Burst interconnections of local sources of solar cm-wave radio emission

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The problem of the origin of sympathetic flares are studied in a broad range of solar emission,in particular using H_α, radio, and X-ray emission. First observation of simultaneous brightenings at 3-4 widely separated spots on the Sun in H_α emission was performed by Richardson (1936). Similar events in solar radio emission at 21 cm wavelength were observed by Mullaly (1961).The observations of the sympathetic bursts of solar local sources were carried out with the radio interferometer in Fleurs (Australia),in Culgoora as well as with VLA, and Nobeyama interferometer. Recently the sympathetic flares are investigated in X-ray emission (Hanaoka, 1996).

The observations of the local solar sources were carried out with the radio telescope RATAN-600 by the "relay" method at wavelengths 2.3 cm and 4.5 cm. Successive radio scans of the Sun were obtained every 14 min during 2–4 hours.The spatial resolution of the radio telescope operating in this mode at the 0.5 power level was $1' \times 17'$ at 2.3 cm and $2' \times 27'$ at 4.5 cm. The scans were processed to reveal the fine phenomena like synchronous enhancements of relative radio fluxes of local solar sources (LSs) separated by a distance up to $L > 10^5$ km. The observations were carried out on 9, 10 February 1980 and 17, 24, 29 July 1981. About 30 synchronous variations of relative radio fluxes of local solar sources were detected. The synchronous enhancements were observed both inside the one group at distance < 10 degrees and in LSs which were identified with the bipolar groups remoted up to $L > 10^5$ km. Such synchronous enhancements were recorded very often. They were observed practically in 100% of bursts of various types, like 3s, 5s, 8s, 28PRF, 31ABS, 45s, 20GRF, 21GRF, 30PBI according to the Solar service data at the frequencies of 17000, 15400, 11800, 9400, 9100, 8800, 4995, and 1000 MHz (Golubchina, 1999). These frequencies fit well to the frequencies of RATAN-600. As a rule, synchronous brightenings of LSs are observed during the enhancement of soft X-ray emission. The enhancement of the relative fluxes of LSs at the moments of the synchronous brightenings is 0.1–12.3 % with absolute errors 0.1–1.1 %. The absolute errors are given here as percentages since the relative fluxes were determined as percentages. The variations of absolute fluxes of LSs correspond to a few or a few tens of percentages. The lower bound of velocity of disturbing agent is about $(2 - 12) \times 10^3$ km/s.

A linear correlation between radiation of a number of LSs was found on the base of the observations on 17 July and 29 July, 1981. It was performed not only at the moments of synchronous enhancements but mainly during the four-hour time interval of observation as well. The linear correlation obtained is quite high, with the correlation coefficient $r = 0.64 - 0.96$. The large-scale component of dynamics of the LSs radiation was revealed after the application of the procedure of linear smoothing by a moving average through 3 and 5 points (or 28 and 56 min integration). It means that this correlation is due to the solar flare/burst activity (Golubchina, 1995).

There were many assumptions concerning the mechanisms of sympathetic flares and radio bursts. "Some deep phenomena occurring at widely separated points on the Sun" (Richardson, 1936), corpuscular fluxes, shock waves and Moreton waves (Moreton, 1961), high-energy electrons moving along magnetic lines connecting regions of the original and the secondary phenomena with velocity $v = 10^5$ km/s (Tang and Moore, 1982; Nakajima et al., 1985) are among them. The observations of Moreton waves (400 km/s), corpuscular fluxes ($v = 1000 - 2500$ km/s) triggering the sympathetic flares and the observations of sympathetic bursts at distance of $10^5 - 10^6$ km from the primary burst with a time delay of $2 - 25$ s confirm the reality of triggers noted above.

The cases of observation of synchronous enhancements in 5 LSs synchronous brightenings during the very weak and fast bursts of various types (3s, 5s, 8s), and existence of large-scale component of burst dynamics of LSs according to RATAN-600 observations (Golubchina, 1995; Golubchina, 1999) suggested strongly the action of the common source of the disturbance located below the solar photosphere. Such idea was proposed more than two decades ago by Fritzova-Svestkova et al. (1976).

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