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Radio Observations of Filaments at the SSRT

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Abstract

2-dimensional images produced by the Siberian Solar Radio Telescope are presented. Particular attention is paid to radio filaments. Brightness temperatures, sizes, and locations of low-contrast features are considered.

Key words: Sun: radio emission — Sun: filaments — Radio telescope — filament: bright strips

Two-dimensional solar images from the Siberian Solar Radio Telescope (SSRT, 5.7 GHz) frequently show stretched features of relatively low contrast. Those regions have both increased and decreased brightness with respect to the quiet Sun. Their location and size correspond well to filaments observed in H_α images. Following Chiuderi-Drago (1990), we call them "radio filaments". We present here characteristics of the low-contrast features such as brightness temperature, size, location, and lifetime, and compare them with data of other wavelength ranges.

Table 1. Observed radio filaments.

Date	Brightness temperatures	Bright edges	Latitude	Correspondence to magnetograms	Correspondence to H_α
21.09–01.10 1996	10000/28000*	Yes	S14	Yes	Yes
18.10–29.10 1996	10000/18000	Yes	S17	Yes	Yes
01.03–06.03 1997	10000	No	S6–S45	No	Yes
04.10–07.10 1997	10000/20000	Yes	N39	Yes	Yes
04.10–08.10 1997	4000 – 9000	No	S50	No	Yes
11.10–17.10 1997	6000 – 10000	No	N48	No	Yes
11.10–17.10 1997	9000/40000	Yes	S27	Yes	Yes
18.10–28.10 1997	11000/20000	Yes	N34	Yes	Yes
08.02–14.02 1998	13000/25000	Yes	N31	Yes	Yes
01.04–06.04 1998	7000	No	N58	No	Yes
09.05–12.05 1998	10000/40000	Yes	S27	Yes	Yes
21.05–31.05 1998	7000	No	S56	No	Yes

* Values after slashes denote brightness temperatures of bright strips.

Radio filaments are generally elongated in latitude. The length-to-width ratio of a dark filament varies from a few units to several tens, and in the latter case the filament can extend from one limb to the other one. Dark filaments have sometimes bright strips by their sides. Such a system may be regarded as a single whole. Investigated radio filaments are listed in the Table 1.

We will call the regions of decreased brightness with bright strips "radio filaments of type I" to distinguish them from dark regions without bright strips. Location of type I radio filaments corresponds to regions of weak magnetic field (visible on Kitt Peak magnetograms), whereas such a correlation is not observed for other filaments. Moreover, the bright strips by sides of the radio filaments correspond to odd-polarity magnetic fields, and the depression region corresponds to the inversion line of the magnetic field. The lifetime of type I radio filaments can be as long as several solar rotations, such as observed in September–October 1996. They are observed in both the northern and southern hemispheres and exhibit the following tendency: the higher the radio filament's latitude, the lower the probability the bright edges being observed.

We will call dark regions without bright edges "type II radio filaments". As a rule, they are located at high latitudes. There is no correlation of type II radio filaments with magnetic fields (which was, possibly, not revealed because of the low values of magnetic fields at high latitudes).

For example, in the solar images obtained at the SSRT during October 25–28, 1997, a dark type I radio filament is clearly seen in the northern hemisphere. It extended from the eastern to the western limb and had narrow areas of increased emission of $20 - 40''$ (Fig. 1). On the western side, the filament pointed to an active region. On the eastern side, there was a system of bright strips under the bend of the filament. Correspondence between the radio filament and the magnetic field can be seen from Fig. 1.

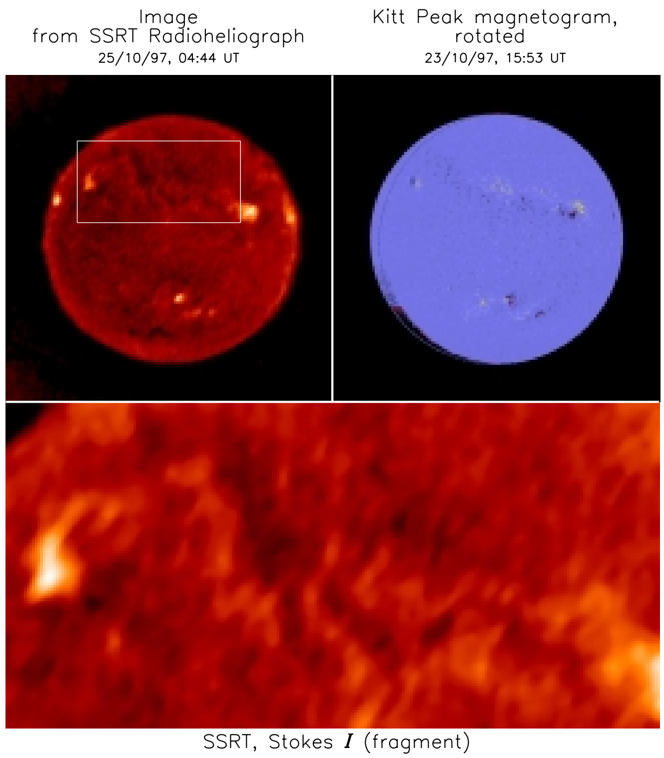

Fig. 1.. Comparison of the SSRT radio image (here and after – dirty maps) with Kitt Peak magnetogram

The width of the depression region of the radio filament varied from $0.5'$ to $1.5'$. As the filament traversed the disk, changes of its structure correlated with changes visible in soft X-ray images. On October 25, the filament was broken up into two parts, and this coincided with the appearance of loops across the filament seen in soft X-rays; at the same time, the strips along the filament decreased their brightness. The bright strips located under the eastern bend of the filament became a closed structure on October 27 with almost uniform brightness temperature (Fig. 2). Different areas of the system of bright strips undergo different day-to-day changes in brightness. Note that during that period, there were no visible changes both in structure and brightness of the dark filament located in the southern hemisphere. The brightness temperature along the dark filament varied from 8×10^3 K to 10×10^3 K. The brightness temperature of the brighter regions along the filament on October 25 and 26 was 22×10^3 K. On October 27 and 28, in the western part of the radio filament, it became close to the brightness temperature of the quiet Sun (16×10^3 K at 5.7 GHz), and this part of the radio filament became invisible. Before October 28, the system of strips in the eastern part of the disk had essentially different brightness in its different parts. The temperature of bright features reached 52×10^3 K. On October 28, the temperature of all features that had constituted a closed system $3' - 4'$ in size, became almost the same and reached 30×10^3 K.

One can observe on some images produced by the SSRT high-latitude limb filaments as prominences with the temperature of $(7 - 10) \times 10^3$ K. For example, in the radio image produced on April 1–7, 1998, the limb feature was

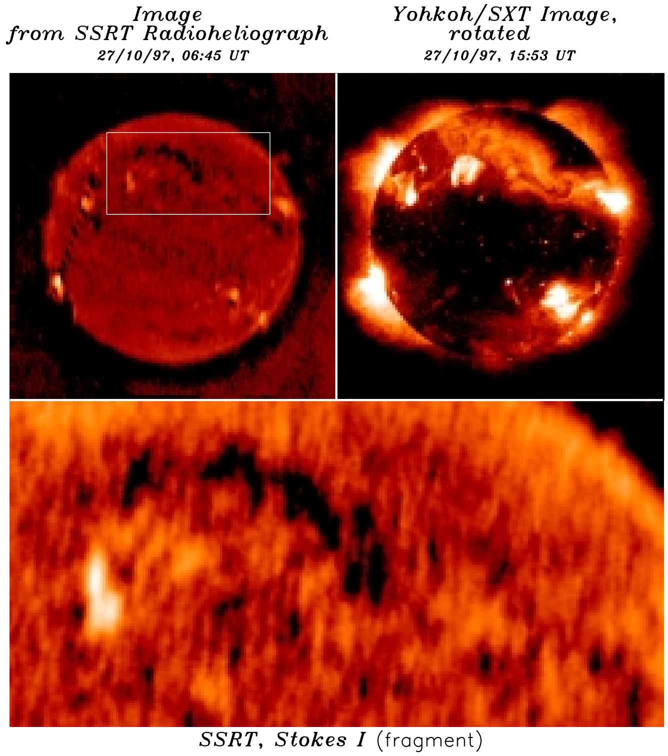

Fig. 2.. SSRT and Yohkoh/SXT images

observed which corresponded to a quiescent prominence. Such radio filaments have no bright edges. An interesting case is shown in Fig. 3. Here, a loop-like structure was observed when the filament went outside the solar disk due to the own rotation of the Sun. On the contrary, low-latitude filaments are seen on the limb as regions with the temperature of bright strips, no loop-like structure is observed, and the height above the limb is small.

A comparison with 17 GHz radio images produced by the Nobeyama Radioheliograph shows that not all depression regions observed at the SSRT are clearly seen at 17 GHz. Specifically, this applies to low-latitude regions with bright strips (Fig. 4). The low contrast of those filaments at 17 GHz, i.e. closeness of their brightness temperatures to the brightness temperature of the quiet Sun at 17 GHz ($\simeq 10^4$ K), may be due to their somewhat higher kinetic temperature. Another possible reason – an addition of optically thin emission of overlying hot plasma whose existence is suggested by the bright strips. At 5.7 GHz, the brightness temperature of the quiet Sun is 16×10^3 K. Therefore, those filaments are seen in images produced by the SSRT with better contrast.

An important characteristic of the studied radio filaments is that two types can be identified. One involves radio filaments with bright edges lying over the polarity inversion line of the magnetic field and observed mainly at low latitudes. Regions of increased brightness on their edges correspond to different-polarity magnetic fields. The other type includes radio filaments without bright edges generally located at high latitudes which do not show such a correlation (possibly because of the low values of magnetic fields at high latitudes).

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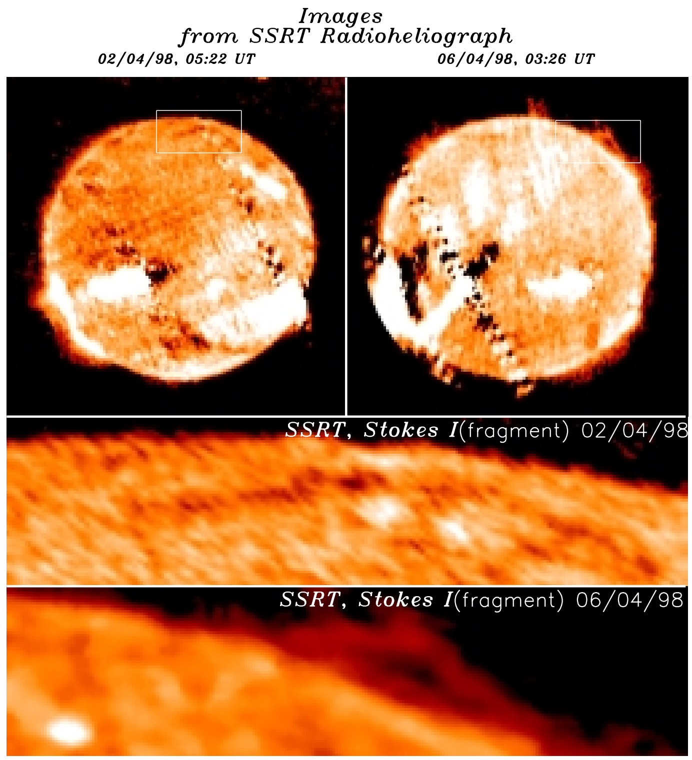

Fig. 3.. An example of high-latitude filament visible on SSRT image

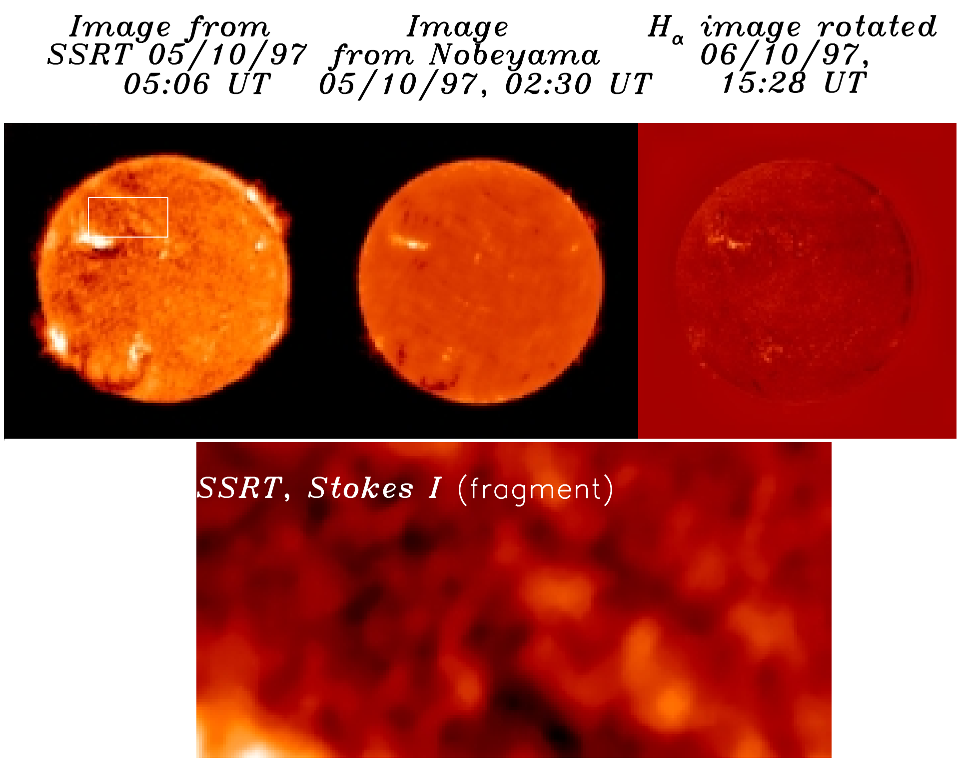

Fig. 4.. Juxtaposition of SSRT and Nobeyama radio maps.