Investigações de Dados do "Brazilian Solar Spectroscope – Bss" Incluindo Criação de Software E Adaptação.

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RESUMO

Iniciado em agosto de 2003, tem como objetivo a continuidade ao projeto de Iniciação Científica em andamento para a implementação de rotinas computacionais e da aplicação e desenvolvimento de novas aplicações para dinamizar o estudo de dados na análise de explosões solares registradas pelo Brazilian Solar Spectroscope (BSS), em operação no INPE desde 1998, tendo como nova solução a criação de novos softwares como apoio no tratamento dos dados . Dois programas para a visualização e o tratamento dos dados do BSS são usados atualmente: BSSView e BSSData. Os Softwares auxiliar(*VELODERI*), assim criado facilita o cálculo da taxa de deriva em freqüência e da densidade de fluxo das explosões solares. Assim pelo curto período de execução do projeto (4 meses), foram realizadas apenas atividades introdutórias sobre o funcionamento global do BSS, em particular do sistema de aquisição e do formato dos dados digitais e dos programas de visualização e tratamento de dados em utilização. Os resultados parciais obtidos são: o início ao aprendizado do ambiente de programação **IDL** (*Interactive Data Language from Research Systems)*, uma linguagem mundialmente utilizada em diversas áreas de pesquisas espaciais e na qual os programas para o tratamento dos dados do **BSS** são desenvolvidos. Início do aprendizado na manipulação dos programas **BSSView**, incluindo duas atualizações realizadas pelo desenvolvedor " *Cláudio Faria* ", (acompanhada e sugestionado) e BSSData apenas analisado. Através da utilização destes programas, promoveu-se uma atualização da listagem das explosões solares ocorridas em 2002, 2003. Para dar continuidade a este projeto de Iniciação Científica estão programadas as atividades; aperfeiçoamento do conhecimento da linguagem IDL, Visual Basic 6 para implementação e aplicação de rotinas específicas e softwares auxiliares para análise dos dados do BSS, em particular na determinação da taxa de deriva em freqüência e da densidade de fluxo do sol calmo a partir de dados diários em diferentes freqüências obtidos via Internet e conclusão da obtenção dos espectros dinâmicos das explosões solares registradas pelo BSS em 2002 , 2003 e 2004.

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MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

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INVESTIGAÇÕES DE DADOS DO "BRAZILIAN SOLAR SPECTROSCOPE – BSS"

Luis César Pereira de Moraes

Relatório Final de Projeto de Iniciação Científica
(PIBIC/CNPq/INPE)

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São José dos Campos
2004

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INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

**RELATÓRIO FINAL DE PROJETO DE INICIAÇÃO CIENTÍFICA
(PIBIC/CNPq/INPE)**

INVESTIGAÇÕES DE DADOS DO "BRAZILIAN SOLAR SPECTROSCOPE – BSS"

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INVESTIGAÇÕES DE DADOS DO "BRAZILIAN SOLAR SPECTROSCOPE – BSS"

RELATÓRIO FINAL DE PROJETO DE INICIAÇÃO CIENTÍFICA
(PIBIC/CNPq/INPE)

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Observação solar de alta resolução e investigação de explosões solares em banda larga de freqüência ondas decimetricas (1000 – 2500 MHz),particularmente explosões **Tipo III, Spikes e Patches**, para um melhor entendimento de problemas fundamentais de física solar, como o armazenamento e a liberação de energia dos **flares** e processos de aceleração de partículas e sua interação com a atmosfera solar (cromosferica e coroa) e também de explosões solares Tipo II e Tipo IV para investigação de relações sol-terrestres.

CAPITULO 2 – RESULTADOS ALCANÇADOS

Estudo sobre flare, estudo do sistema de funcionamento do BSS (Brazilian Solar Spectroscope), pelo seu todo, começando do funcionamento da antena , transmissão de dados para o sistema de aquisição e toda sua diagramação algorítmica para a geração de dados (*.esp), visualizados pelo programa Bssview, estudo de explosões solares e estruturas finas em freqüência e tempo .

Acompanhamento de aquisição de dados em tempo real do instrumento BSS obtendo informação passo a passo sobre a aquisição.

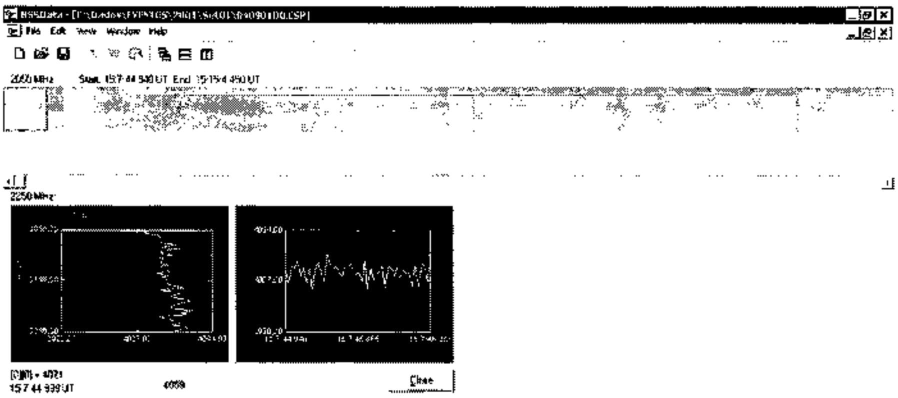
Extração de estruturas finas, através da ferramenta de extração de conjunto, para estudo avançado de eventos detectados e verificação de deriva através do estudo detalhado do evento através de medição de tempo detalhado em milisegundos obtendo a estimativa da velocidade do agente emissor a partir da taxa de deriva usando um modelo de densidade da atmosfera solar.

Identificação de estruturas pela sua medição, aplicação de ferramentas do BSSVIEW, sobre dados adquiridos pelo instrumento (tratamento) e estudo de rotinas do IDL *(Interactive Data Language from Research Systems),* com o Código fonte do BSSVIEW, para correção de erros ou upgrade`s no software (Autor: Cláudio Faria) no uso de aquisição de dados do projeto BSS.

2.1 Trabalhos com software BSSDATA (C++ Builder).

Medição de eventos com precisão (Mhz / Tempo), com uso de ferramentas do software BSSDATA e do MS Excel, para elaboração de gráficos.Estudo de Código fonte para possível alteração.

BSSData



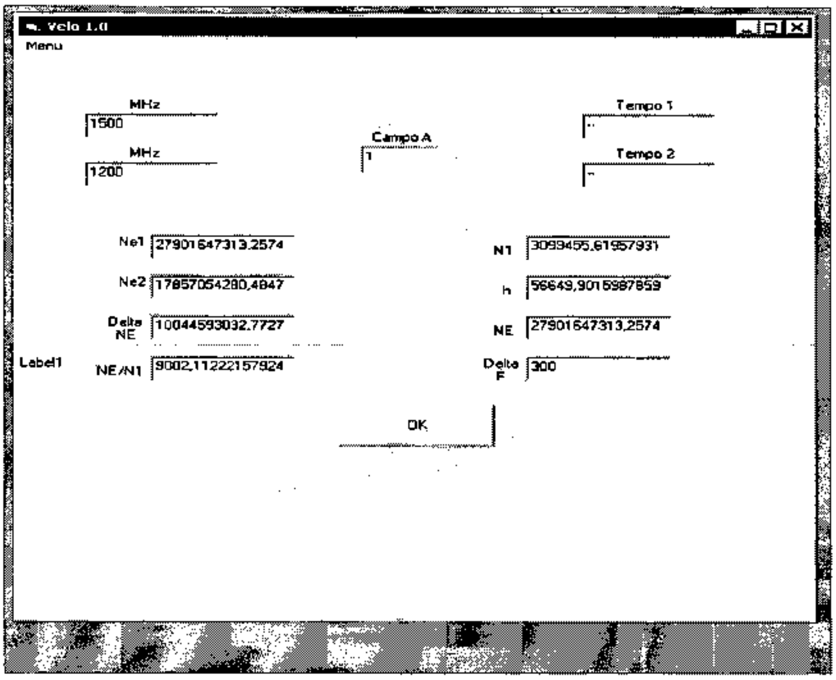
2.2 Estudo de criação de software de Calculo de velocidade e Deriva.

Estudo de software de calculo de velocidade e deriva em linguagem de alto nível, com desenvolvimento lógico avançado em **(C++ Builder)** para possível integração ao software BSSDATA, com criação de tabelas de calculo e fórmulas inseridas no contexto do programa para simplificar o uso do programa de forma
lógica e usual.

2.3 Desenvolvimento de Software de Cálculo

Desenvolvimento de software de cálculo de deriva e velocidade em MHz, dos dados, adquiridos através do *Brazilian Solar Spectroscope (BSS)* e BSSView (software de visualização). Software foi desenvolvido em linguagem Orientada a objetos Visual Basic 6, com layout simplificado para usuário, com cálculo de deriva, altura e velocidade das dados adquiridos.

VELODERI - Velo1.0



MHz 1500

MHz 1200

Campo A 1

Tempo 1

Tempo 2

Ne1 27901647313.2574

Ne2 17857054280,4847

Delta NE 10044593032.7727

NE/N1 9002,11222157924

N1 3099455,61957931

h 56649,9015987859

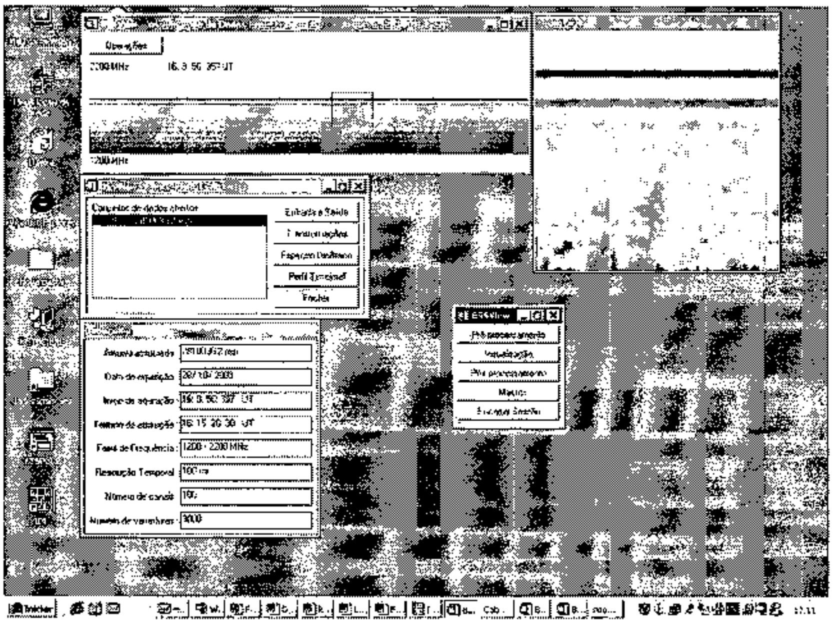
NE 27901647313,2574

Delta F 300

CAPITULO 3 - MATERIAIS E METODOS

3.1 Toda a estrutura do *Brazilian Solar Spectroscope (BSS)* e BSSView (software de visualização) e softwares de desenvolvimento (Visual Basic, IDL, C++Builder)

BSSView



CAPITULO 4 – PRODUÇÃO CIENTIFICA

4.1 F. C. R. Fernandes, J. R. Cecatto, M. C. Andrdade, F. R. H. Madsen, L. C. P. Moraes and H. S. Sawant., DECIMETRIC FINE STRUCTURES AS A POSSIBLE SIGNATURE OF CHROMOSPHERIC EVAPORATION, ***Aceito*** Brazilian - Journal of Physics, 2004. Artigo Publicado Anexo

4.2 F. C. R. Fernandes, José R. Cecatto, Maria Conceição de Andrade, Felipe R. H. Madsen, Luis. C. P Moraes, Hanumant S. Sawant, CHROMOSPHERIC EVAPORATION AND ASSOCIATED SHOCK-LIKE STRUCTURES IN SOLAR FLARES. ***Apresentado*** no 7o. Encontro Brasileiro de Física de Plasma & X Latin American Workshop on Plasma Physics, São Pedro, SP, Dezembro, 2003.

4.3 L. C. P, Moraes, L. C. P., Fernandes, F. C. R., Cecatto, J. R., Sawant, H. S. PRE-FLARE DECIMETRIC FINE STRUCTURES – ***Apresentado*** no COLAGE - VII Latin-American Conference on Space Geophysics, Atibaia, - Março-Abril, 2004.

4.4 Francisco C. R. Fernandes, Alan W. S. Silva, Robert A. Sych, José R. Cecatto, Felipe R. H. Madsen, Luís C.P. Moraes, Hanumant S. Sawant SLOWLY DRIFTING DECIMETRIC FINE STRUCTURES SSOCIATED WITH PRE- FLARE PHASE - National Institute of Space Research - INPE, São José dos Campos, Brasil – Submetido ao IAU223 - IAU Symposium 223, St. Petersburg, Rússia, Junho, 2004.

CAPITULO 5 - CONCLUSÃO

5.1 Conclusão de implementação dos softwares ***BSSVIEW*, *BSSDATA*** (software's de linguagens diferenciadas IDL e C++ Builder).

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6.2 Estudo de dados adquiridos do *Brazilian Solar Spectroscope (BSS)* dos anos 2003 e 2004.

6.3 Implementação de softwares BSSView *(Interactive Data Language from Research Systems)* e BSSdata *(C++ Builder).*

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DECIMETRIC FINE STRUCTURES AS A POSSIBLE SIGNATURE OF CHROMOSPHERIC EVAPORATION

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ABSTRACT

In this work, we concentrate in the analysis of radio slowly drifting fine structures associated with solar flares recorded in the frequency range of (1000-2500) MHz by the Brazilian Solar Spectroscope (BSS), in regular operation at National Institute of Space Research (INPE) - Brazil. The main morphological aspects of each fine structure are narrow-band of about 5-10 MHz and small duration of the order of 50 milliseconds. The majority of these fine structures are observed over a time interval of a couple of minutes before the maximum of the associated flare, in the impulsive phase. However, some observations during the gradual decay phase are also reported. They drift towards lower frequencies, with slow rates typically of about of 10-100 MHz s^{-1}. Estimated velocities of the exciter from the negatively drifting structures suggest that the shock-like exciter is propagating in the higher chromosphere. Than, those fine structures are interpreted as a possible signature in decimetric emissions from the chromospheric evaporation phenomenon. Details of these observations and their interpretation in terms of the plasma emission produced by accelerated particles and the chromospheric evaporation front is presented.

Key Words: Sun: flares - Sun: radio radiation - Sun: chromospheric evaporation

1 INTRODUCTION

Decimetric band is known to exhibit various types of fine structures (Droege, 1977; Guedel and Benz, 1988; Allaart et al., 1990; Isliker and Benz, 1994). However, observations in the decimetric band became stagnant till 80's. Around that time the Skylab satellite observations showed that energy to the flare is released where the electron density range is around 10^9 - 10^{10} cm^{-3}, i.e., in the decimetric range of the solar radio spectrum (Moore et al., 1980 and references within). Since then, various high frequency-time resolution spectroscopes were put into operation (Kruger and Voight, 1995). The Brazilian Solar

Spectroscope (BSS) (Fernandes, 1997; Sawant et al., 2001) belongs to this new generation of solar radio spectroscopes. BSS is in regular operation since 1998 and it has recorded many different types of fine structures. Here, we analyze some particular groups of decimentric fine structures with slowly drifting high frequency edge. Karlický et al. (2002) also reported the observations of slowly drifting structures in decimetric range.

Recently, the chromospheric evaporation has been invoked to explain the occurrence of the slowly drifting fine structures in radio wavelengths (Karlický, 1998). In fact, the first suggestion the chromospheric evaporation could be investigated by radio observations in decimetric wavelengths generated by electron beam going down in magnetic loop and crossing up-going evaporation front was given by Aschwanden and Benz (1995).

The basic scenario of chromospheric evaporation is the following (Antonucci et al., 1984; Silva et al., 1997). During the very beginning of the flare, the turbulence in plasma of the active region begins and the flare energy is released up in the corona. This energy then accelerates particles and heats the plasma. The accelerated particles then move down toward the upper chromosphere along the magnetic lines, where they lose their energy by collisions with denser plasma. The heated plasma expands rapidly. However, it is confined by the magnetic loop structure, and then it flows upward with velocities of about a few hundreds of km s^{-1}. The up-flow of the hot plasma is known as chromospheric evaporation (Sturrock, 1973). The up-flowing hot plasma can be inferred by broadening and blue shifting of the lines as observed in soft X-ray (Antonucci et al., 1984; Antonucci et al., 1985; Tanaka, 1986; Watanabe, 1990; Antonucci et al., 1990; Silva et al., 1997).

Based especially on X-ray lines observations, many estimations of the velocity of chromospheric evaporation have been done. The determined evaporation front velocity ranges from aproximately 100 km s^{-1}, for the transition region (Teriaca et al., 2003) or of about 150 km s^{-1} (Cauzzi et al., 2002 and Teriaca et al., 2003) for coronal lines up to 950 km s^{-1} for decimetric layer (Karlický, 1998). Also, Mariska et al. (1989) estimated the velocity of 650 km s^{-1} and Silva et al. (1997) inferred the interval of 350-450 km s^{-1} for the velocity of the evaporation front.

While the hot and dense plasma rises up it creates a discontinuity in temperature and density, in the loop. Beam of energetic electrons moving towards the foot-points of the loop interacts with this slowly upward moving "shock front" where a optical thickness (τ) is reduced due to its temperature dependence ($\tau \propto n \times T^{-3/2}$) allowing to escape of high frequency radio emission. As the beam travels further it encounters high densities and lower temperature which increases opacity and radio emission is absorbed. Thus, as the shock front moves up, the cut off in high frequency will be slowly decreased allowing to infer the velocity of shock front. Eventually, the shock front will come in equilibrium with loop plasma and enabling escape of radio emission. Based on this scenario, Aschwanden and Benz (1995) have suggested that the decimetric fine structures with slow drifting variation can be observed as result of the chomospheric evaporation process. However, there is a lack of observations in radio wavelengths as an evidence of emission caused by the cromospheric evaporation.

Here, we present the decimetric fine structures associated with the solar flares recorded by BSS as a possible signature in decimetric waves of the chromospheric evaporation process. In section 2 we briefly describe the BSS instrument and its main characteristics. In section 3 the observations and the main properties of the fine structures recorded are presented. The shock velocity determinations and results are presented in section 4 and 5, respectively. The summary and conclusions are presented in section 6.

2 INSTRUMENTATION

The BSS was put into regular operation at INPE for systematic solar observations in 1998 (Fernandes et al., 2000; Sawant et al., 2001). It operates in conjunction with a 9 meter diameter polar mounted parabolic antenna, over the frequency range of (1000-2500) MHz, with high time (10-50 ms) and frequency (3 MHz) resolutions. The data are recorded in up to 100 digital channels (Sawant et al., 2000), with absolute timing accuracy of 3 milliseconds. Thus, the BSS system has the capability to detect fine structures with narrow bandwidth and short durations (Fernandes et al., 2001).

3 DECIMETRIC OBSERVATIONS

Since the BSS has been put into regular operation, in 1998, it recorded more than 350 groups of solar decimetric emissions, most of them showing fine structures in time and/or frequency (Fernandes, 2003a,b,c,d). Out of them, we have selected the emissions associated with 8 solar flares recorded by BSS showing decimetric fine structures with high frequency edge slowly drifting from high to low frequencies observed in the period of March, 1999 to July, 2002. The Figures 1 and 2 show the dynamic spectra of the recorded fine structures selected for analysis.

In the Table 1 we present a list of these emissions. The associated soft X-ray flares (GOES satellite) were also included. For 6 flares the fine structures occur prior the maximum of the soft X-ray associated emission, in the impulsive phase. In 3 cases, they are associated with the gradual decay phase of the X-ray emission, and for 1 case they are observed during the peak time of the soft X-ray emission. Except for 1 flare (classified as C1.6), the soft X-ray flares reported by GOES satellite associated with the fine structures were very intense: 3 flares reached X class and others 4 the M class.

Table 1: Solar flares showing decimetric slowly drifting fine structures.

				Associated activity				
Event No.	Day	Time (UT)	Band (MHz)	Start (UT)	Max (UT)	End (UT)	Goes Class	Active Region #
1	28/JUN/99	12:21	1615-1260	12:13	12:17	12:25	C1.6	8611
2	27/NOV/99	12:08	1460-1015	12:05	12:12	12:16	X1.4	8771
3	06/JUN/00	15:05	1660-1265	14:48	15:25	15:40	X2.3	9026
4	06/JUN/00	16:26	1460-1210	14:48	15:25	15:40	X2.3	9026
5	06/JUN/00	16:32	1350-1235	14:48	15:25	15:40	X2.3	9026
6	16/SEP/00	14:21	1675-1535	14:16	14:28	14:32	M3.3	9165
7	21/SEP/00	18:22	1130-1010	-	-	-	245-606 MHz	
8	24/NOV/00	15:07	1970-1880	14:51	15:13	15:21	X2.3	9236
9	05/SEP/01	14:32	2170-2125	14:25	14:32	14:34	M6.0	9601
10	04/APR/02	15:28	1240-1000	15:24	15:32	15:38	M6.1	-
11	11/JUL/02	14:48	1190-1150	14:44	14:51	14:57	M5.8	10030

4 DATA ANALYSIS

4.1 Frequency Drift Rate

The high frequency and time measurements for each individual fine structure have been done using the BSSView and BSSData software. Then, the drift rate of the high frequency edge of each group of fine structures was determined from a linear regression in the frequency-time plane as shown in the Figure 3. The drift rates determined are given in the Table 2.

4.2 Chromospheric Evaporation Shock Velocity

The frequency drift rate (df/dt) of the bursts group can be given by

$$\frac{df}{dt}=\frac{df}{dNe}\,\frac{dNe}{dh}\,\frac{dh}{dt}=\frac{df}{dNe}\,\frac{dNe}{dh}\,v_{ce}cos\theta \ , \tag{1}$$

where f is the plasma frequency, N_e is the electron density, h is the height above the photosphere, θ is the angle between the direction of propagation of the front and the vertical direction and v_{ce} is the chromospheric evaporation front velocity.

For the plasma emission the plasma frequency can be given as function of electron density in the solar atmosphere as:

$$f = s \times 8.98 \times 10^{-3} N_e^{1/2} \text{ (in MHz)}. \tag{2}$$

where s is the harmonic radiation number ($s = 1$ for fundamental emission and $s = 2$ for second harmonic emission).

We have used a density model for the solar chromosphere derived from the statistical relation between drift rate and frequency of decimetric type III bursts (Melendez et al., 1999):

$$\frac{df}{dt} = A f^{\alpha} , \tag{3}$$

where $A = 0.09$ and $\alpha = 1.35$.

The density model used (Melendez et al., 1999) was adapted from Aschwanden and Benz (1995) model and it assumes a power-law dependence for the low corona and an exponential shape for the upper corona as follows:

$$N_e(h) = \begin{cases} N_1 \left(\frac{h}{h_1}\right)^{-p} & \text{if } h \leq h_1 \\ N_q \, exp\left(\frac{-h}{H}\right) & \text{if } h > h_1 \end{cases} , \tag{4}$$

where h is the height in the solar atmosphere, h_1 is the height of the transition in the density variation regime, where the power-law model is changed into exponential one, N_1 is the density transition, and N_q is the electron density at the bottom of quiet solar corona obtained by barometric model, p is the power-law index and H is the density height scale. From the continuity conditions at the height h_1 we have:

$$h_1 = p H \tag{5}$$

and

$$N_1 = N_q \, exp(-p) . \tag{6}$$

As shown by Aschwanden and Benz (1995), the constants p and N_q can be expressed as:

$$p = \frac{2}{(\alpha - 1)} \tag{7}$$

and

$$N_q = \left(\frac{e\,v}{2\,A}\right)^p (s \times 8980)^{-2}\,, \tag{8}$$

where v is the beam velocity expressed in units of the speed of light, A and α are constants in the empirical type III drift rate by Melendez et al. (1999). We considered the second harmonic radiations ($s = 2$), and assuming the following values for the constants $H = 7 \times 10^4$ km, $h_1 = 3.5 \times 10^5$ km, $N_q = 4.6 \times 10^8$ cm^{-3} and $p = 5$ we determined the density and height intervals covered by the fine structure groups.

5 RESULTS

Considering the frequency drift rates for the high frequency edge of the decimetric emissions, the shock-front velocity of the source was estimated assuming a displacement in a vertical direction. The measurements of total duration of the global structure (Δt), frequency drift rate (df/dt), density interval (ΔN_e), height interval (Δh) and shock-front velocity of the fine structure source (v_{ce}) are shown in Table 2.

Table 2: Measurements of the fine structures parameters.

Event No.	Δt (s)	df/dt (MHz s^{-1})	ΔN_e ($\times 10^9$ cm^{-3})	Δh ($\times 10^3$ km)	v_{ce} (km s^{-1})
1	4.5	80	3.1	7.7	1700
2	30.0	15	2.3	9.0	300
3	15.7	25	3.5	8.1	515
4	2.5	100	1.0	3.2	1280
5	6.0	19	1.0	3.1	520
6	5.8	24	1.4	2.6	450
7	15.3	8	0.8	3.9	250
8	1.7	53	1.5	2.3	1350
9	3.8	12	0.6	0.1	30
10	7.2	38	1.7	7.4	1025
11	23.0	2	0.3	1.7	75

6 SUMMARY AND DISCUSSIONS

We have presented some radio fine structures showing slowly drifting frequency associated with solar flares recorded Brazilian Solar Spectroscope (BSS), in the frequency range of (1000-2500) MHz. The common characteristics of those fine structures are the narrow-band and short duration. The high frequency edge of the fine structure groups slowly drifts towards lower frequency, with rates less than 100 MHz s^{-1}.

Those fine structures were interpreted as a possible signature of chromospheric evaporation process in decimetric wavelengths. In this case, the evaporation shock front causes the frequency drift of layer with reduced optical thickness, from where the decimetric radiation can escape. This drift depends upon the evaporation front velocity. Thus, there is a drifting "window" in which the electromagnetic radiation of plasma emission can escape and can be observed. The scenario of the visibility "window" for decimetric emission (1000-2500 MHz) drifting towards lower frequencies is valid at the very beginning of the flare, during the pre-impulsive phase in which the accelerated electron beam is heating the dense plasma. However, we have observed slowly drifting fine structures during the pre-flare phase but also associated with the gradual phase. These results also reported previously by (Czaykowska et al., 1999) is an evidence that, even in the late phases of some particular flares, the dynamic of the heated plasma into the magnetic configuration permits the escape of the electromagnetic radiation in the decimetric range.

We considered the plasma emission at second harmonic, which has higher possibility to escape from dense layer of the solar atmosphere (10^9 cm^{-3}) and we have used a density model for the solar chromosphere based on frequency drift rates of type III bursts observations (Melendez et al., 1999). From the frequency drift rate of the high frequency edge of the fine structures we are able to estimate the front velocity of the evaporation shock in the range of 30-1700 km s^{-1}. These velocities are comparable with those computed by Mariska et al. (1989) and Karlický (1998) and other authors as mentioned in the Introduction, and they agreed with the upper limit of the chromospheric evaporation velocities reported by Fisher et al. (1984).

These results permit to interpret those fine structures as a possible signature of the chromospheric evaporation phenomenon in decimetric wavelengths. Complementary investigations of those emissions in other wavelengths are ongoing to confirm the results and will be reported elsewhere.

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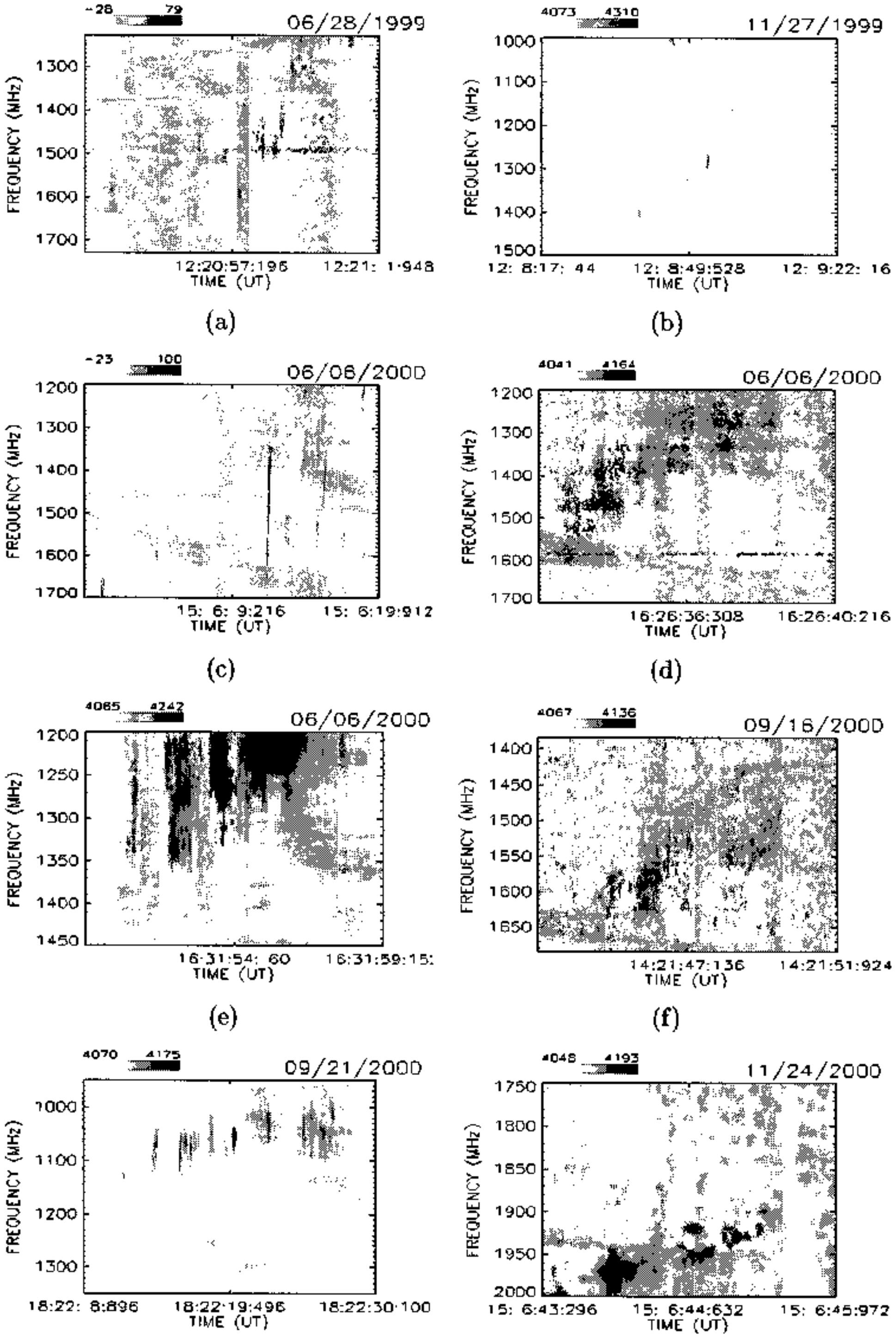


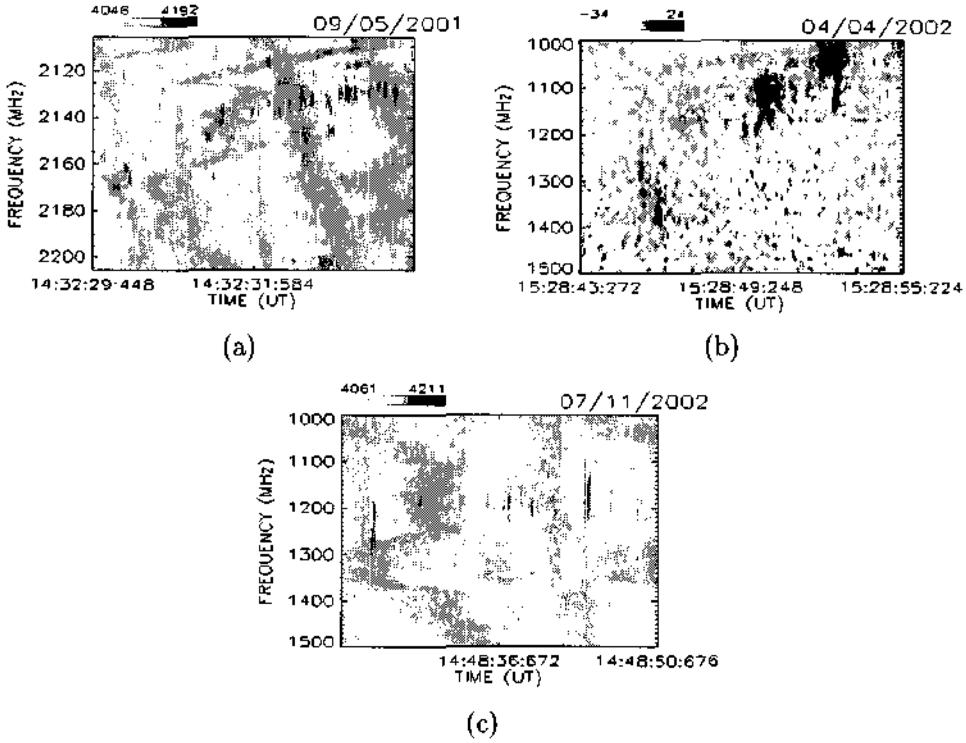
(a) (b)

(c) (d)

(e) (f)

(g) (h)

Figure 1: Examples of dynamic spectrum of decimetric fine structures showing slow drifting frequency variation: (a) June 28, 1999 (~12:21 UT); (b) November 27, 1999 (~12:08 UT); (c) June 6, 2000 (~15:05 UT); (d) June 6, 2000 (~16:26 UT); (e) June 6, 2000 (~16:32 UT); (f) September 16, 2000 (~14:21 UT); (g) September 21, 2000 (~18:22 UT); (h) November 24, 2000 (~ 15:07 UT). For all dynamic spectra, the background level of the emission was subtracted.



(a) (b)

(c)

Figure 2: Examples of dynamic spectrum of decimetric fine structures showing slow drifting frequency variation: (a) September 5, 2001 (~14:32 UT); (b) April 4, 2002 (~15:28 UT); (c) July 11, 2002 (~14:48 UT). For all dynamic spectra, the background level of the emission was subtracted.

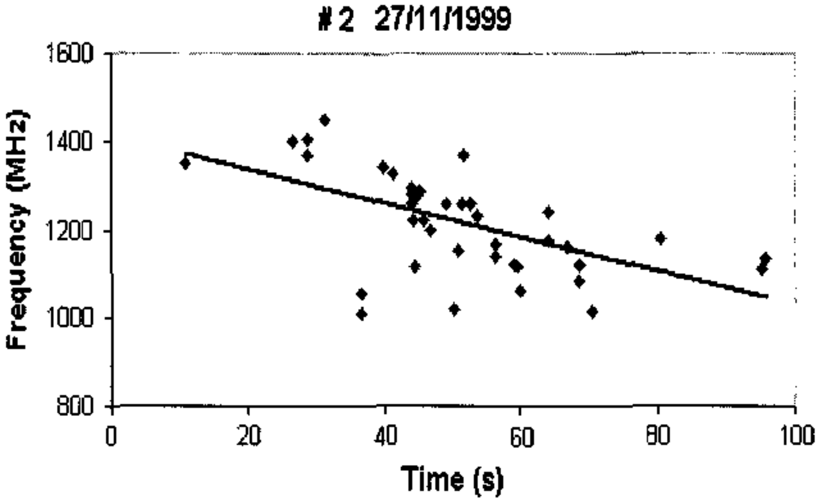


Figure 3: Example of frequency drift rate determination by linear fit of the high frequency edge points of the emission structures.

VII COLAGE -
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PRE-FLARE DECIMETRIC FINE STRUCTURES

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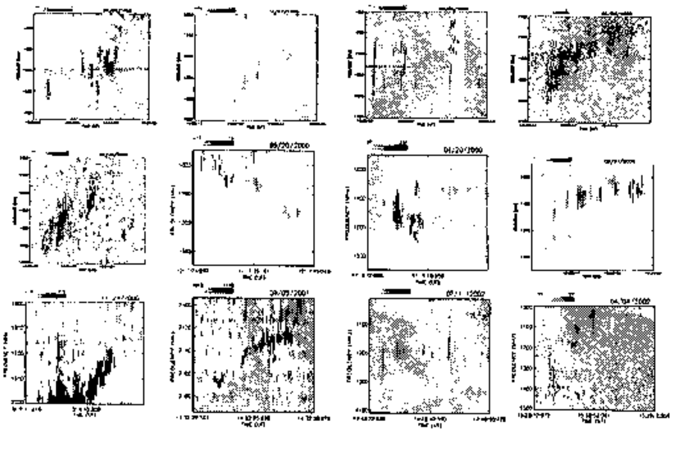
The Brazilian Solar Spectroscope (BSS) is operating at INPE, in the frequency range of (1000- 2500) MHz, with high frequency and time resolution, and having 25 up to 100 digital channels. With this instrument, we have carried out solar observations for last ten years. From 1999 to 2002, BSS have recorded various types of decimetric fine structures associated with pre-flare phase of many solar flares. Fine structures are typically having frequency range and total durations up to the frequency and time resolutions of the BSS, i.e. up to 5 MHz and 20 milliseconds, respectively. The observed flux density values are above 10 sfu. Their frequency drift range varies from almost zero to maximum up to the limit of the BSS. The most important types of fine structures observed are the intermittent chains of fast drifting, narrow-band and small duration fines structures. They are drifting towards either lower or higher frequencies with slow rates typically of about of 100 MHz s-1. Total duration of these drifting fine structures is couple of minutes. The main characteristics of different types of pre-flare fine structures and the details of the chains of the fine structures were obtained and will be presented.

OBSERVATIONS

#	DAY	Time (UT)	Freq (MHz)	ASSOCIATED ACTIVITY				
				Start	Max	End	Goes	AR
1	28/JUN/99	12:21	1700-1200	12:13	12:17	12:25	C1.6	8611
2	27/NOV/99	12:08	1500-1000	12:05	12:12	12:16	X1.4	8771
3	06/JUN/00	15:05	1700-1200	14:48	15:25	15:40	X2.3	9026
4	06/JUN/00	16:26	1650-1300	16:17	-	1710	RBR 54-5600	
5	06/JUN/00	16:32	1400-1250	16:17	-	1710	RBR 54-5600	
6	16/SET/00	14:21	1700-1400	14:16	14:28	14:32	M3.3	8611
7	20/SET/00	12:07	1200-950	11:52	11:56	12:10	N05E52	8771
8	20/SET/00	17:03	1250-1050					
9	21/SET/00	18:22	1200-1050	18:24	18:25	18:27	RBR 245-606	
10	24/NOV/00	15:07	1980-1900	14:51	15:13	15:21	X2.3	9236
11	05/SEP/01	14:32	2160-2060	14:25	14:32	14:34	M6.0	9601
12	04/APR/02	15:28	1240-1000	15:24	15:32	15:38	M6.1	limb
13	11/JUL/02	14:48	2150-2130	14:44	14:51	14:57	M5.8	10030



FRONT VELOCITY

The frequency drift rate (df/dt) of the bursts group is given by

$$df/dt = df/dNe \, . \, dNe/dh \, . \, dh/dt = df/dNe \, . \, dNe/dh \, . \, v_f \cos\theta \qquad (1)$$

where f is the plasma frequency, Ne is the electron density, h is the height above the photosphere, θ is the angle between the direction of propagation of the front and the vertical direction and vf is the front velocity.
For plasma emission, the frequency can be given as function of electron density as

$$f = 8.98 \times 10^{-3} Ne^{1/2} \quad (\text{in MHz}) \qquad (2)$$

We used a density model that assumes a power-law and an exponential-law for the low and upper corona respectively

$$Ne(h) = N1\,(h/h1)^{\alpha} \qquad \text{if} \quad h \leq h1 \qquad (4)$$
$$Ne(h) = Nq\exp(-h/H) \qquad \text{if} \quad h > h1 \qquad (5)$$

where h is the height of source, h1 is the height of the transition for density variation regime; N1 is the density transition, and Nq is the electron density at the bottom of quiet corona and H is the density height scale. From the continuity conditions

$$h1 = pH, \qquad (6)$$
$$N1 = Nq\exp(-p) \qquad (7)$$

the constants p and Nq can be expresses as

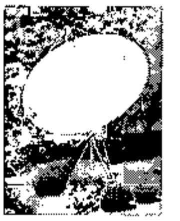
$$p = 2/(\alpha - 1) \qquad (8)$$
$$Nq = (e\,v / 2A)^{p} \, (s \times 8980)^{-2}$$

where s is the harmonic radiation number, v is the beam velocity in units of the speed of light, A and α are constants in the empirical drift rate and frequency relationship obtained for type III bursts. We considered the second harmonic emission $s = 2$, and the following values $H = 7 \times 10^4$ km, $h1 = 3.5 \times 10^5$ km, $Nq = 4.6 \times 10^8$ cm^{-3} and $p = 5$

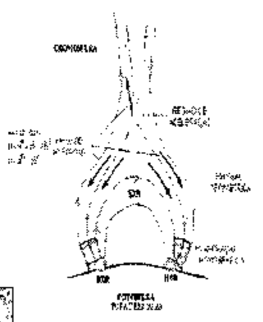
We determined the density and height intervals covered by the fine structure groups and the front velocity of the source

BRAZILIAN SOLAR SPECTROSCOPE

The BSS is in regular operation at INPE, in São José dos Campos, for systematic solar observations in since 1998. The BSS operates in conjunction with a **9 meter diameter polar mounted parabolic antenna**, over the frequency range 1000-2500 MHz, with high time (10-100 ms) and frequency (3-10 MHz) resolutions. The data are recorded in up to 100 digital channels (Sawant et al., 2000), with absolute timing accuracy of about 3 milliseconds. Thus, the BSS system has the capability to detect fine structures with narrow bandwidth and short durations



FLARE SCENARIO



The conditions of an active region concerning to the its activity, prior the impulsive phase of a solar flare are of essential importance for understanding the triggering and the evolution of the flare, in respect to the energy release. The magnetic fields at or near the flare source location plays the most important role. The main phenomena the reveal changes in the magnetic field of the active regions and may result in the production of a flare are erupting filament, emerging and twisting magnetic tubes, sunspot motions, **decimetric fine structures**.

There are only few evidences of radio emission associated with pre-flare phase reported. Most evidences are observations in soft X-rays and H-alpha. Recently, the chromospheric evaporation have been invoked to explain the occurrence of the **pre-flare slowly drifting fine structures in radio waves**

While the hot-dense plasma rises up, it creates a discontinuity in temperature and density. Electron beam moving towards the foot-point of the loop interacts with this slowly upward moving "shock front", where the optical thickness (t) is reduced due to its temperature dependence ($t \propto n \times T^{-3/2}$) allowing the high frequency radio emission to escape. As the beam travels further it encounters high densities and lower temperature which increases opacity and radio emission is absorbed. Thus, as the shock front moves up a cut off in high frequency will slowly decreased allowing to infer the velocity of shock front

RESULTS

#	df/dt (MHz/s)	Slope	ΔNe ($\times 10^9$ cm^{-3})	Δh ($\times 10^3$ km)	v (km/s)
1	80	N	3.1	7.7	1700
2	15	N	2.3	9.0	300
3	25	N	3.5	8.1	515
4	100	N	1.0	3.2	1280
5	19	N	1.0	3.1	520
6	24	N	1.4	2.6	450
7	2	RS	3.1	3.1	220
8	12	RS	2.5	6.1	310
9	8	N	0.8	3.9	250
10	53	N	1.5	2.3	1350
11	12	N	0.6	0.1	30
12	38	N	1.7	7.4	1025
13	2	N	0.3	1.7	75

SUMMARY

Decimetric fine structures are associated with the pre-impulsive phase of 13 solar flares recorded by BSS
The fine structures characteristics are
- **narrow-band: ~5-10 MHz**
- **short duration: ~50 ms**
- **high frequency edge slow drif: < 100 MHz/s**

Fine structures interpreted as a possible signature of evaporation process in decimetric wavelengths

The shock front causes the drift of layer with reduced optical thickness, from where the decimetric radiation escapes. This drift depends on the evaporation front speed

There is a drifting "window" in which the electromagnetic radiation can escape and can be observed.

The estimated front velocity of the shock is in the range of **30-1700 km/s.**

These velocities are comparable with those computed previously for radio emission. They agreed with the upper limit of the chromospheric evaporation velocities obtained by from X-ray lines observations.

ACKNOWLEDGEMENTS

FMI BSS CNPq FAPESP