADUAL (PBI) MICROWAVE BURST EMISSION FROM RATAN-600 OBSERVATIONS

A. Krüger[1], V.M. Bogod[2], Sh.B. Akhmedov[3]

[1]AdW der DDR, Zentralinstitut fur Astrophysik,
DDR-1500 Potsdam, Telegrafenberg, GDR

[2]Acad. Sci. USSR, Special Astrophysical Observatory,
SU-196140 Leningrad, USSR

[3]Acad. Sci. USSR, Main (Pulkovo) Astronomical Observatory,
SU-196140 Leningrad, USSR

ABSTRACT. Usually the exploration of the physical nature of solar gradual microwave bursts is hindered by the lack of spatially resolved observations and spectral information. On April 11, 1980 at RATAN-600 a gradual burst (PBI) was observed at 2.0, 2.3, 2.7, 3.2, and 4.0 cm wavelength. This event was analysed in comparison with single-frequency total-flux observations. The capacity of the informations about the source size and the spectrum of the Stokes parameters I and V was checked in order to get conclusions on the emission process and the structure of the source region.

ИССЛЕДОВАНИЕ СПЕКТРА МИКРОВОЛНОВЕГО ВСПЛЕСКА ПОСЛЕ ВСПЫШЕЧНОГО ГРАДУАЛЬНОГО ИЗЛУЧЕНИЯ, ПО НАБЛЮДЕНИЯМ НА РАТАН-600: Обычно изучение физической природы солнечных микроволновых всплесков бывает затруднено недостаточным пространственным разрешением и отсутсвием данных о спектре. 11-ого апреля 1980 г. на РАТАН-600 был зарегистрован микроволновой всплеск градуальной фазы вспышки на длинах волн 2.0, 2.3, 2.7, 3.2 и 4.0 см. Это событие было рассмотрено с учетом наблюдений временных профилей полного потока Солнца на отдельных частотах. Данные этих наблюдений (размер источника, его спектр и параметры Стокса) были проанализированы с целью получить информации о механизме генерации излучения и структуре источника.

ŠTÚDIUM SPEKTRA MIKROVLNNÉHO ZÁBLESKU GRADUÁLNEHO POERUPČNÉHO ŽIARENIA, POZOROVANÉHO NA RATANE 600. Vo všeobecnosti, štúdium fyzikálnej podstaty slnečných mikrovlnných zábleskov býva sťažené nedostatočným priestorovým rozlí-

šením merania a chýbajúcimi údajmi o spektre javu. 11. apríla 1980 na RATANe-600 bol zaregistrovaný mikrovlnný záblesk graduálnej fázy erupcie na vlnových dĺžkach 2,0; 2,3; 2,7; 3,2; a 4,0 cm. Tento jav bol analyzovaný vzhľadom na pozorovania celkového toku zo Slnka pre jednotlivé frekvencie. Údaje z týchto pozorovaní (rozmer zdroja, jeho spektrum a Stokesove parametre) boli analyzované z hľadiska získania informácií o mechanizme generovania rádiovej emisie a štruktúre zdroja.

1. INTRODUCTION

It is generally accepted that the impulsive and gradual phases observed, e.g., in X-ray bursts are manifestations of two basic processes of solar flares (de Jager, 1983). These phases are also displayed in microwaves where custromarily the term "gradual burst" comprises the types "gradual rise and fall" (GRF), "preburst increase" (or precursor) (PRE), and "post-burst increase" (PBI) (Wild et al., 1963). Time profilles of total-flux observations lead to the impression of a similar nature of all these types, but already Kundu (1959) pointed upon possible differences in source sizes and brightness temperatures between GRFs and PBIs. Unfortunately, up to the present no sufficient material is gathered in the literature to gain a satisfactory picture of the totality of gradual flare processes.

Recently Kosugi et al. (1983) published an interesting interferometric study of bursts at 17 GHz where also source characteristics of PBIs were included. But there remains still a lack of sufficient spectral information together with adequate spatial resolution. In this respect the observations of the great radio telescope RATAN-600 could help to provide new information, although, due to the transit-type observations of this instrument, the burst observations are only obtained by chance and missing time resolution. Taking into account these cirsumstances, the present communication presents some preliminary information on a PBI observed on April 11, 1980.

2. OBSERVATIONS

The available material consists of original records of RATAN-600 at 2.0, 2.3, 2.7, 3.2, and 4.0 cm wavelength (15, 13, 11, 9.3, and 7.5 GHz, respectively) on three consecutive days and of total-flux records of the observatory for solar radio astronomy (OSRA) at Tremsdorf near Potsdam at 3.2, 10, 15, and 20 cm wavelength (9.5, 3, 2, 1.5 GHz, respectively) for the burst event starting on April 11, 1980 at 09.02,5 UT.

Observations of RATAN on April 11, 1980 are shown in Figure 1. The hatched area indicates the burst flux as compared with the observations on April 10 (and 12), 1980. The time of the RATAN observations was about 09.16 UT in each case. For comparison, the total-flux time profile recorded at OSRA at 9.5 GHz (and 1.5 GHz) is shown in Figure 2.

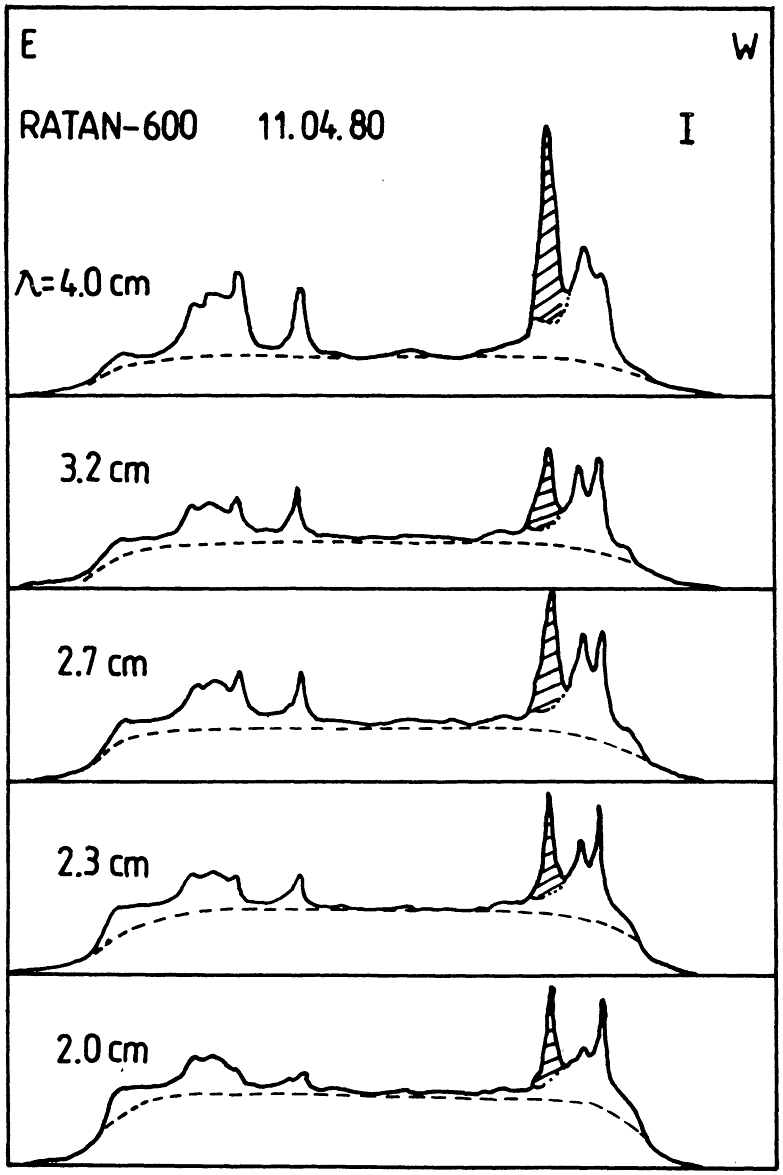

Fig. 1: RATAN observation of the Sun on April 11, 1980 at 09.16 UT. The hatched areas refer to PBI-emission.

The observed spectra of the burst flux and the degree of polarization are shown in Figure 3. Full and broken lines refer to flux differences with respect to the day before and to the average of the days before and after the burst, respectively.

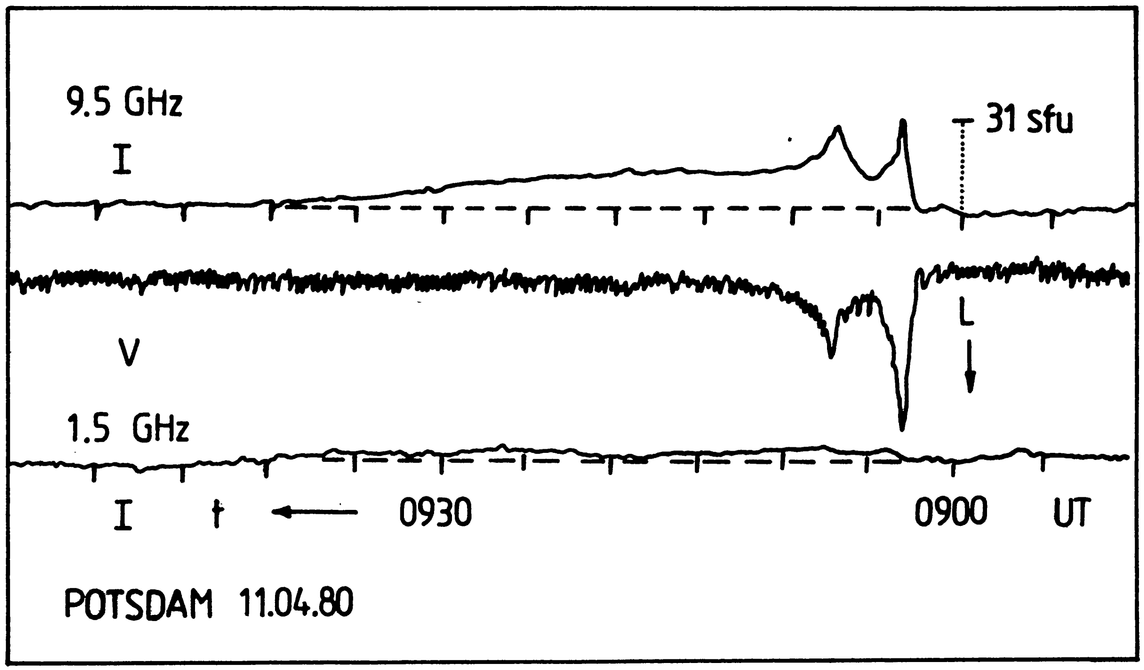

Fig. 2: Time profiles of total-flux observations at 9.5 GHz (Stokes parameters I and V) and 1.5 GHz on April 11, 1980.

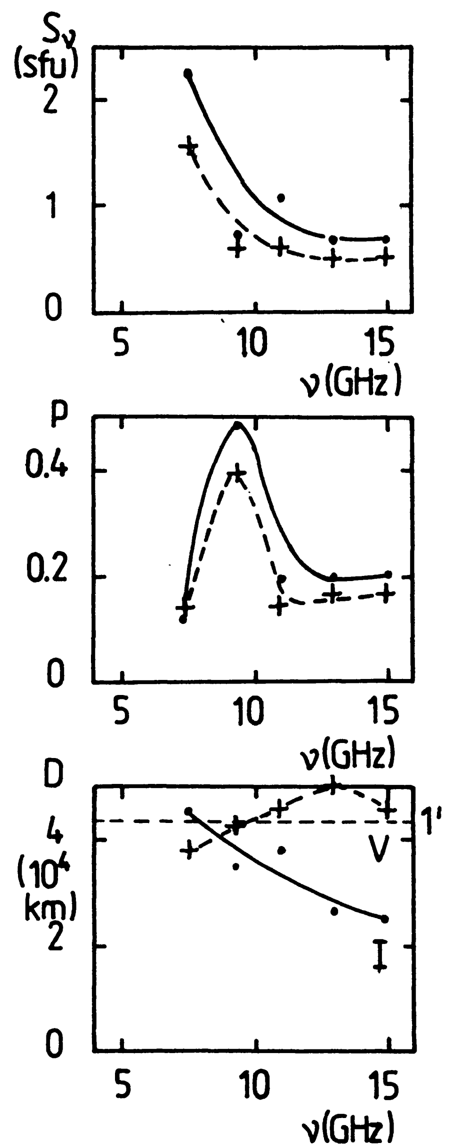

Fig. 3: Spectra of flux density (top) and the degree of polarization (middle) and the variation of source sizes (bottom) referring to the PBI on April 11, 1980 deduced from RATAN-600 observations. (cf. text).

3. DISCUSSION

From the observations the following features can be concluded:

- Apart from the amplitude, the burst flux spectrum has a similar shape as that of the S-component source of the same region on the adjacent days.
- Also the sense of polarization (L) is the same for both, the S-component and the burst source.
- Both, the S-component and burst observations indicate an inhomogeneous (bipolar) source structure which, however, for the burst source cannot be properly resolved (the burst radiation exhibits higher fluxes and smaller sourcece sizes than the S-component source) (cf. below).
- The burst source diameters are roughly of the order of one arc minute (cf. Figure 3).
- The different characteristics of the source diameters for the Stokes parameters I and V imply a loop-like burst source structure where shorter wavelengths are emitted at locations nearer to the loop feet.
- The sizes of the related S-component sources on the adjacent days behave according a cosine law of their central meridian distances.
- The S-component radiation of the considered region on the day after the event is considerably larger than that of the day before.

The above characteristics indicate the presence of an at least partial contribution of gyromagnetic (g-r) radiation to the PBI-emission from a bipolar loop-like source region. More quantitative diagnostics would require special model calculations (similar as carried out for the S-component above sunspots, cf. Kruger et al., 1983). The measured discrepancy between the source diameters in I and V can be only explained if an inhomogeneous source structure with different contributions of g-r and bremsstrahlung is assumed: For shorter wavelengths the g-r- emission (the g-r-levels sinking down) appears increasingly concentrated near the (projected) loop foot points which is apparent not the case for bremsstrahlung- The investigation of more cases is highly desired in order to get a broader experimental basis for more conclusions.

REFERENCES

de Jager, C.: 1983, Solar Physics 86, 21.
Kosugi, T., Kai, K., Suzuki, T.: 1983, Solar Physics 87, 373.
Kruger, A., Hildebrandt, J., Furstenberg, F.: 1985, Astron. Astrophys. 143, 72.
Kundu, M.R.: 1959, Ann. Astrophys. 22.1.
Wild, J.P., Smerd, S.F., Weiss, A.A.: 1963, Ann. Rev. Astron. Astrophys. 1, 291.