ON THE POSSIBILITY OF RADIO OBSERVATIONS OF CURRENT SHEETS ON THE SUN

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Abstract.Possibility of a discovery of current sheets in the radioband by using their screening and reflective properties as also their own emission is discussed.It is shown,that the thermal bremsstrahlung of the sheet may be of a sufficiently large intensity ($\tau_s \gtrsim I$) on the maximal critical frequency for the plasma in the sheet.In dependence from electron density N_o and temperature T_s the thickness of the sheet from tens centimetres to hundreds metres is sufficient to provide optical depth $\tau_s \gtrsim I$.Spectral observations with sufficient angular resolution may give such characteristics of the sheet as its temperature,electron density, thickness and height in the solar atmosphere.

I.INTRODUCTION.

The physical model of a solar flare based on the development and following ruptute of the current sheet in the solar atmosphere (Syrovatskii, I970,I977;Heyvaerts et al.,I977) indicates a possible ways of the search of current sheets for the purpose of the study and forecast of solar flares.

The process of magnetic energy storage in the current sheet before the flare takes hours for the powerful flares (Syrovatskii,I977a) that in principle allows to discover beforehand a current sheet in the solar atmosphere and predict by using its parametrs a probability of the beginning,full energy and power of the flare (Syrovatskii,I976).

One method of the search of the current sheet in the solar atmosphere is the observations in radioband (Syrovatskii,I977a).Remaind of, that current sheet is a plasma feature with distribution of the electron density N(x) and magnetic field H(x) of the type shown in Figure I. Such layer,maximum size of which may reach a value bxl=20"xI50" usually situates in upper chromosphere or lower corona,where the concentration of the surrounding plasma is $N_\infty = I0^9\,cm^{-3}$The height distribution of the electron density and temperature in the solar atmosphere in presence of

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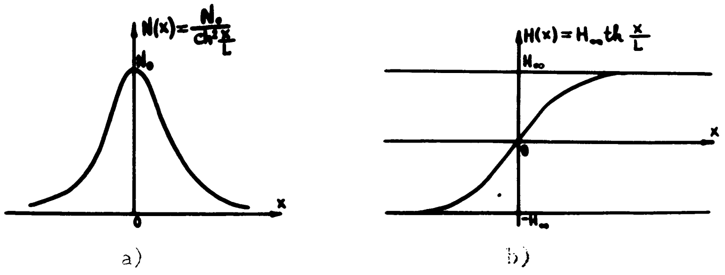

Figure I.The distribution of the (a) electron density and (b) magnetic field in the neutral current sheet.

the horizontal current sheet is qualitatively (and not in scale) shown in Figure 2.A top concentration in the layer center may reach before the large flare a value of $N_o = 2 \cdot 10^{14}$ cm^{-3} (Syrovatskii,1976),which corresponds to plasma wavelength $\lambda_0 = 2\pi c/\omega_0 = 2.4$ mm ($\omega_0^2 = 4\pi N_o e^2/m$).For this reason,the first evident property of the current sheet is the screening the emission with wavelength above critical.For example,current sheet may wholly or partly eclipse a radiosource situated in chromosphere or transition region.

In paper by Gel'freih et al.(1977) the optical identification of the radiogranulation (λ=I.35 cm) with the chromosphere network details was carried out and was proposed for the study of the solar atmosphere. This procedure may be used for search of the current sheet.The presence of the current sheet in the solar atmosphere may lead to the screening of the radiogranulation whereas the optical pattern remains unchanged. Then in corresponding place of the solar disk (of size $\leqslant$ 20") the bright details of the optical granulation will be accompanied by a reduced radiogranulation.

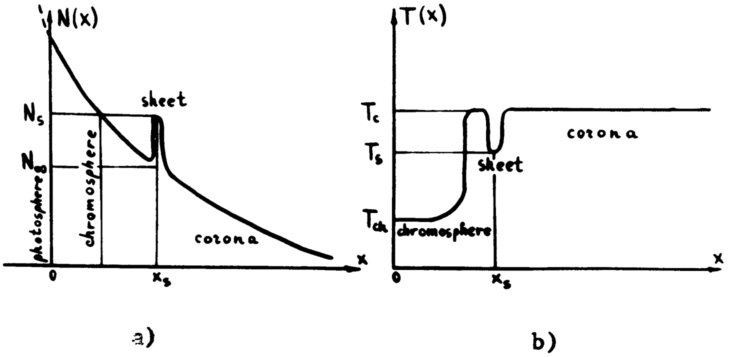

Figure 2.A possible alteration of the (a) electron density and (b) temperature distribution of the solar atmosphere,caused by formation of the current sheet.

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2. CALCULATIONS

For observation of the current sheet the properties of its own emission may be used, in particularly, a local change of the radiobrightness of the solar surface. If $T_o(\lambda)$ is the observed brightness temperature of a quiet solar surface, and $T(\lambda)$ is a brightness temperature of the surface but with a sheet above (see Figure 3), then the wavelength dependence of its ratio may be written for the step distribution of the T(x) (see Figure2) in the form:

$$\frac{T(\lambda)}{T_o(\lambda)} = t(\lambda) = \frac{T_c(I-e^{-\tau_c}) + T_s(I-e^{-\tau_s})e^{-\tau_c} + T_{ch}(I-e^{-\tau_{ch}})e^{-\tau_s}e^{-\tau_c}}{T_c(I-\exp(-\tau_c)) + T_{ch}(I-\exp(-\tau_{ch}))\exp(-\tau_c)} \quad (I)$$

where τ_c and T_c, τ_{ch} and T_{ch}, τ_s and T_s are the optical depth and temperature for the corona, chromosphere and current sheet respectively. $T_o(\lambda)$ is a known wavelength dependence of the observed brightness temperature for a quiet Sun (Kislyakov, I970; Shimabukuro et al. I968). For the optical depth of the layer we have ($\lambda \ll L$):

$$\tau_s = \int \mu\, dx = \frac{L}{\lambda_s} v_o \mathcal{J} \; ; \quad \mathcal{J} = \int \frac{dy}{ch^3 y \sqrt{ch^2 y - v_o}}$$

$$\lambda_s = \frac{c}{\nu_c} \; ; \quad \nu_c = \frac{5.5 N_o}{T_s^{3/2}} \ln\left(\frac{4.6 \cdot I0^5\, T_s}{\omega^{2/3}}\right) \; ; \quad v_o = \left(\frac{\omega_o}{\omega}\right)^2 \quad (2)$$

Here μ is the absorption coefficient for the bremsstrahlung (Ginzburg, I967), and the integration is carried out along the trajectory of the ray, which is suggested normal to the surface of the layer.

The influence of the magnetic field is ignored, since it is supposed that $\omega \gg \omega_{H_\infty} = eH_\infty/mc = 2 \cdot I0^9$ Hz for $H_\infty = 330$ gauss. For equilibrium neutral current sheet $(\omega_{H_\infty}/\omega_o)^2 = 4kT_s/mc^2 \ll I$. Besides, we utilize here the absorption coefficient μ calculated for the maxwell distribution of the particles in the layer. This is true, if the velocity of the directed motion of the particles V is small with respect to the thermal velocity $V_T = \sqrt{kT_s/m}$. That condition is always fulfiled, if we consider the thickness of the layer large compared with λ_o, since $L = cr_d/V = V_T \lambda_o/V$ and if $L/\lambda_o \gg I$, then $V_T/V \gg I$ (see Bulanov and Syrovatskii, I974).

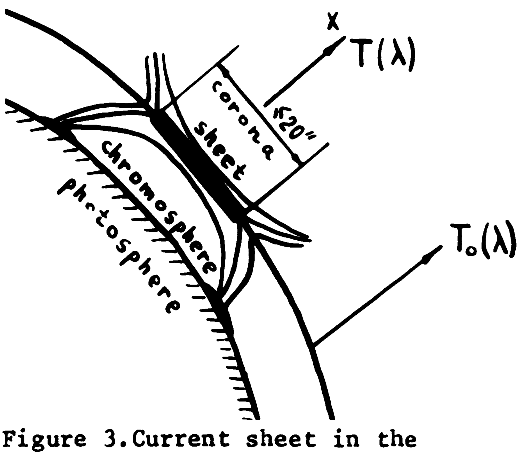

Figure 3. Current sheet in the solar atmosphere.

In two limit cases $\omega \ll \omega_o$ ($v_o \gg I$) and $\omega \gg \omega_o$ ($v_o \ll I$) we have:

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$$\mathfrak{J}_{v_o \gg I} = 2\int_{y_k} \frac{dy}{ch^3 y\sqrt{ch^2 y - v_o}} = \frac{I}{v_o}\left[\frac{I}{2}\left(\sqrt{v_o} + \frac{I}{\sqrt{v_o}}\right)\ln\left(\frac{v_o+I}{v_o-I}\right) - I\right] \approx$$

$$\approx \frac{4}{3v_o^2} \ll I \; ; \quad \tau_s = \frac{4L}{3\lambda_s v_o} \quad ; \; y_k = \mathrm{Arccosh}\sqrt{v_o} \tag{3}$$

$$\mathfrak{J}_{v_o \ll I} \simeq \frac{4}{3} \; ; \; \tau_s = \frac{4Lv_o}{3\lambda_s} \tag{4}$$

To have the optical depth of the layer sufficiently large $\tau_s \geq I$ we need $L \geq 3\lambda_s v_o/4 \gg \lambda_s$ (for $\omega \ll \omega_o$) and $L \geq 3\lambda_s/4v_o \gg \lambda_s$ (for $\omega \gg \omega_o$), which gives a lower limit for the thickness of the layer.

For appropriate values of the concentration and temperature of the layer $5\cdot 10^{10}\mathrm{cm}^{-3} \leq N_o \leq 2\cdot 10^{14}\mathrm{cm}^{-3}$, $8\cdot 10^4 K \leq T_s \leq 10^6 K$ the condition $\tau_s \geq I$ is carried out only for thick sheets $L \gg \lambda_s \geq I00\text{-}I0^4$ cm. For $L \geq 3\lambda_s v_o/4$ the observed brightness temperature $T(\lambda)$ in a given waverange ($\lambda < \lambda_c$, see below) will be approximately equal to the temperature of the layer T_s since at this wavelength the influence of the corona is small. So, the equality $T_c \tau_c = T_s$ ($\tau_c = T_s/T_c = 8\cdot I0^4/I0^6 = 8\cdot I0^{-2}$) is reached at $\lambda = \lambda_c = 37$ cm. If $\lambda < \lambda_c = 37$ cm, then $T_c\tau_c < T_s$ and $T(\lambda) = T_c\tau_c + T_s \approx T_s$.

Near the critical freguency $\omega \approx \omega_o$ ($v_o \approx I$) the emission is generated by the central part of the layer and the penetration through the sheet becomes essential. In this case we have:

$$\tau_s = \frac{L}{\lambda_s}\left[\ln\left(\frac{4\pi L}{\lambda_o}\right) - I\right] \quad ; \; \frac{L}{\lambda_o} \gg I \tag{5}$$

Now $\tau_s \geq I$ will be true for sheet thickness of the order of λ_s or even smaller. Indeed, the condition $\tau_s \geq I$ can be written in the form

$$\frac{\lambda_s}{L} + \ln\left(\frac{\lambda_s}{L}\right) \leq \ln\left(\frac{4\pi\lambda_s}{\lambda_o}\right) - I = \ln\left(\frac{2\omega_o}{\nu_c}\right) - I$$

If x_o is a root of the equation $x + \ln x = \ln(2\omega_o/\nu_c) - I$ then the condition $\tau_s \geq I$ is equivalent to $L \geq \lambda_s/x_o$. Substituting $\nu_c = 3\cdot I0^8$Hz, $\omega_o = 8\cdot I0^{II}$ Hz we obtain $\ln(2\omega_o/\nu_c) = 7.6$, $x_o = 5.8$ and $L \geq \lambda_s/x_o = I7$ cm. The sheet thickness L at various values N_o and T_s which gives $\tau_s(\lambda_o, L) = I$ are given in the Table I. At this thicknesses $T(\lambda_o) = T_s$, $t(\lambda_o) = I + T_s/T_o(\lambda_o) = t_o$ depends on λ_o (that is $N_o = \pi mc^2/e^2\lambda_o$) and is also included in the Table I.

Qualitatively the dependence $t(\lambda)$ given by expression (I) is prepresented in Figure 4. The appearence of the minimum t_I at some wavelength λ_I is due to the screening by current sheet of the emission of the lower more hot layers of the solar atmosphere. The dashed line in the Figure 4 shows a long wavelength part of the spectrum ($\lambda_o \ll \lambda \approx \lambda_{H_\infty} = 2\pi c/\omega_{H_\infty}$) without account of a possible contribution of magnetobremsstrahlung (Zheleznyakov, Zlotnik, I978).

Let us consider the layer for which $\tau_s(\lambda_o,L)\gg I$ (see (5)); actually this denote also that $L\geq\lambda_s\gg\lambda_o\approx\lambda$ and $T_s(I-\exp(-\tau_s(\lambda_o,L)))\simeq T_s$. The concentrations $N_o\geq 5\cdot10^{10}cm^{-3}\gg N_\infty=5\cdot10^{8}cm^{-3}$ are of interest (that is $\lambda_o\leq I5$ cm $\ll\lambda_\infty=I50$ cm), therefore not only $\tau_c(\lambda_o)\ll I$ but $T_c(I-\exp(-\tau_c(\lambda_o))=T_c\tau_c(\lambda_o)\ll T_s$, if the temperature of the layer is in the interval of interest $T_s\geq 8\cdot I0^4K$ $(T_c\tau_c(\lambda\leq I5\ cm)\leq I0^6\cdot I.3\cdot I0^{-2}=I.3\cdot I0^4K<8.I0^4K\leq T_s))$ In that case according to (I) we have $T(\lambda_o)=T_s$ and $t_o=I+T_s/T_o(\lambda_o)$. At 4 cm $\leq\lambda\leq$ I50 cm, $T_o(\lambda)=5\cdot I0^3\lambda$ (Zheleznyakov, 1964), therefore, since $\lambda\leq$ $\leq$ I5 cm, then $T_o(\lambda_o)\leq 7.5\cdot I0^4K$ and for $T_s\geq 8\cdot I0^4K$ it will be always $t_o>2$, that is the emission at the wavelength λ_o will be enhanced due to the current sheet. It can be see from (3) and (4) that for $\lambda\gtrless\lambda_o$ we obtain $\tau_s(\lambda,L)<I$ and $T_s>T(\lambda)\approx T_s\tau_s\sim\lambda^2$ for $\lambda<\lambda_o$, and $T(\lambda)\approx T_s\tau_s\sim\lambda^{-2}$ for $\lambda>\lambda_o$.

At $\lambda\geq\lambda_\infty$ we have $T(\lambda)=T_o(\lambda)$ and $t(\lambda)=I$ if we don't take into account a possible contribution from the magnetic bremsstrahlung mechanism at these wavelength. Waves with $\lambda\geq\lambda_\infty$ are reflected from the critical layers in the corona above the sheet and don't "feel" the current sheet.

At $\lambda_o\ll\lambda\approx\lambda_I\ll\lambda_\infty$, the behaviour of the spectrum is defined by competition of the terms in the expression

$$T_s[I-\exp\{-\tau_s(\lambda,L,N_o,T_s)\}]\exp\{-\tau_c(\lambda)\}+T_c[I-\exp\{-\tau_c(\lambda)\}]$$

giving the contribution to the brightness temperature from the layer and from the corona, respectively. For the layer which is cold relative to the corona, $T_s\approx 8\cdot I0^4K\ll T_c=I0^6K$, the term $T_c(I-\exp(-\tau_c))$ surely predominate over the term $T_s(I-\exp(-\tau_s))\exp(-\tau_c)$ for $\lambda_c<\lambda<\lambda_\infty$ where $\lambda_c=37$ cm is defined above. In that range of wave-length $T(\lambda)=T_c\tau_c(\lambda)\sim\lambda^2$ (see Figure 5) and $t(\lambda)\sim\lambda$ because $T_o(\lambda)\sim\lambda$ (see Figure 4).

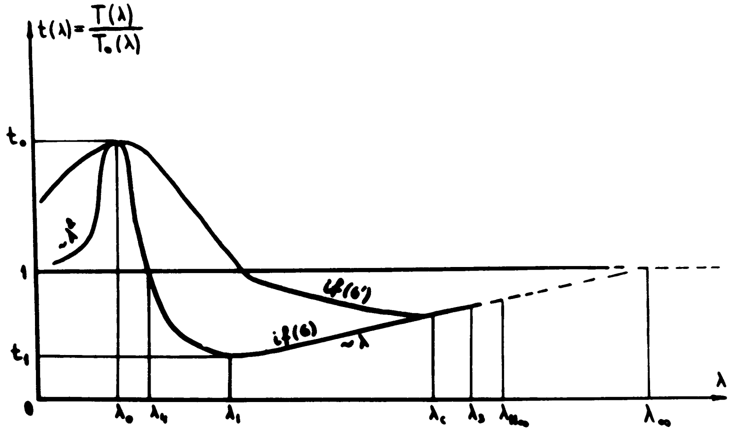

Figure 4. The wavelength dependence of the brightness (contrast) of the solar surface section with current sheet (from Figure 5, see below).

Further, at $\lambda_o<\lambda<\lambda_c$ two limiting cases are possible.

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If $\lambda_o \ll \lambda_c$ then it may be

$$\tau_s(\lambda_c, L) \ll I \qquad \text{or} \qquad L \ll \frac{3}{4}\lambda_s\left(\frac{\lambda_c}{\lambda_o}\right)^2 \tag{6}$$

for which case the predominance of the term $T_s\tau_s(\lambda)$ over $T_c\tau_c(\lambda)$ will continue in the range of more short wavelength $\lambda < \lambda_c$ (see Figure 5). However, the term $T_c\tau_c(\lambda) \sim \lambda^2$ decreases with the decreases of λ and the term $T_s\tau_s(\lambda) \sim \lambda^{-2}$ increases. Hence at some wavelength λ_I THE TERM $T_s\tau_s$ begin to predominate and $T(\lambda) \sim \lambda^2$ turn at $\lambda < \lambda_I$ into $T(\lambda) \sim \lambda^{-2}$ (see Figure 5). It is clear, that λ_I and t_I are defined approximately from equalities:

$$T_c\tau_c(\lambda_I) = T_s\tau_s(\lambda_I) \tag{7}$$

$$t_I = 2t(\lambda_I) = 2\frac{T_s\tau_s(\lambda_I)}{T_o(\lambda_I)} \tag{8}$$

Note here that minimum of $t(\lambda)$ coincides approximately with minimum of $T(\lambda)$ because of $T_o(\lambda) \sim \lambda$ is a monotonous function of λ in wide range of wavelength. Using (3) and (7) we obtain

$$T_c\tau_c(\lambda_I) = T_c\left(\frac{\lambda_I}{\lambda_\infty}\right)^2 = T_s\tau_s(\lambda_I) = T_s\frac{4L}{3\lambda_s}\left(\frac{\lambda_o}{\lambda_I}\right)^2$$

whence it follows

$$\lambda_I = (\lambda_o\lambda_\infty)^{\frac{1}{2}}\left(\frac{4LT_s}{3\lambda_s T_c}\right)^{1/4} \tag{9}$$

Using this value of λ_I in the condition $\tau_s(\lambda_I, L) \ll I$ we obtain that (9) is true if:

$$\frac{\lambda_\infty}{\lambda_o} = \sqrt{\frac{N_o}{N_\infty}} \gg \sqrt{\frac{4T_c L}{3T_s\lambda_s}} \qquad \text{or} \qquad L \ll \left(\frac{\lambda_\infty}{\lambda_o}\right)^2\frac{3T_s}{4T_c}\lambda_s \tag{I0}$$

Then

$$T_{min}(\lambda) = 2T_s\tau_s(\lambda_I) = \frac{4\lambda_o}{\sqrt{3}\lambda_\infty}\left(\frac{L}{\lambda_s}T_sT_c\right)^{\frac{1}{2}} \tag{II}$$

For 4 cm $\leqslant \lambda \leqslant$ I50 cm we have $T_o(\lambda_I) = 5\cdot I0^3\lambda_I$. Defining wavelength λ_b for which $T_o(\lambda_b) = T_s = 5\cdot I0^3\lambda_b$ we obtain $T_o(\lambda_I) = 5\cdot I0^3\lambda_I = T_s\lambda_I/\lambda_b$ and

$$t_I = 2\left(\frac{\lambda_o\lambda_c^2}{\lambda_\infty^3}\right)^{\frac{1}{2}}\left(\frac{4L}{3\lambda_s}\right)^{1/4}\left(\frac{T_c}{T_s}\right)^{3/4} \tag{I2}$$

For given N_o and T_s the condition (I0) of validity of (9) and (I2) can be rewritten like that:

$$L \ll \left(\frac{\lambda_\infty}{\lambda_o}\right)^2\left(\frac{3T_s}{4T_c}\right)\lambda_s = \left(\frac{N_o}{N_\infty}\right)\left(\frac{3T_s}{4T_c}\right)\lambda_s \tag{I0'}$$

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Other limit relates to the case $\tau_s(\lambda_c, L) \geq I$, that is

$$L \geq \frac{3}{4}\lambda_s\left(\frac{\lambda_c}{\lambda_0}\right)^2 \qquad (6')$$

then λ_I is defined by the condition:

$$T_c\,\tau_c(\lambda_I) = T_c\left(\frac{\lambda_I}{\lambda_\infty}\right)^2 = T_s \qquad (I3)$$

from which we obtain:

$$\lambda_I = \sqrt{\frac{T_s}{T_c}}\,\lambda_\infty \ll \lambda_\infty, \text{ if } \sqrt{\frac{T_s}{T_c}} \ll I \qquad (I4)$$

For validity of (I4) the condition $\tau_s(\lambda_I, L) \geq I$ is enough and yields:

$$L \geq \frac{3}{4}\lambda_s\left(\frac{\lambda_\infty}{\lambda_0}\right)^2 \frac{T_s}{T_c} = \lambda_s \frac{3T_sN_0}{4T_cN_\infty} \qquad (I5)$$

As can be seen from Figure 5, minimum of $T(\lambda)$ in this case is weak or

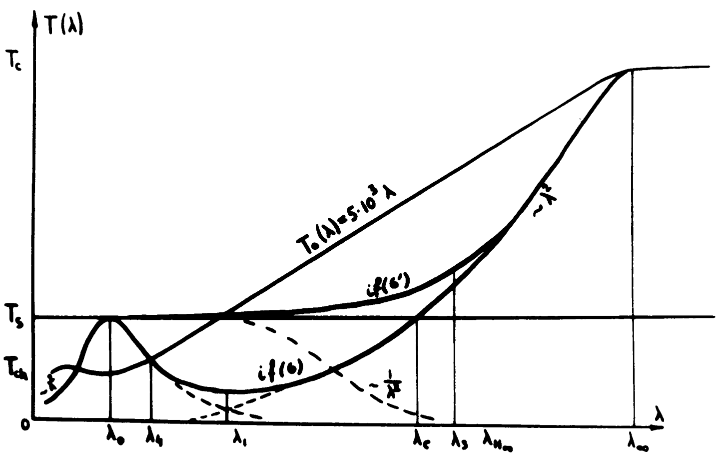

Figure 5. The alteration of the brightness temperature of the solar surface section caused by formation of the current sheet.

fully absent. Minimum of $t(\lambda)$ equals

$$t_I = 2t(\lambda_I) = \frac{2\lambda_b}{\lambda_I} = \frac{2\lambda_b}{\lambda_\infty}\sqrt{\frac{T_c}{T_s}} \qquad (I6)$$

and is also unimportant.

At $\lambda > \lambda_I$, $T(\lambda) = T_c\,\tau_c(\lambda) = T_c(\lambda/\lambda_\infty)^2$ and $t(\lambda) = T_c\,\lambda_b\,\lambda / T_s\,\lambda_\infty^2 \sim \lambda$.

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At $\lambda<\lambda_I$ $T(\lambda)=T_s$ and $t(\lambda)=\lambda_b/\lambda \sim I/\lambda$ (see Figure 4).

Figure 4 and 5 yield a general representation of the behaviour of spectra $T(\lambda)$ and $t(\lambda)$ under alteration of the sheet parameters.Note once more that these spectra are represented in no scale and yield only qualitative pattern of the dependences of $T(\lambda)$ and $t(\lambda)$.It was not also taken into account a possible influence of the magnetobremsstrahlung at $\lambda\sim\lambda_H\gg$ $\gg\lambda_o$.The point λ_3 on the Figures 4 and 5 for the case (IO) is defined from the condition that at $\lambda<\lambda_3$ a term $T_s\tau_s(\lambda)$ begins to give a noticeable contribution in $T(\lambda)=T_c\tau_c+T_s\tau_s$,but still $T_c\tau_c\gg T_s\tau_s$ (for example $T_c\tau_c\approx IOT_s\tau_s$).The point λ_4 is defined from the approximate equality:

$$T_s\tau_s(\lambda_4) = T_o(\lambda_4) \qquad (I7)$$

The values of t_o, t_I, λ_I for different values of the parameters N_o, T_s and L are given in the Table I.

Thus,the presence of the current sheet may lead to the increase of the radiobrightness at some frequencies and to its decrease on the others. The analysis carried out shows that observations of the radiospectrum with

Table I.Characteristic parameters t_o, t_I, λ_I of the spectrum $t(\lambda)$ and a thickness of the sheet for which $\tau_s(\lambda_o, L)=I$. $T(\lambda)=T_o(\lambda)[t(\lambda)-I]$.

T_s	N_o cm^{-3}	$2\cdot IO^{I4}$	$2\cdot IO^{I3}$	$I.2\cdot IO^{I2}$	$3\cdot IO^{II}$
	λ_o cm	0.24	0.75	3	6
	$T_o(\lambda_o)$	6500	6000	$I.4\cdot IO^4$	$2.5\cdot IO^4$
$8\cdot IO^4$	t_o	I3	I4	7	4
	t_I	$6.6\cdot IO^{-2}$	0.I8	0.29	0.3I
	λ_I	2.4 cm	4.I	7.9	I0.6
	L	20 cm	I40	$I.2\cdot IO^3$	$8.7\cdot IO^3$
IO^5	t_o	I6	I8	8	5
	t_I	$7.4\cdot IO^{-2}$	0.2	0.32	0.35
	λ_I	2.5	4.2	8.3	II.3
	L	25	I80	$I.5\cdot IO^3$	$I.2\cdot IO^4$
$5\cdot IO^5$	t_o	80	84	36	20
	t_I	0.I4	0.4	0.64	0.7
	λ_I	3.5	6	II.7	I6
	L	I60	$I.2\cdot IO^3$	$I.2\cdot IO^4$	IO^5
IO^6	t_o	I55	I70	72	40
	t_I	0.I9	0.5	0.87	0.95
	λ_I	4	6.8	I3.6	I8.7
	L	380	$3.2\cdot IO^3$	$2.6\cdot IO^4$	$2.2\cdot IO^5$

sufficient spatial resolution can give such important characteristics of the current sheet,as its thickness,height in the solar atmosphere,maximum concentration and temperature.This manifests the importance of spectral investigations for the problems of the solar flares mechanism and flare forecasting.

III.OBSERVATIONS

At present there seem already to exist observations qualitatively confirming the above effects.We mean the papers which indicate indirectly the existence of sources which can be attributed to the current sheets. So,the study of the radioemission of active regions at λ=3.3 mm with resolution 2!8 by Mayfield et al,(I970,I973,I976)shows a clearly correlation of the enhanced emission ($\sim$10%) at that wavelength with neutral lines of magnetic field and with flares which took place on these lines.Similarly Kundu (I970) relates the sources of enchanced brightness temperature with the matter in the corona which have high electron density and low temperature.

Eclipse radioobservations at λ=4 cm with resolution 8" allowing to resolve detail structure of the local source between two bright magnetic details (spots) a source for which it is typical the absence of the polarization,a closeness to the neutral line of the magnetic field,a small size 0'.2,a flat character of the spectrum allowing the bremsstrahlung mechanism.

The nature and the identification of sources mentioned was not discused until because of the lack of detail information especially of simultaneous high resolution observations on different wavelengths.It was noted (Boldyrev et al,I978) that the twice lower resolution gives a smooth pattern without any distinct sources.

Depression of radiobrightness associated with prominences is interpreted usually in terms of weak emission from prominence itself or from the thin prominence-corona interface (see a rewiev by Schmahl I978).However, it is observed simetimes the radio depression not associated with Hα filaments. This was interpreted in terms of radio absorption by material tenuous enought to be transparent in Hα (Buhl and Tlamicha I970).The same effect may be due to the current sheet (depression at $\lambda \sim \lambda_I$,see Figure 4), not in terms of radio absorption but as screening of the emission from lower layers of solar atmosphere as was described above.

The presence of a cool filament near the current sheet will greatly complicate the situation.In this respect the discussed properties of a current sheet will be observed in the best way for active regions where flares are not connected with quiescent prominences.

As it is clear from the preceding for this case the enhancement and the deficiency of the radiobrightness at different wavelength can be explained in the fremework of the current sheet model.

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DISCUSSION

D.Smith: You have considered the sheet as completely passive, whereas observations show that even quasi-stable sheets are slowly evolving with corresponding energy transformation processes. The resulting radio emission may completely dominate the bremsstrahlung emission which you have calculated.

Syrovatskii: Really the preflare current sheet is steady from the point of view of observation because it develops only slowly (from tens of minutes to tens of hours). Besides, it is steady in the sense of absence of plasma oscillations. The resistivity is simply the Coulomb resistivity up to the beginning of the flare itself.

Hudson: Is high spectral resolution in frequency necessary for the detection of the cool current sheet? What spectral bandwidth would the plasma-frequency radiation typically have?

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Kundu: Do you really need $N_e \sim 10^{14}$? The reason I am asking this question is that if N_e were $\sim 10^{12}$ then the optimum wavelength to observe the current sheet may be $\sim$ 2.5 cm instead of $\sim$ 2.5 mm.

Syrovatskii: The extinction at maximum density in the sheet was given for the extreme case of the situation just before the occurrence of a very strong flare with energy release of 10^{32} ergs. In more moderate cases the maximum concentration is one or two orders of magnitude lower and the maximum of the spectrum will move to the cm wavelength band.

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