Evolution of active regions in microwave emission at the stage of their initiation

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An active region comes into existence after the emergence of a new magnetic flux into the photosphere within or in the immediate vicinity of the old field (Bappu, Grigorijev and Stepanov 1968). It is known that the evolution of active regions is accompanied by various structural changes whose duration can be as long as several minutes. These are such phenomena as the appearance and development of pores, their merging together to form sunspots, a change in magnetic field strength at the photospheric level, as well as a stepwise increase in the flux of circularly polarized radio emission. The nonmonotonic character of an increase in the flux of circularly polarized radio emission at the stage of sunspot development was pointed out for the first time by Gelfreikh and Nefedyev (1975).

This paper presents a detailed study of the birth and development of more than 20 active regions, which traversed the solar disk in 1997, using radio maps obtained at the SSRT (5.7 GHz) and at the Nobeyama radio heliograph (17 GHz). The SSRT sensitivity in the mode of two-dimensional mapping make sit possible to observe with confidence relatively weak features on the solar disk with the 0.1 sfu flux. The spatial resolution was as high as 21 arcsec, with time intervals of 2–3 min. The active regions under investigation include 23 cases of a stepwise increase in the flux with a mean duration of 19 min and with a mean increase in the flux by 0.32 sfu.

It was found that in some cases a stepwise increase in the active region flux preceded or was accompanied by the appearance of the intermediate source between two main sources. An increase in radio brightness in the region between sunspots may be caused by the appearance of energy release regions as a result of the interaction of the tops emerging from beneath the photosphere to the corona of magnetic field arches of pores and sunspots.

Data from the Baikal astrophysical observatory were used in the analysis of the active region evolution at the photospheric and lower-chromospheric level. The proper motion of sunspots was estimated. It was established that a stepwise increase in the radio emissiuon flux of active regions is accompanied by the moving apart of the leading and following sunspots, which is an indication of the emergence of the magnetic field to the corona.

A model of the active region evolution accompanied by a stepwise increase in the radio flux is discussed. The appearance of a source at the magnetic loop top corresponds to the stage of a fast increase in microwave emission. The decay of this source is accompanied by a gradual increase in the flux, size and brightness temperature of sources located in the immediate vicinity of sunspots. At this stage, the integral flux of the active region remained almost unchanged. On the whole, the phenomenon of a stepwise increase in the flux signals the evolutionary transition of the active region from one quasi-stationary state to another.

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References

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