Synthesis Imaging and Data Processing of Chinese Spectral Radioheliograph

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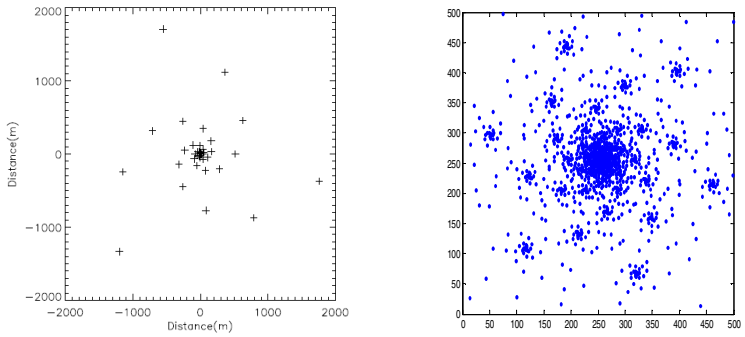
Chinese Spectral Radio Heliograph (CSRH) is an advanced synthesis aperture solar radio heliograph, developed by National Astronomical Observatories, Chinese Academy of Sciences independently. It consists of 100 reflector antennas, which are grouped into two antenna arrays (CSRH-I and CSRH-II) for low and high frequency bands respectively. It is about to start official operation for daily observation and provided scientific data to the peer researchers.

It is urgently necessary to commence imaging and data processing on CSRH. The imaging principle of CSRH lies in the well-known interferometry concerning synthesis aperture. Due to the limited number of antennas, the captured data by CSRH is extremely sparse, and cannot recover the brightness of the Sun clearly. We investigate the imaging of CSRH by the aid of Compressed Sensing (CS). In addition, we exploit the examples-facilitated strategy in image reconstruction of CSRH. This strategy has the following specifics: 1) we take a dictionary based CS framework to recover signal, assuming that the signal is sparse in the given dictionary specifically designed for CSRH, instead of using the commonly-used wavelet or Fourier transform to represent the sparsity property of signal; 2) to get a specific dictionary for CSRH, a set of good examples with high quality are collected to learn the dictionary, where the good examples come from available processed data of CSRH and high quality observations of other solar radio observators; 3) machine learning approaches are employed to learn dictionary; 4) we also investigate possible signal processing techniques to do denoising, feature detection and extraction and image enhancement for imaging of CSRH.

The antennas layout of CSRH adopts 3-arm spiral structure. 40 antennas are arranged along 3 spiral arms in CSRH-I (CSRH-II has 60 antennas) as shown in Fig. 1 (a). The UV coverage of CSRH-I is shown in Fig. 1(b). According to interferometry principle, there are only 40×39/2 pixels recorded by CSRH-I in UV space. In this sense, it is an extremely sparse sampling, so the reconstruction (widely known as synthesis imaging in radio astronomy) of image from observed data is very challenging.



(a)The antenna layout (b) UV pattern

Fig.1. CSRH antenna layout and its sparse sampling pattern in UV space.