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Analysis of Solar Radio Observations and the Influence of Interference

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Abstract. Based on the data observed by a solar radio spectrometer at 2.6-3.8 GHz and other measurements at Shahe Station, we analyze the radio interference and its influence on observations. We have identified three different types of interference: (a) from antenna; (b) from IFs; and (c) internal signals, etc. Corresponding measures can be taken to reject or correct these errors and to improve the observations.

1. Introduction

Solar radio spectrometers covering 1.0-2.0, and 2.6-3.8 GHz have been in operation since 1994 and 1996 respectively at Shahe Station of Beijing Astronomical Observatory (Fu et al. 1995). Shahe Station has suffered from radio interference in recent years. In this paper we analyze the radio interference and its influence on observations, and suggest measures to reject or correct for interference and so improve the observations.

2. Data Description

The data employed in the present work include the following materials taken at Shahe Station:

(i) Measurement of the radio interference in the 0.1-7 GHz range (Yan et al. 2001).

(ii) Long-term observational data at 2.6-3.8 GHz taken using the radio spectrometer with 0.2 s temporal resolution.

(iii) Measurements of radio interference at intermediate frequency (IF) range.

(iv) Data at 2.6-3.8 GHz taken by the radio spectrometer with 0.2 s temporal resolution under the following conditions:

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(a) one end of the IF cable was connected to the indoor receiver but the other end was disconnected from the outdoor device and in open circuit;
(b) one end of the IF cable was connected to the indoor receiver but the other end was disconnected from the outdoor device and connected with a matched load;
(c) no IF cable connected to the receiver at all.

From these data we can identify the sources and characteristics of radio interference, which are discussed in the next section.

3. Sources and Characteristics of Radio Interference

The performance of the 2.6-3.8 GHz radio spectrometer is shown in Table 1 and its block diagram is shown in Figure 1. The sources of radio interference may be summarized as follows: (a) from the antenna; (b) from transmission lines that connect the outdoor device and the indoor receiver; and (c) internal interference signals.

Table 1. The 2.6-3.8 GHz Solar Radio Spectrometer

Frequency range	2.6-3.8 GHz (operated since Sept. 1996)
Temporal resolution	8 ms
Frequency resolution	10 MHz (120 channels)
Sensitivity	2% $S_{\text{quiet Sun}}$
Polarization	LHCP, RHCP
Observing time	22-10^h UT(Summer), 0-8^h UT(Winter)

We identified the category of the interference by checking: (a) whether the intensity of the interference varied when rotating the antenna; (b) whether the sun, the sky background, the calibration noise source, or the terminal signal, suffered interference; and (c) whether the interference had repeatability or similarities under different conditions.

We found that interference introduced from the antenna frequently occurs, either when observing the sun or the background, or rotating the antenna, but it does not have regularities over long-term observations. When the instrument is connected to the noise source or terminal load, this kind of interference does not occur.

Interference introduced from IF transmission lines is not influenced by the rotation of the antenna and it may occur whenever observing the sun, the background, or connecting to either the noise source or the terminal load. It may exhibit repeatability, but this does not frequently occur.

Internal interference is not influenced by the rotation of the antenna and occurs occasionally. It can occur when observing the sun or the background, or when connecting to either the noise source or the terminal load.

The effects of the radio interference on the observations are as follows:

(1) Microwave interference introduced from the antenna influences data from 0-10 channels.

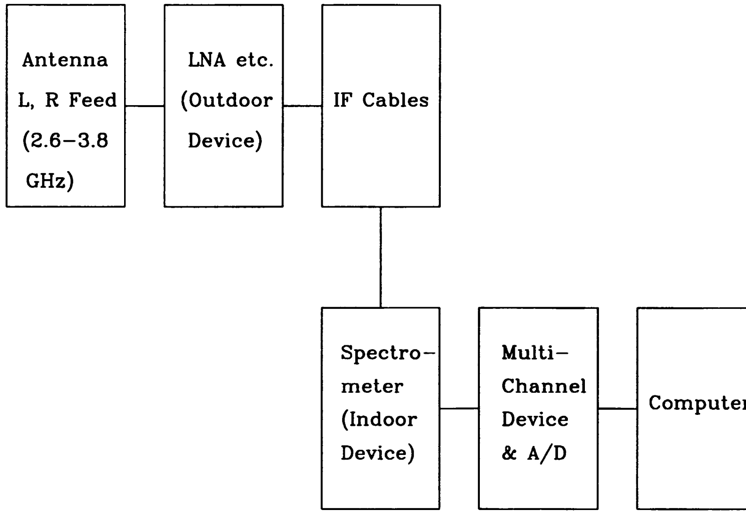

Figure 1. The block diagram of the solar radio spectrometer at 2.6-3.8 GHz.

(2) Interference introduced from the IFs influences data of 28-29 channels. For example, the environment noise levels are respectively -39.7 dBmW at 489.3 MHz and -48.2 dBmW at 496 MHz.

(3) The internal interference, e.g., due to the computer and/or interfaces influences data in one particular channel, 106.

4. Measures to Eliminate Interference

Hardware Methods:

(1) Measuring the environment interference and then choosing the frequency range of the radio instrument to escape from the worst interference band. Using an antenna with low sidelobes and backlobes, and adding resistance filters when necessary.

(2) Selecting a suitable intermediate frequency to get rid of IF interference. Compressing the IF band as small as possible. Increasing IF transmission power. Making the IF cable as short as possible with good sheath, ground and connectors.

(3) Using absorbing and separation techniques to eliminate leakage signals, if any, and eliminating interference from the computer.

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Software Methods:

(1) Using data processing techniques to eliminate known fixed interference.
(2) Using wavelet transform for noise depression and edge enhancements.

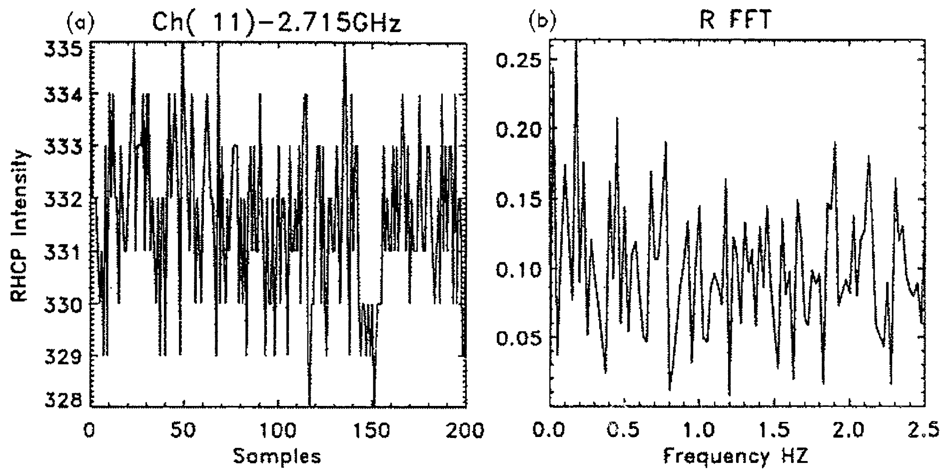

Figure 2. Signal when pointing to the background shows typical white noise feature and no significant structure due to interference. (a) recorded signal of right-hand circular polarization at channel 11. (b) its FFT spectra (arbitrary unit).

Having taken into account the above measures to eliminate errors and to improve the observations, the Solar Radio Broadband Dynamic Spectrometer works quite well. Figure 2 shows an example of a normal signal that was not affected by any interference when pointing to the background. The data shows typical white noise features. Therefore in this channel there is no significant structure due to interference.

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