MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO DE PESQUISAS ESPACIAIS

AUTORIZAÇÃO PARA PUBLICAÇÃO
AUTHORIZATION FOR PUBLICATION

PALAVRAS CHAVES/KEY WORDS

FINE STRUCTURE
ACTIVE REGION

AUTORIZADA POR/AUTHORIZED BY

Volker W.J.H. Kirchhoff
Director Space Atmos. Sci

AUTOR RESPONSAVEL / RESPONSIBLE AUTHOR

Hanumant S. Sawant

DISTRIBUIÇÃO/DISTRIBUTION

- [ ] INTERNA / INTERNAL
- [x] EXTERNA / EXTERNAL
- [ ] RESTRITA / RESTRICTED

REVISADA POR / REVISED BY

Osmar Pinto Júnior
Editor Space Atmos. Sci.

CDU/UDC: 523.03

DATA / DATE: July 1990

PUBLICAÇÃO Nº / PUBLICATION NO: INPE-5099-PRE/1601

ORIGEM / ORIGIN: DAS

PROJETO / PROJECT: RADIO

Nº DE PAG. / NO OF PAGES: 06

ULTIMA PAG. / LAST PAGE: 05

VERSÃO / VERSION:

Nº DE MAPAS / NO OF MAPS:

TÍTULO/TITLE

FINE STRUCTURE IN THE MM-WAVELENGHT SPECTRA OF THE ACTIVE REGION

AUTORES/AUTHORSHIP

H.S. Sawant
J.R. Cecatto

RESUMO - NOTAS / ABSTRACT - NOTES

There is a lack of mm-wavelenght spectroscopic solar observations. There are suggestions that a fine structure in frequency may be superimposed on the S-component of solar active region as well as on the burst component at mm-wavelengths. To study fine structure in frequency and time, a high sensitivity step frequency receiver operating in the frequency range 23-18 GHz with frequency resolution of 1 GHz and variable time resolution 1.2 to 96 sec, using 13.7 m diameter Itapetinga radome covered antenna, has been developed. Here, we discuss mm-wavelength spectra of active regions and their time evolution. Study of time evolution of an active region AR 5569 observed on 29th June, 1989 suggests existence of fine structures as a function of time.

OBSERVAÇÕES / REMARKS

This work was accepted for publication in Revista Mexicana de Astronomia Y Astrofísica, vol. 20, 1990.

FINE STRUCTURE IN THE MM-WAVELENGTH SPECTRA OF THE ACTIVE REGION

H. S. Sawant and J. R. Cecatto

Departamento de Astrofísica
Instituto de Pesquisas Espaciais, Brazil

ABSTRACT. There is a lack of mm-wavelength spectroscopic solar observations. There are suggestions that a fine structure in frequency may be superimposed on the S-component of solar active region as well as on the burst component at mm-wavelengths. To study fine structure in frequency and time, a high sensitivity step frequency receiver operating in the frequency range 23-18 GHz with frequency resolution of 1 GHz and variable time resolution 1.2 to 96 sec, using 13.7 m diameter Itapetinga radome covered antenna, has been developed. Here, we discuss mm-wavelength spectra of active regions and their time evolution. Study of time evolution of an active region AR 5569 observed on 29th June, 1989 suggests existence of fine structures as a function of time.

Key words:

I. INTRODUCTION

Unique spectroscopic observations of active region, carried out by Kaverin et al. (1979) in the frequency range of 5 to 7 GHz with $\Delta f/f \leq 0.1$, suggested the existence of a fine structure in frequency. Recently, same authors have extended their studies up to 12 GHz by using two spectroscopes operating in the frequency range of 12-8 and 7-5 GHz and have confirmed their earlier results (Kaverin et al. 1983). On theoretical grounds, Zheleznyakov and Zlotnik (1980) and Zheleznyakov and Tikhomirov (1982) have suggested that there is a possibility of superposition of cyclotron-lines on the spectra of the active region, which will appear as a frequency structure in the course of development of time. Detection of these lines will furnish information on the neutral sheet and the processes of development of flare. In view of the above mentioned fact, we have developed a mm-λ (23 - 18 GHz) spectroscope (in conjunction with 13.7 meter-diameter Itapetinga antenna) which is operational since 1988. Since then, we carry out periodically observations of active region and that of the burst component. Here we report spectral observations of the active region in particular, indicating presence of fine frequency structures, which are also time dependent.

II. INSTRUMENTATION

R.F. signal (23 - 18 GHz) received by a rectangular horn in a vertical polarization is fed into a mixer where a sweep frequency L.O. signal, derived from Yig oscillator by applying suitable variable voltage, is also fed. The sweep rate can be varied from 1.2 to 96 s - the frequency is varied in step of 1 GHz, the bandwidth of the receiver is 500 MHz. The dynamic range of the receiver is 20 dB. After suitably amplifying, the signal is detected by square law detector; and is recorded in series on one of channel of Ampex analogue tape recorder along with time marker. Digitization and data reduction are carried out off the line. For observations of active region, each frequency is observed for 8 sec. Thus, same frequency is observed after 48 sec. Front and backend arrangements of 13.7 m radome covered antenna, operating at 22 and 44 GHz, and also frequency accuracy, calibration, etc. have been described in detail by Kauffmann et al. (1982).Calibration of the antenna temperature is done by using a reference absorber. This method eliminates the effect of atmospheric attenuation to a good approximation (Ulich and Haas, 1976).

III. OBSERVATIONS

In May 1988, observations of solar active region were carried out for about 20 days. Observations were restricted to ± 2 hr of local noon. Most of these active regions were having percentage P above the quiet sun, of about 4%.

AR 5025 - Active region NOAA AR 5025 was having P ≥ 15% and was observed for five days from 20 May, 1988. When it appeared for the first time on the east limb, it had P ≥ 10%. It reached maximum of P = 37% on 23 May and then decreased to 20% on the following day. During its course, it gave flares for two days. Only on 22 May, there was no activity and observing conditions were excellent. On this day, AR 5025 was located at E37 S22.

From 13:05 UT to 14:03 UT, center of the sun, quiet sun level was observed in the frequency range 23 to 18 GHz.

From 14:03 to 15:30 UT, calibration of the system with absorber as load was carried out. From 15:30 UT to 17:10 UT, active region AR 5025 was observed in variable frequency mode as mentioned above.

Time evolution of the spectra of active region AR 5025 for near about 2 hours did not show any significant variation either with frequency or with time even though active region was situated near eastern limb. The nature of the spectra was similar to that of spectra obtained for center of the sun. The spectral index of the spectra in the frequency range of (23 - 18) GHz was ≲ 0.1. Thus there was not much dependence of flux on frequency.

June 14 - 31, 1989 "MAX-91 Campaign" - In June 1989, along with "MAX-91" campaign solar observations were carried out for 21 days. Depending upon the programme, solar observations were carried out either with time resolution of 48 s for observations of active region or with time resolution of 1.2 s in case of observations of the burst component. Observation of burst components observed in the (23 - 18 GHz) will be reported elsewhere. Here, we are reporting observations of active regions. Active regions were observed for 45 hours. Out of these only 14 hours were suitable for carrying out spectral investigations.

AR 5528 - The active region AR 5528 was observed from 15/06 to 19/06. We report here observation of the region for 19/06/89. On this day, active region was situated at N17 W50 and was having, Tar, the antenna temperature of the active region = 33% and is represented by the percentage above the quiet sun, P = 100 x Tar/Tsun = 33%, where Tsun is the adopted quite sun temperature.

Spectra of this active region showed time dependent frequency variation and in almost all cases, fluxes decreased by about 15 to 20% during one and a half hour except at one frequency (20 GHz), where there was almost negligible (~ 2%) decrease in flux. However, it should be noted that this region was near western limb and needs more detailed investigation of the time evolution of the spectra.

AR 5569 - This active region was observed from 28/06 up to 01/07/89. We are reporting observations of this active region for 29/06/89. On this day, this active region was located at N19 W08 and was having Tar, the temperature of the active region above quite sun equal to 17%. Fig. 1 shows radio map obtained at 22 GHz and the position of the active region.

The beamwidth (HPBW) of the antenna at 22 GHz is 4'. It should be noted that this active region was practically located near the center of the sun. The observing conditions on this day were excellent. The center of the sun, a region away from the active region, was observed from 11:55 to 12:15 UT. The average spectra of the center of sun for an half hour are shown in fig. 2 and are normalized to 18 GHz.

The spectra are almost flat over the frequency range of 23 to 18 GHz and the spectral index over this frequency range is ~ 0.1. From 12:16 to 17:00 UT the active region was traced. The position of the active region was decided from 22 GHz radio map. In order to obtain the spectra of the active region and to eliminate all common sources of errors, the flux value of the center of the sun at each frequency was subtracted from the observed flux values of active region at the same frequency, averaged over ten minutes and then spectra of the active region were plotted. Fig. 3(a,b,c,d) show that the first four plots, corresponding to time interval of 12:16 to 13:26 UT are similar in nature to that of the center of sun plot (fig. 2). During this interval flux variation ranged from 1 to 9 percent and there was decrease in flux values.

Spectra of the active region, obtained in the same manner as described above, for the further interval 16:25 to 17:00 UT are shown in fig. 3(e,f,g).

As seen from the spectra, there is a clear excess of emission by of about 13% of the original value over a narrow band around 20 GHz.

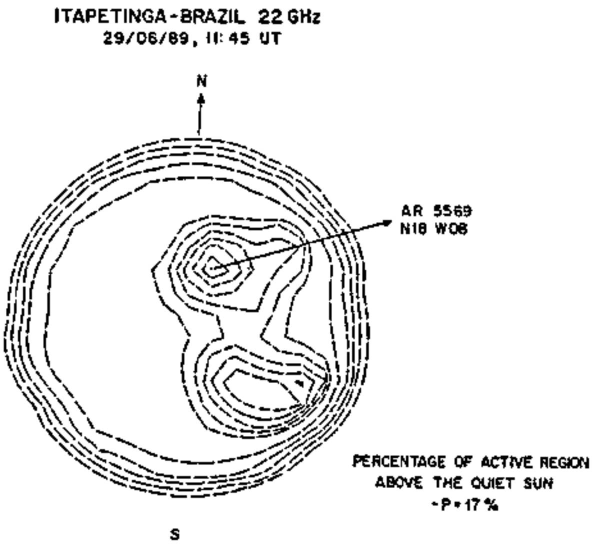

Fig. 1. 22 GHz sun map obtained in 6 min at Itapetinga at 11:45 UT, displaying mm-wave active region. Maximum corrected antenna temperature was 6420 K at 22 GHz for AR 5569. Isophotes were taken every 136 K, except four outer circles which correspond to 50%, 62%, 75%, and 88% respectively to the quiet sun level. Antenna temperature is not corrected for beam efficiency.

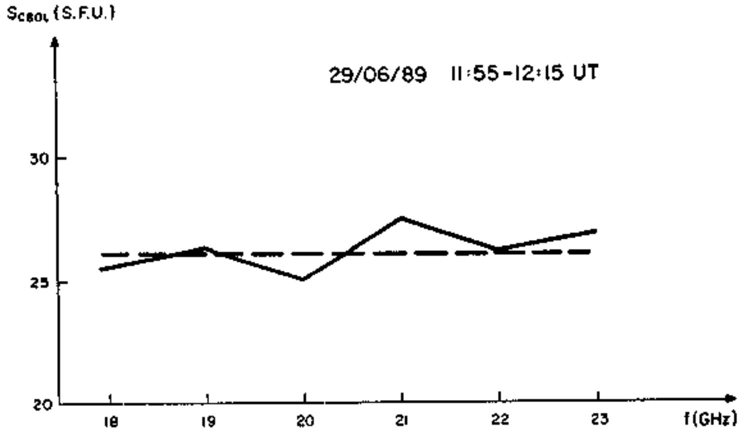

Fig. 2. Plot of flux, normalized to 18 GHz, versus frequency for the center of the Sun, averaged over twenty minute intervals as indicated.

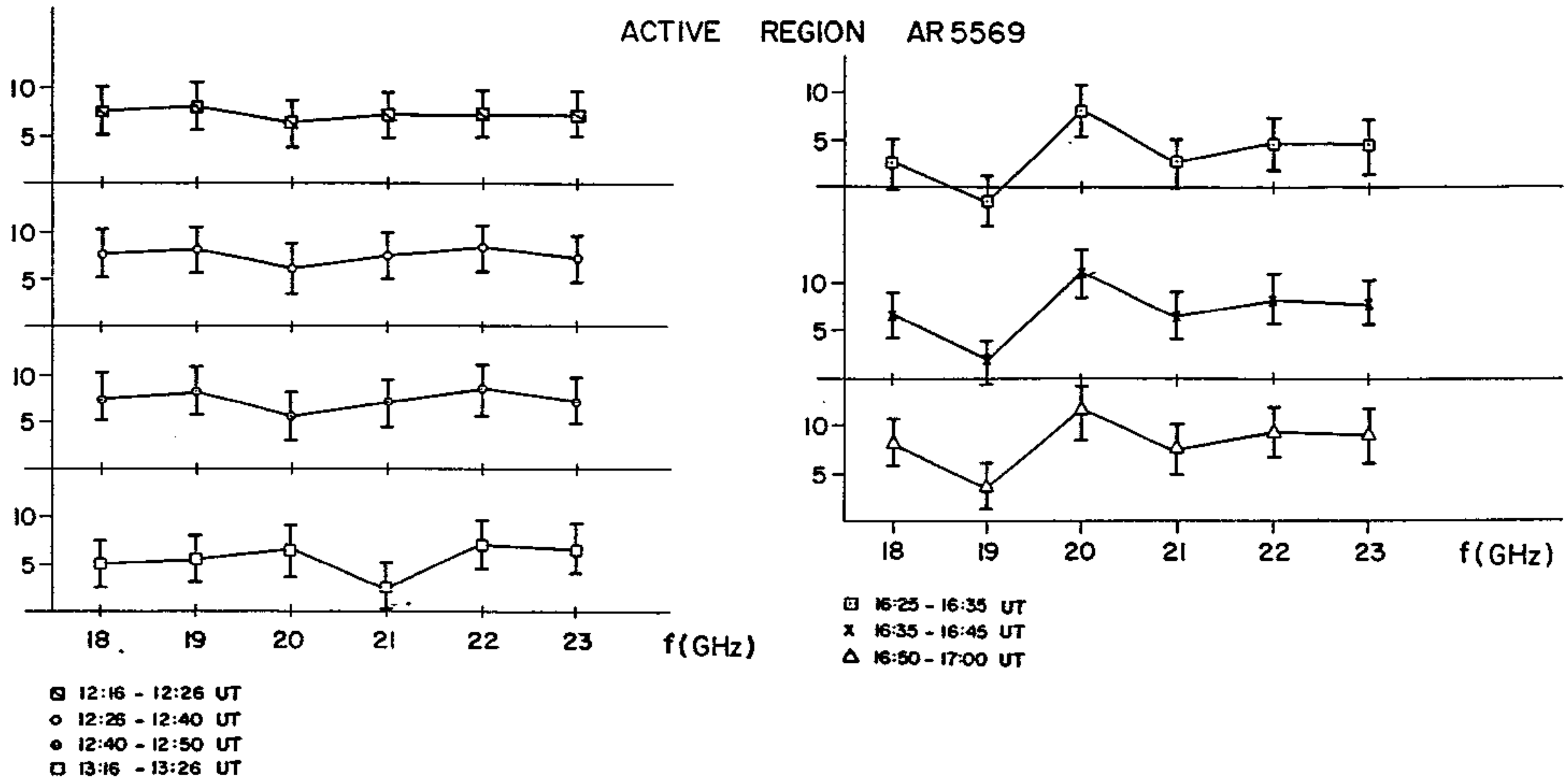

Fig. 3(a,b,c,d) Plot of flux of the active region averaged over ten minutes intervals after subtracting values for the center of the sun, corresponding to the period 12:15 to 13:26 UT.

Fig. 3(e,f,g) Similar values for the further period 16:25 to 17:00 UT.

IV. DISCUSSIONS

Spectra of the center of sun: The spectra of the center of the sun obtained for about one hour on each day of observation discussed in the text, showed flux variation of about 1%. Also there was not much dependence of flux on frequency and time. Spectral index ranged between 0.10 to 0.15 for different days. This suggests that the radio emission observed in the frequency range of (23 - 18) GHz was mostly of thermal origin.

Active regions at limbs:

AR 5025 - Observed for about two hours on eastern limb on May 22, 1988, surprisingly did not show significant (≤ 10%) flux variation. Moreover, the nature of spectra of active region and that of the center of sun was similar.

AR 5528 - Observed on western limb on 19/06/89 for about one and half hour showed frequency and time dependent flux variation of the order of ≥ 15%. This variation may be due to limb effect.

Active region near center of sun:

AR 5569 - Observed on 29/06/89. Spectra of the active region observed for the first forty minutes did not show significant (< 5%) frequency time dependent variation. Whatever flux variation was there, was decreasing and spectra of the active region was of a nature similar to that of center of sun. However, the next half of the observations for thirty minutes showed enhancement of the flux around 20 GHz by ~ 10%. We feel this may be possible detection of a cyclotron line superimposed on the 'S-component' - of thermal origin - of active region. Details of this are being worked out.

ACKNOWLEDGEMENTS

Thanks are due to Prof. R. P. Kane for discussions and suggestions.

REFERENCES

Kauffmann,P. R., Strauss,F. M., Schaal,R.E., and Laporte,C., 1982, Sol. Phys., 78, 389.
Kaverin,N. S., Kobrin,M. M., Korshunov,A. I., and Shushunov,V. V., 1979, Sol. Phys., 63, 379.
Kaverin,N. S., et al., 1983, Proceedings of the 11th Regional Consultation on Solar Physics, Debrecen Heliophysical Observatory, Vol. 5(part II), 631-638.
Ulich,B. L., and Haas,R. W., 1976, Astrophys. J., (Suppl. Ser.), 30, 247.
Zheleznyakov,V. V., and Zlotnik,E. Ya, 1980, Radio Physics of the sun Ed. Kundu, M. R., and Gergely, 87.
Zheleznyakov,V. V., and Tikhomirov,Yu. V., 1982, Sol. Phys., 81, 121.

Hanumant S. Sawant, José Roberto Cecatto: Departamento de Astrofísica, Instituto de Pesquisas Espaciais, C.P. 515, 12201 São José dos Campos, SP, Brasil.

MFN= 002963
01 SID/SCD
02 5099
03 INPE-5099-PRE/1601
04 CEA
05 S
06 as
10 Sawant, Hanumant Shankar
10 Cecatto, Jose Roberto
12 Fine structure in the mm-wavelength spectra of the active region
14 552-556
30 Revista Mexicana de Astronomia y Astrofisica
31 21
32 Numero Especial
40 En
41 Es
41 En
42 <E>
58 DAS
61 <PI>
64 <1990>
68 PRE
76 ASTROFISICA
83 There is a lack of mm-wavelenght spectroscopic solar observations. There are suggestions that a fine structure in frequency may be superimposed on the S-component of solar active region as well as on the burst component at mm-wavelenghts. To study fine structure in frequency and time, a high sensitivity step frequency receiver operating in the frequency range 23-18 GHz with frequency resolution of 1 GHz and variable time resolution 1.2 to 96 sec, using 13.7 m diameter Itapetinga radome covered antenna, has been developed. Here, we discuss mm-wavelenght spectra of active regions and their time evolution. Study of time evolution of an active region AR 5569 observed on 29th June, 1989 suggests existence of fine structures as a function of time.
88 SUN
90 b
91 FDB-19960325
92 FDB-MLR

Rev. Mexicana Astron. Astrof., 21, 552-556 (1990)

FINE STRUCTURE IN THE MM-WAVELENGTH SPECTRA OF THE ACTIVE REGION

H.S. Sawant and J.R. Cecatto

Departamento de Astrofísica
Instituto de Pesquisas Espaciais, Brazil

RESUMEN. Faltan observaciones solares espectroscópicas en la longitud de onda milimétrica. Hay sugerencias de que se puede superponer una fina estructura en frecuencia a la componente-S de la región solar activa, así como a la componente del brote en las longitudes de onda milimétricas. Se ha desarrollado un receptor de alta sensibilidad de pasos de frecuencia que opera en el intervalo de 23-18 GHz con una resolución de 1 GHz y resolución de tiempo variable entre 1.2 y 96 sec, usando la antena de Itapetinga de 13.7-m para estudiar la estructura fina en frecuencia y tiempo. Discutimos el espectro en longitud de onda-mm en regiones activas y su evolución en el tiempo. El estudio de la evolución en el tiempo de la región activa en AR 5569 observada el 29 de junio de 1989, sugiere la existencia de estructuras finas como función del tiempo.

ABSTRACT. There is a lack of mm-wavelength spectroscopic solar observations. There are suggestions that a fine structure in frequency may be superimposed on the S-component of solar active region as well as on the burst component at mm-wavelengths. To study fine structure in frequency and time, a high sensitivity step frequency receiver operating in the frequency range 23-18 GHz with frequency resolution of 1 GHz and variable time resolution 1.2 to 96 sec, using 13.7 m diameter Itapetinga radome covered antenna, has been developed. Here, we discuss mm-wavelength spectra of active regions and their time evolution. Study of time evolution of an active region AR 5569 observed on 29th June, 1989 suggests existence of fine structures as a function of time.

Key words: SUN-ACTIVITY — SUN-RADIO RADIATION

I. INTRODUCTION

Unique spectroscopic observations of active region, carried out by Kaverin et al. (1979) in the frequency range of 5 to 7 GHz with $\Delta f/f \leq 0.1$, suggested the existence of a fine structure in frequency. Recently, same authors have extended their studies up to 12 GHz by using two spectroscopes operating in the frequency range of 12-8 and 7-5 GHz and have confirmed their earlier results (Kaverin et al. 1983). On theoretical grounds, Zheleznyakov and Zlotnik (1980) and Zheleznyakov and Tikhomirov (1982) have suggested that there is a possibility of superposition of cyclotron-lines on the spectra of the active region, which will appear as a frequency structure in the course of development of time. Detection of these lines will furnish information on the neutral sheet and the processes of development of flare. In view of the above mentioned fact, we have developed a mm-λ (23 - 18 GHz) spectroscope (in conjunction with 13.7 meter-diameter Itapetinga antenna) which is operational since 1988. Since then, we carry out periodically observations of active region and that of the burst component. Here we report spectral observations of the active region in particular, indicating presence of fine frequency structures, which are also time dependent.

II. INSTRUMENTATION

R.F. signal (23 - 18 GHz) received by a rectangular horn in a vertical polarization is fed into a mixer where a sweep frequency L.O. signal, derived from Yig oscillator by applying suitable variable voltage, is also fed. The sweep rate can be varied from 1.2 to 96 s - the frequency is varied in step of 1 GHz, the bandwidth of the receiver is 500 MHz. The dynamic range of the receiver is 20 dB. After suitably amplifying, the signal is detected by square law detector; and is recorded in series on one of channel of Ampex analogue tape recorder along with time marker. Digitization and data reduction are carried out off the line. For observations of active region, each frequency is observed for 8 sec. Thus, same frequency is observed after 48 sec. Front and backend arrangements of 13.7 m radome covered antenna, operating at 22 and 44 GHz, and also frequency accuracy, calibration, etc. have been described in detail by Kauffmann et al. (1982).Calibration of the antenna temperature is done by using a reference absorber. This method eliminates the effect of atmospheric attenuation to a good approximation (Ulich and Haas, 1976).

III. OBSERVATIONS

In May 1988, observations of solar active region were carried out for about 20 days. Observations were restricted to ± 2 hr of local noon. Most of these active regions were having percentage P above the quiet sun, of about 4%.

AR 5025 - Active region NOAA AR 5025 was having P ≥ 15% and was observed for five days from 20 May, 1988. When it appeared for the first time on the east limb, it had P ≥ 10%. It reached maximum of P = 37% on 23 May and then decreased to 20% on the following day. During its course, it gave flares for two days. Only on 22 May, there was no activity and observing conditions were excellent. On this day, AR 5025 was located at E37 S22.

From 13:05 UT to 14:03 UT, center of the sun, quiet sun level was observed in the frequency range 23 to 18 GHz.

From 14:03 to 15:30 UT, calibration of the system with absorber as load was carried out. From 15:30 UT to 17:10 UT, active region AR 5025 was observed in variable frequency mode as mentioned above.

Time evolution of the spectra of active region AR 5025 for near about 2 hours did not show any significant variation either with frequency or with time even though active region was situated near eastern limb. The nature of the spectra was similar to that of spectra obtained for center of the sun. The spectral index of the spectra in the frequency range of (23 - 18) GHz was $\lesssim$ 0.1. Thus there was not much dependence of flux on frequency.

June 14 - 31, 1989 "MAX-91 Campaign" - In June 1989, along with "MAX-91" campaign solar observations were carried out for 21 days. Depending upon the programme, solar observations were carried out either with time resolution of 48 s for observations of active region or with time resolution of 1.2 s in case of observations of the burst component. Observation of burst components observed in the (23 - 18 GHz) will be reported elsewhere. Here, we are reporting observations of active regions. Active regions were observed for 45 hours. Out of these only 14 hours were suitable for carrying out spectral investigations.

AR 5528 - The active region AR 5528 was observed from 15/06 to 19/06. We report here observation of the region for 19/06/89. On this day, active region was situated at N17 W50 and was having, Tar, the antenna temperature of the active region = 33% and is represented by the percentage above the quiet sun, P = 100 x Tar/Tsun = 33%, where Tsun is the adopted quite sun temperature.

Spectra of this active region showed time dependent frequency variation and in almost all cases, fluxes decreased by about 15 to 20% during one and a half hour except at one frequency (20 GHz), where there was almost negligible (~ 2%) decrease in flux. However, it should be noted that this region was near western limb and needs more detailed investigation of the time evolution of the spectra.

AR 5569 - This active region was observed from 28/06 up to 01/07/89. We are reporting observations of this active region for 29/06/89. On this day, this active region was located at N19 W08 and was having Tar, the temperature of the active region above quite sun equal to 17%. Fig. 1 shows radio map obtained at 22 GHz and the position of the active region.

The beamwidth (HPBW) of the antenna at 22 GHz is 4'. It should be noted that this active region was practically located near the center of the sun. The observing conditions on this day were excellent. The center of the sun, a region away from the active region, was observed from 11:55 to 12:15 UT. The average spectra of the center of sun for an half hour are shown in fig. 2 and are normalized to 18 GHz.

The spectra are almost flat over the frequency range of 23 to 18 GHz and the spectral index over this frequency range is ~ 0.1. From 12:16 to 17:00 UT the active region was traced. The position of the active region was decided from 22 GHz radio map. In order to obtain the spectra of the active region and to eliminate all common sources of errors, the flux value of the center of the sun at each frequency was subtracted from the observed flux values of active region at the same frequency, averaged over ten minutes and then spectra of the active region were plotted. Fig. 3(a,b,c,d) show that the first four plots, corresponding to time interval of 12:16 to 13:26 UT are similar in nature to that of the center of sun plot (fig. 2). During this interval flux variation ranged from 1 to 9 percent and there was decrease in flux values.

Spectra of the active region, obtained in the same manner as described above, for the further interval 16:25 to 17:00 UT are shown in fig. 3(e,f,g).

As seen from the spectra, there is a clear excess of emission by of about 13% of the original value over a narrow band around 20 GHz.

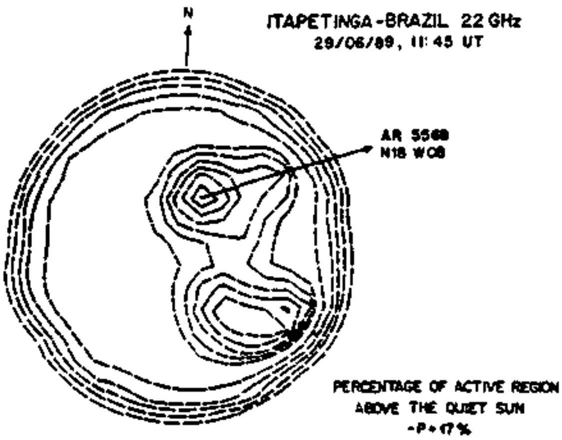

Fig. 1. 22 GHz sun map obtained in 6 min at Itapetinga at 11:45 UT, displaying mm-wave active region. Maximum corrected antenna temperature was 6420 K at 22 GHz for AR 5569. Isophotes were taken every 136 K, except four outer circles which correspond to 50%, 62%, 75%, and 88% respectively to the quiet sun level. Antenna temperature is not corrected for beam efficiency.

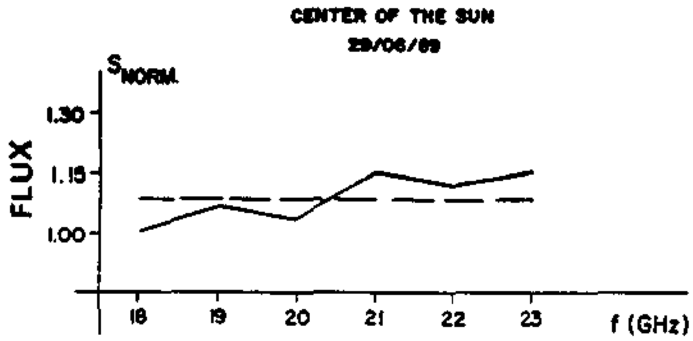

Fig. 2. Plot of flux, normalized to 18 GHz, versus frequency for the center of the Sun, averaged over twenty minute intervals as indicated.

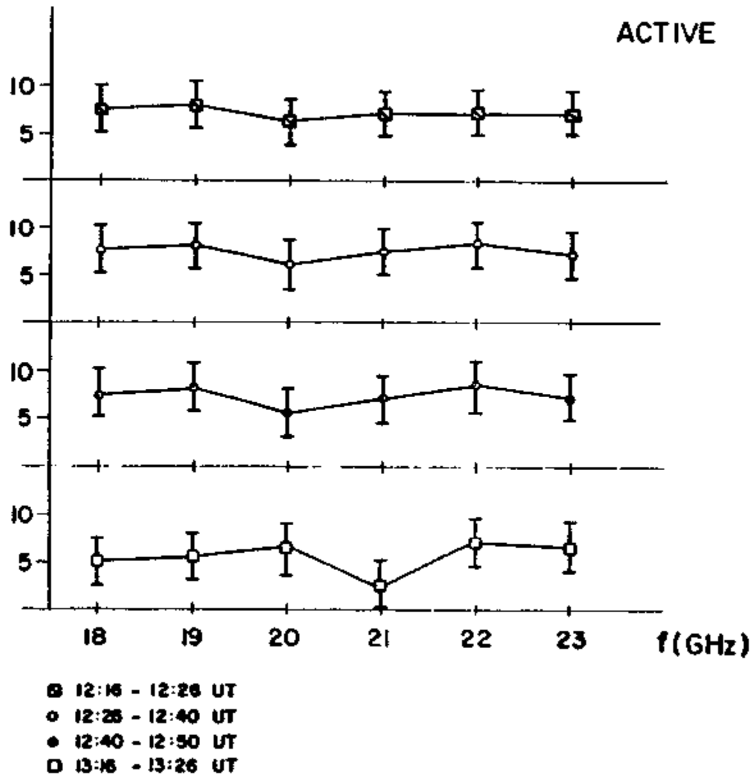

Fig. 3(a,b,c,d) Plot of flux of the active region averaged over ten minutes intervals after subtracting values for the center of the sun, corresponding to the period 12:15 to 13:26 UT.

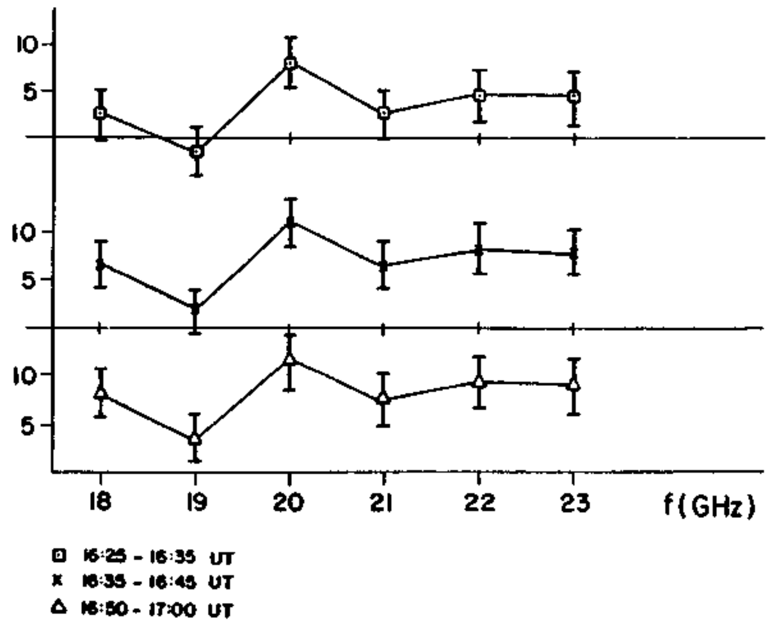

Fig. 3(e,f,g) Similar values for the further period 16:25 to 17:00 UT.

IV. DISCUSSIONS

Spectra of the center of sun: The spectra of the center of the sun obtained for about one hour on each day of observation discussed in the text, showed flux variation of about 1%. Also there was not much dependence of flux on frequency and time. Spectral index ranged between 0.10 to 0.15 for different days. This suggests that the radio emission observed in the frequency range of (23 - 18) GHz was mostly of thermal origin.

Active regions at limbs:

AR 5025 - Observed for about two hours on eastern limb on May 22, 1988, surprisingly did not show significant (≤ 10%) flux variation. Moreover, the nature of spectra of active region and that of the center of sun was similar.

AR 5528 - Observed on western limb on 19/06/89 for about one and half hour showed frequency and time dependent flux variation of the order of ≥ 15%. This variation may be due to limb effect.

Active region near center of sun:

AR 5569 - Observed on 29/06/89. Spectra of the active region observed for the first forty minutes did not show significant (< 5%) frequency time dependent variation. Whatever flux variation was there, was decreasing and spectra of the active region was of a nature similar to that of center of sun. However, the next half of the observations for thirty minutes showed enhancement of the flux around 20 GHz by ~ 10%. We feel this may be possible detection of a cyclotron line superimposed on the 'S-component' - of thermal origin - of active region. Details of this are being worked out.

Thanks are due to Prof. R. P. Kane for discussions and suggestions.

REFERENCES

Kauffmann,P. R., Strauss,F. M., Schaal,R.E., and Laporte,C., 1982, Sol. Phys., 78, 389.
Kaverin,N. S., Kobrin,M. M., Korshunov,A. I., and Shushunov,V. V., 1979, Sol. Phys., 63, 379.
Kaverin,N. S., et al., 1983, Proceedings of the 11th Regional Consultation on Solar Physics, Debrecen Heliophysical Observatory, Vol. 5(part II), 631-638.
Ulich,B. L., and Haas,R. W., 1976, Astrophys. J., (Suppl. Ser.), 30, 247.
Zheleznyakov,V. V., and Zlotnik,E. Ya, 1980, Radio Physics of the sun Ed. Kundu, M. R., and Gergely, 87.
Zheleznyakov,V. V., and Tikhomirov,Yu. V., 1982, Sol. Phys., 81, 121.

Hanumant S. Sawant, José Roberto Cecatto: Departamento de Astrofísica, Instituto de Pesquisas Espaciais, C.P. 515, 12201 São José dos Campos, SP, Brasil.