Solar radiobursts observations at 29.9 MHz in Stara Zagora: First data, results and analysis

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Abstract. This paper presents the first series of solar radio bursts observations at f=29.9 MHz during the time period April 2009 – March 2011 in Stara Zagora, Bulgaria, as well as their analysis and intepretation. The main interest is focused on the observations in February 15, 2011, one of the most active days during the upward phase of the solar cycle No 24.

Key words: Sun, solar radiobursts, solar flares, CME

Наблюдения на слънчеви радиоизбухвания на 29.9 MHz в Стара Загора: Първи данни, резултати и анализи

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Тази статия представя първите наблюдения на слънчеви радиоизбухвания на честота f=29.9 MHz, проведени през периода април 2009 – март 2011 година в Стара Загора, както и техните анализ и интерпретация. Интересът е фокусиран главно върху наблюденията на 15 февруари 2011 година – един от най-активните дни по време на възходящата фаза на слънчевия цикъл No 24.

1 Introduction

The solar radiobursts are generally caused by different non-stationary processes in the Sun's atmosphere and near-solar interplanetary space. Five types of radiobursts (I-V), corresponding to different solar plasma events are considered. The so called "Type II" radiobursts occur usually in the low MHz range ($f \leq 200$ MHz). Their typical duration is in the range of few minutes. They are very often associated with CME's events and plasma shock waves (Lobzin et al., 2010). About 25% of these events are related to the X-ray solar flares (see f.e.Duchlev, 2006). That's why the solar bursts in the range of decametric radiowaves are an object of interests for the better understanding of the non-stationary events in the solar corona and solar wind.

There are different types of observations of MHz-radiobursts. A list of radiobursts data for fixed frequences is published and systematically updated on the STP-server of the National Geophysical Data Center (USA). On other hand there are also observations with radiospectrometers. In these cases the study of frequency evolution of radiobursts in time is possible and the corresponding changes of plasma conditions in the zones of these events may be examined (Melnik et al., 2004; Lobzin et al., 2010).

The associations between the solar MHz Type II radiobursts from one side, and solar flares and CME's from the other one (including interplanetary CME's too), could play a role of prompt indicator for active processes in the near-Sun and interplanetary space. Thus it could be useful not only for the better physical understanding of the coronal and solar wind phenomena, but also for different monitoring functions in the field of medicine or technical infrastructure security. This has been a motivation for us to begin some first steps (tests) of solar radiobursts observations at fixed frequency f=29.9 MHz.

2 Instruments, observations and data

For our tests in the range 1 – 30 MHz a bulgarian military radio-set (model "P-32", builded in 1974) is used. A fixed frequency f=29.89 MHz has been chosen(Fig.1). The range near 30 MHz is noted as interesting for radioobservations of the Sun by Melnik et al. (2004) in aspect of type II radiobursts. On the other hand there are regular observations in the range 29-33 MHz since 1972 in Upice Observatory (Czhech republic).

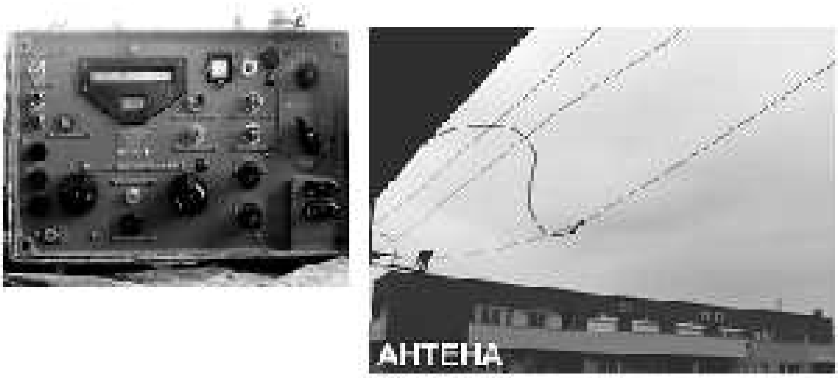

Fig. 1. Left: the radio-set "P-32"; right: the antenna

The antenna is of "opened dipole" type and length of 5 meters. The connection between the antenna and radio-set is a co-axial by resistance of 50 W + matching device. The audio signal is in the range 0.8 to 1 V and it enters into a separating transformer (made in Hungary) for galvanic separation of the radio signal. An intermediate device (detector) is used for a signal transformation and the final device is a PC-computer with build-in sound card.

The first observation has been provided in April 10, 2009. There are 342 observation sessions, covering 76 days during the whole period up to April 30, 2011. During the almost all of this period the Sun was totally quiet and very small number of radio disturbances has been detected. Only few of them could be associated with weak X-ray flares of class B or CME's. There are also some radio events for which no solar analogues has been established. In the largest part of our observations no any potential solar radio events has been detected except some, which are caused by natural terrestrial factors like relative far thunderstorms (40-50 km) or by well known nearby industrial sources.

That's why the most of these observations has been used for technical tests and improvements. It concerns not only the problems of detection, but the registration too. During the 2009 and the earlier part of 2010 the last one has been provided by using of shareware version of the Sky Pipe I software. Our observations are saved as Windows Bitmap files. For their digitizing with low time resolution a half automatic low effective software procedure has been used.

After that, in the middle of 2010 the observations has been registered and saved as ASCII files through a digital multimeter VA-188. However, during this time the Sun has remained predominantly quiet and no any interesting events has been detected.

Finally we have bought the Sky Pipe II software, which could be used for different types of data saving, including ASCII and WAV files, for visualizing of radiospectrometer data etc.

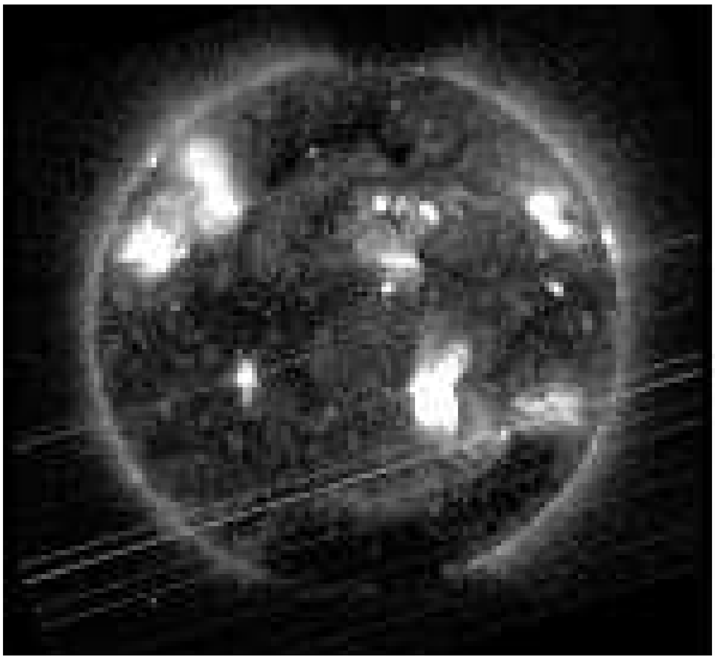

Fig. 2. A x-ray image of the Sun in February 15, 2011, by GOES-15 satellite

3 February 15, 2011: An active day on the Sun

February 2011 is one of the most active periods of the Sun during the upward phase of present Zurich sunspot cycle No 24 (SC24). The date February 15 is interesting with the first x-ray flare of the most powerful X-class (X2.2). It has been started at UT 01 h 44 min, reach the maximum at 01 h 56 min and ended at 02h 06 min. There are also other 7 flares of the weaker C-class on this date. Two of them had occurred at 10 h 02 min – 10h 16 min (C1.0) and UT 14 h 32 min – 14 h 51 min (C4.8) respectively, i.e. during the daytime in Bulgaria. The C 4.8 flare, which started at UT 04 h 27 min and ended at 04 h 37 min is interesting for us too. A x-ray image of the Sun, obtained by GOES-15 satellite imager at UT 15 h 17 min is shown on Fig.2.

The radio-set has been turned on at EET 07 h 34 min (UT 05 h 34 min). The observation has been stopped at EET 17 h 40 min (UT 15 h 40 min), i.e. very close to the sunset moment on this date. The time step between adjacent data points is 0.109 sec The variation of radio flux level in relative sound card units are plotted on Fig.3.

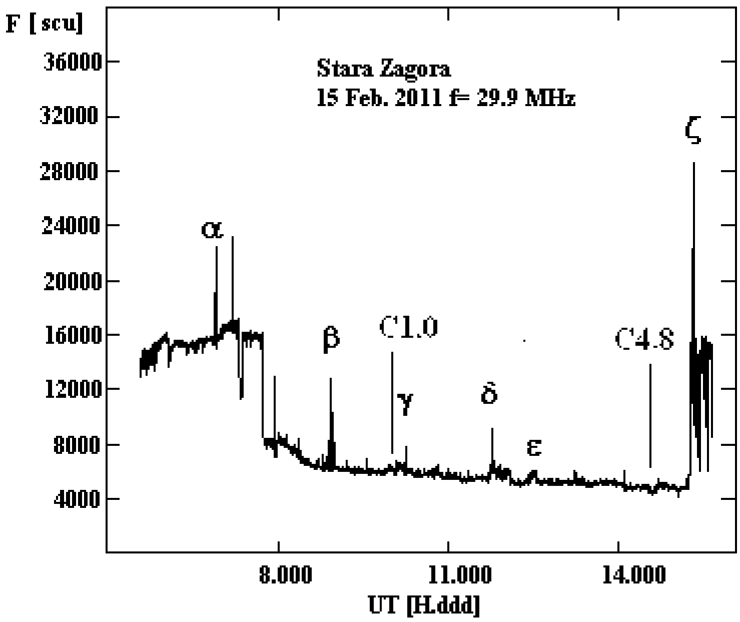

Fig. 3. The measured radioflux at f=29.9 MHz on February 15, 2011, in relative sound card units [scu]. The moments of C-class flares, as well as the probable radiobursts are also shown

As it is shown, during the first two hours of observation the radioflux is generally high. There is a very slight and flat increasing tendency, which reaches its maximum in UT 07 h 15 min. It is followed by fast decrease lasting 7-8 minutes between UT 07 h 18 min and 07 h 25 min and restoring after that. A very sharp fall starts at UT 07 h 45 min and the corresponding decrease is about of 50%. A new, much more slower decrease started at 08 h 09 min and ended at 08 h 45 min. After that a period of a relative low level signal begins, which continued until 15 h 12 min. In 15 h 12 min an eruptive increase of the signal occurs again, which strong maximum is at 15 h 18 min. The radio flux increased 6 times. The event ended at 15 h 25 min, but the conditions remains unsettled until the stop of observation. There are also an additional and well separated minimum at 15 h 36 min.

By our opinion there are totally 6 events during the whole periods of observation in February 15, 2011, which could be considered as potential candidates for Type II radiobursts. They are labeled on Fig.3 by symbols α ,β ,....ζ. The arguments for this one are the frequency of detection (29.9 MHz), as well as their typical duration (few minutes, never more than 10). The maximal phases of these events are as it follows: 07 h 14 min (α), 08 h 55 min (β), 10 h 12 min (γ), 11 h 45 min (δ), 12 h 31 min (ε) and the already mentioned peak at 15 h 18 min (ζ). The last one, as well as the event at 08 h 55 min, are interesting because of their well expressed structure. It is possible to associate the weak peak at 10 h 22 min with the relative weak C1.0 flare between 10 h 02 min – 10 h 16 min, while the radio-peak at 15 h 18 min may be associated with the C4.8 flare at 14 h 32 min – 14 h 51 min, respectively. The delaying of radio event in order of 10 to 30 minutes in the both cases could be explained by different zones of generation of flare and radioburst. If we assume that the main zone of the optical flares is the chromosphere, and for MHz-radiobursts it is the outer corona, a time delay of 10 to 30-40 minutes is appropriate if the velocity of the plasma disturbance through the solar atmosphere is in the range of 300-1000 km/s.

There are also some single high values like this one at 06 h 55 min, which most probably should be considered as "false signals".

As it is shown on the series of LASCO-C3 images on the board of SOHO satellite (Fig.4), there is a halo-type CME approximately between UT 03 h and 9 h in February 15, 2011. It has been visually fading after 08h. On the other hand the starting moment of visibility (03 h) precedes the C4.8 flare at least for 1 hour 30 minutes. Obviously, the last circumstance excludes the possibility that the halo-type CME is caused by this flare. It is much more probable that the primary source is the X2.2 flare, which occurs about 2 hours earlier. It is interesting that the period of the best appearance of CME and their fading well coincide with the period of relative high radio flux during the first three hours of our observation and their fast fading after 08 h 15 min. One of the possible explanations of this coincidence could be that the source of this increased MHz radioflux is the shock wave of CME, which is generated by its motion through the "quiet" solar wind.

4 Conclusions

The analysis of our first test radio observations of the Sun at f =29.9 MHz points out that their use as an indicator of the active processes in the corona is perspective indeed. As a next task we consider the accumulation of a large number of observations during an active period like that in the mid February, 2011. The reaching of this aim needs more regular observations and their corresponding organization. Observations on other frequencies, including also the use of a radiospectrometer for better and clearer physical understanding of the phenomena, should be the next step of developing this field of our activity.

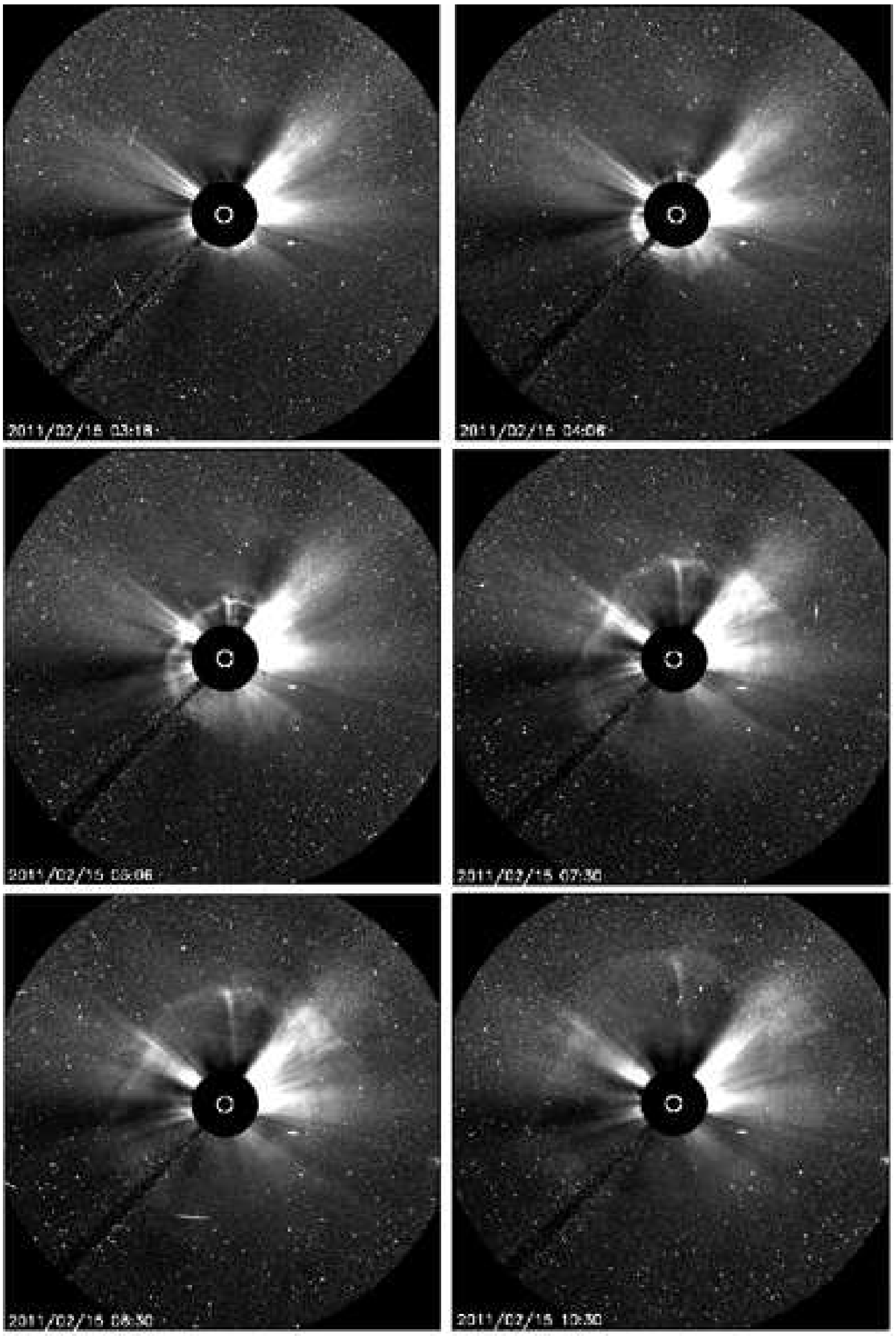

Fig. 4. LASCO-C3 images of a halo-type CME evolution on February 15, 2011. The first image (top-left) is at 03 h 06 min, while the last one (bottom-right) is at UT 10 h 30 min

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