35 GHz OBSERVATIONS OF SOLAR FLARES

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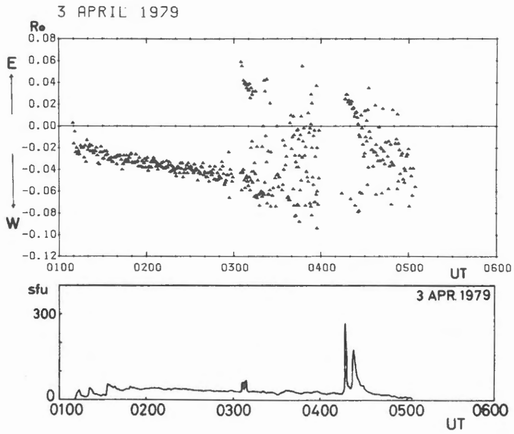
1. Introduction

Observations of the sun at 35 GHz have been carried out by using the sixteen element east-west fanbeam interferometer since May 1976 and 189 distinctive bursts have been observed until July 1980. 88 of these bursts were great or impulsive bursts and 99 were GRF. Some observational results on these bursts and the quiet sun brightness have been already published elsewhere(Kawabata et al 1978,1980a,1980b). In this paper we describe some recent results of observations.

The longest baseline of the interferometer is 5849.1 wavelengths (50.1m). The east-west HPBW and the beam intervals in the meridian are 29" and 8'49" respectively. HPBW of the primary beam is 69'. The whole solar disk are scanned by drift scanning for example in each 35 sec in the meridian observations and in each 70 sec in off-meridian observations at the hour angle of 4 hours. Under ideal conditions, the accuracy of positional determination of radio sources is $\pm$10" in absolute measurements and $\pm$3" in relative measurements.

2. Motion of Radio Sources

On 3 April 1979, an Hα flare occurred at 0105 in the precding part of McMath Region 15918 at S25 W14. The flare produced GRF at 35 GHz started at 0110(Fig.1). Apparent motion of the radio source seen in Fig. 1 from 0110 through 0300 is due to the solar rotation. The radio source is composed of a core with angular size less than 30" and an extended source with angular size 100". McMath Region 15918 produced also Hα flares at 0246 and 0417 respectively and these flare were accompanied by impulsive bursts started at 0306 and 0417 respectively. The position of the brightest point at the beginning of these bursts were in the following part of the active region and moved toward the preceding part. The velocity of the motion is 30 Km/sec.



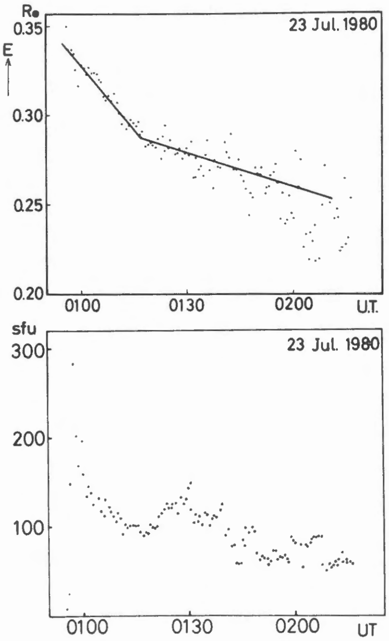


Fig. 1. The fanbeam distance of the source from the disk center(upper) and the time history of flux densities (lower) on the 3 April 1979 flare.

Fig. 2. The same as Fig. 1 but on the 23 July 1980 flare.

The similar motion of a radio source can be seen more clearly in Fig. 2. In this example, the change of the fanbeam distance after 0145 is mainly due to the rotation of the fanbeams relative to the sun by the earth rotation. The change of the fanbeam distances before 0120 indicates the motion of the source. The velocity of the motion is also 30 Km/sec.

When a solar flare occurs near the limb, rising motion of the source is also observed. An example of observations has been published in Kawabata et al(1980b). The velocity of the rising motion is 20-70 Km/sec. The horizontal and rising motion occurs in a declining phase of impulsive or great burst and in an early phase of post-burst increase. Radio sources appear to be stationary in GRF and in the late phase of post-burst increases.

3. X-ray Fe Lines and 35 GHz Emission

X-ray lines of highly ionized iron of 28 May 1980 flare have been

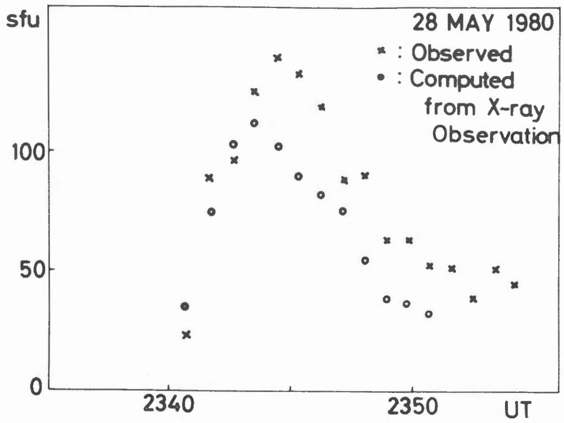


Fig. 3. Flux densities at 35 GHz of the flare on 28 May 1980.

measured by Brag spectrometer on board Tansei-4 by Tanaka, Watanabe, and Nishi. The time history of the flux densities at 35 GHz is compared with the f-f-emission computed from emission measure and temperature deduced from Fe XXV and XXVI lines by Tanaka et al. The general characteristics of the time variation of the observed flux densities is in good agreement with computed ones, though the observed ones are a little bit higher than the computed ones.

The position of the brightest point of the source has been determined two dimensionally from the change of the fanbeam distance from the disk center as a function of position angle under the assumption that the source is stationary. The determination gives the results that the brightest point locates inside the rectangle of the off-band Hα photograph(Fig. 4(b)). If we assume that the radio source is composed of 3 or 4 sources with Gaussian brightness distribution, 70% of 35 GHz emissions is emitted from a small

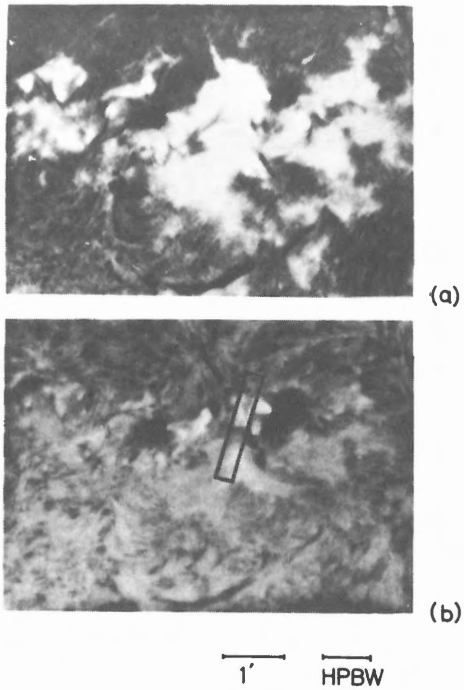


Fig. 4. (a): Hα phtograph of the flare on 28 May 1980 exposed at 2341.49. (b): 0.5 A off-band Hα photograph of the flare exposed at 2359.21. The brightest point of the radio source located inside the rectangle. Photographs are taken at Mt. Norikura by Prof. Moriyama.

source with a size less than 25"(0.5 x HPBW) and the remainings are emitted from extended sources with a size of 70-80" at the two big sunspots. The time variation of the total flux densities is mainly due to the time variation of the small source. These observations indicate that the X-ray line emissions are emitted from the small main source.

If we assume that the source size is 25", X-ray observations yield the electron temperature of 1.3×10^7K, the electron density of $1.5 \times 10^{11} cm^{-3}$, the optical depth at 35 GHz due to ff-absorption of 0.05 and the brightness temperature at 35 GHz of 6×10^5K at the time of maximum. In this case, the optical depth due to the thermal gyro-resonance absorption is smaller than the ff-absorption, in so far as the magnetic field strength in the source is less than 2500 Gauss. the radio burst on 28 May 1980 is a typical example of frequent radio bursts at 35 GHz. The observation suggests that some of radio bursts at mm wave have a thermal origin.

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