The Solar Radio Observations at dm-cm Wavelength
---on Progress of CSRH Project

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Outline

- Introduction
- Some radio FS bursts associated with flare/ CME processes
- Recent progress of CSRH
- Summary
1. Introduction

- Coronal Mass Ejections, flares, and solar energetic particles, etc., have great influence in solar-terrestrial environment.
- These activities are believed due to sudden energy release, particle acceleration, and/or transportation processes of the solar magnetic field.
- Radio bursts are prompt indicators of various solar activities. Therefore radio observations provide important diagnosing tool on the related parameters such as B, n, T, etc.
• Radio emission generated by T and non-T electrons, provides important diagnostics in addition to EUV, SXR, HXR, and $\gamma$-rays (e.g., Aschwanden 2004).

• Freq. in $\sim 10^2$ MHz - $<10$ GHz corresponds to source $n$ of a few $10^8$ - $10^{11}$ cm$^{-3}$, where primary energy release of flares should take place (e.g., Bastian et al. 1998, Benz 2004)

• Radio FSs such as spikes, zebra patterns, pulsations are generally considered to be closely related to the primary energy release processes (e.g., Holman et al. 1980; Zaitsev & Stepanov 1983; Kliem et al. 2000).
Because of high (time/freq) resolutions by Chinese spectrometers in 1-7.6 GHz, detailed spectra of zebra patterns in 3GHz have appeared (Chernov 2006).
Imaging spectroscopy over cm-λ & dm-λ is important for addressing fundamental problems of energy release, particle acceleration and particle transport (Bastian, et al., ARAA, 1998; Gary & Keller 2004; Aschwanden 2004)
### Solar Radio Spectrometers at Huairou/NAOC

(Fu et al. 2004, Sol Phys)

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<tbody>
<tr>
<td>1.0 - 2.0 GHz</td>
<td>20 MHz</td>
<td>100 ms</td>
<td>2% - 10 dB of So</td>
<td>Yes</td>
<td>1994-2003(upgrade)</td>
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<tr>
<td></td>
<td>4 MHz</td>
<td>5 ms</td>
<td>2% - 10 dB of So</td>
<td>Yes</td>
<td></td>
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<tr>
<td>2.6 - 3.8 GHz</td>
<td>10 MHz</td>
<td>8 ms</td>
<td>2% - 10 dB of So</td>
<td>Yes</td>
<td>1996-</td>
</tr>
<tr>
<td>5.2 - 7.6 GHz</td>
<td>20 MHz</td>
<td>5 ms</td>
<td>2% - 10 dB of So</td>
<td>Yes</td>
<td>1999-</td>
</tr>
</tbody>
</table>

((Fu et al. 2004, Sol Phys))
Sub-sec zebras (>50) extended from type IV continuum

02:21

02:25
Spiky Zebra & Pulsations.

From whistler wave model (Chernov et al. 2005) and DPR model (Kuznetsev & Tsap 2007), we estimate $n \sim 10^{11} \text{cm}^{-3}$, $B \sim 50$–170G in impulsive Phase. $\sim 90$–200G 2min after flare peak. But scale height ratio decreased by a factor of 2 (Yan et al 2007).
Drifting bi-directional bursts for ~20s, or upward motion of the reconnection site, for 13 Dec 2006 flare event, was observed.

(Hinode XRT images)

(±) drift rates >10GHz/ s at ~3 GHz means $n_e \sim 10^{11}$ cm$^{-3}$
Another drifting bi-directional bursts around 03:44 UT for 13 Dec 2006 flare event
Exciter at m-dm λ’s: e-beam moving along a magnetic loop with density minimum at the loop top. Plasma parameters are stationary.

But the SSRT image shows the distance between sources at different branches is short (<30 Mm).

In cm-λ’s U-structures are produced by density variations due to a plasma response to a heating pulse. The source size along the loop is of order of a few Mm.
Bounce period or transverse MHD oscillations of loop?

Two variants to explain:
- Bounce period of the short electron beam in the long magnetic loop. From lifetime duration follows beam velocity of 0.45c and the loop length about 20 Mm.
- Transverse MHD oscillations of the loop (for B=100 G, diameter of the loop must be about 100 km).

Trend of the frequency drifting rate corresponds to density rising:

\[
\frac{\partial f}{\partial t} \approx 1.25 \text{ GHz/s} \Rightarrow \frac{\partial n}{\partial t} \approx 5 \times 10^{10} \text{ cm}^{-3}/\text{s}
\]

require a new instrument: capable of true imaging spectroscopy, with high temporal, spatial, and spectral resolutions ---- CSRH or FASR.

III. Recent Progresses of CSRH

• Array design and radio image process studies
• Antenna & feed design
• RF design
• Optic fiber transmission test
• Digital correlation receiver (prototype)
• 2-element aperture synthesis prototype
• Site survey & RF monitoring
Prototypes of Sinuous Feed in 0.4-15 GHz

Assembly of feed in 0.4-2 GHz

Sino-US Workshop on Radio Astronomy, 21 April 2008, Beijing
CSRH Specifications

Range ~0.4–15 GHz \( \lambda \) ~75–2 cm

Frequency Res. 64 or 128 chan \( I: 0.4-2 \) GHz

Spatial Res. 32 or 64 chan \( II: 2-15 \) GHz

Temporal Res. \(~<100\) ms \( 0.4-15 \) GHz)

Dynamic Range 25 db \( \) snapshot

Polarizations Dual circular L, R

Array \( I: 40 \times 4.5 m \)

\( II: 60 \times 2 m \) parabolic antennas

Lmax 3 km

Field of view \( 0.6^\circ–7^\circ \)
2-element prototype

Sino-US Workshop on Radio Astronomy, 21 April 2008, Beijing
2-element prototype

**Indoor:**


**Outdoor:**

2*4.5m dish Feed, LNA, Op. Tx 1.2-1.8GHz, 1Km Op. Fib.
For short baseline of 8 m.
Sino-US Workshop on Radio Astronomy, 21 April 2008, Beijing
UV coverage for 7 & 8 July 2005

7 July

8 July
7 July 2005, Phase of Visibilities vs time

Phase of Visibility (degree) vs Time (UT)
Site survey
Officially approved the Land Transfer to NAOC by Inner Mongolian Government in Dec 2007

Passed evaluations of 8 divisions:

Sino-US Workshop on Radio Astronomy, 21 April 2008, Beijing
Radio Quiet Zone Protection issued by Frequency Allocation Committee of Inner Mongolia, China

关于对正镶白旗太阳射电日像仪重点电磁保护的通知

锡林郭勒盟行署办公室，锡林郭勒盟无线电管理处，正镶白旗人民政府办公室，民航华北地区空中交通管理局内蒙古分局，各电信运营企业：

中科院国家天文台新建正镶白旗太阳射电观测站是国家 973 计划重点项目，该站厘米分米波频谱日像仪通过太阳射电成像观测，研究日冕磁场结构与演化，从而在国际上首次实现厘米-分米波段上同时以高空间、高时间、高频率观测太阳活动的动力学性质，在空间天气监测和研究中起到重要作用。作为国际新一代射电日像仪，望在日冕物理研究中取得重要原创性研究成果。
RFI Measurements

Mobile phone signals
Site view
Array arrangement

Working & Living Area
3.0000 hectare (45 mu)

Operating Area
1.3650 hectare (20.475 mu)

Array & 3 spiral arms
3.8775 hectare (58.1625 mu)
Working and Living Area
Schematic arrangement in central operating area

Sino-US Workshop on Radio Astronomy, 21 April 2008, Beijing
Construction of an Automatic Weather Station in Nov. 2007
Measurements of Soil Temperatures

Sensors

80cm
120cm
160cm
200cm

2008-4-21
Beijing
Distribution of soil temperatures

![Graph showing soil temperature distribution]

Date

2008-4-21

Sino-US Workshop on Radio Astronomy, 21 April 2008, Beijing
Present Status

I. CAS, NSFC & NAOC plan for future solar facilities in Sep. 2006: 1 of 2 major ground-based instruments be developed in next 5 years.


III. CSRHC: included in the "National Basic Research Program 2006-2010" by MOST.

IV. 2007-2009 Key Project by CAS-NSFC joint Foundation.
Evaluation Meeting on CSRH Designs held during 1-2 April 2008 by NAOC
Future Plans

I. Radio quiet zone protection
II. CSRH-I during 2008-2010
III. CSRH-II from 2010(?)

Thanks