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Data Processing for the Siberian Solar Radio Telescope

S. K. Konovalov, A. T. Altyntsev, V. V. Grechnev, and E. G. Lisysian

Institute of Solar-Terrestrial Physics, Lermontov St. 126, Irkutsk, Russia 664033, E-mail: root@sitmis.irkutsk.su

A. Magun

Institute of Applied Physics, University of Bern, Switzerland, 3012 Bern Sidlerstrasse 5, E-mail: magun@sun.iap.unibe.ch

Abstract. The SSRT is a cross-shaped interferometer. The way of forming its response is rather specific, so various programs to process its data were required. Furthermore, fast observations provide us with a large amount of data; therefore, implementation of special techniques for previewing and processing of data is required. We believe IDL to be the most convenient for these purposes. A set of IDL programs was developed which allows us to look through the records and view data in various representations; to measure a radio source size, flux, and its location on the Sun; to build high-sensitivity 1-D images, etc.

1. Introduction

The Siberian Solar Radio Telescope (SSRT) (Smolkov et al. 1986) is a large astronomical instrument. It is a cross-shaped interferometer consisting of 128×128 parabolic 2.5-meter antennas, equally spaced with a separation of 4.9 m. The SSRT is located 220 km from Irkutsk in a beautiful forest valley lying between the two chains of Sayan Mountains. This radio telescope is devoted to the study of solar activity in the microwave range (5.7 GHz), where processes in the solar corona are visible across the entire solar disk. In 1992, fast observations were started for studying of the fine time structure of flare manifestations, such as spikes (Altyntsev et al. 1994). After introduction of a fast data acquisition system developed together with the Institute of Applied Physics (Bern) (Altyntsev et al. 1996), the SSRT can record processes as short as 14 ms with a spatial resolution of down to 15″.

The response of the SSRT is formed in a specific way, unlike that of most other aperture synthesis telescopes. The orientation of the interferometer's beam depends on the receiving frequency, making it possible to scan the solar disk by tuning the receiver in a series of steps. By making this stepwise tuning quick enough, we obtain a series of one-dimensional images (scans) taken across the Sun. This method—frequency scanning—provides fast sampling in one direction. It is used in the fast observations at the SSRT. The Sun passing through the fan beam provides sampling in the other direction. This sampling, together with frequency scanning, is used for 2-dimensional mapping of the Sun. Two-D

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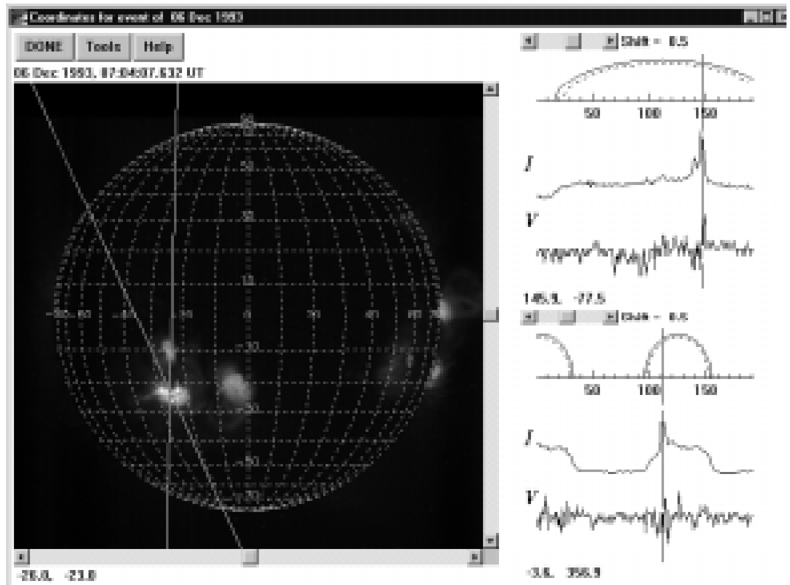

Figure 1. The display window of a program which allows correlating SSRT 1-D images with YOHKOH SXT maps and other images.

mode observations started in autumn, 1995, and have been providing images every day since spring, 1996.

Observations produce a large amount of data, which require special techniques for processing and previewing. To solve this problem, we had to develop our own special programs. Considering the advantages lent by IDL, such as efficiency, easy coding, powerful graphics, and wide acceptance among astronomers, we have chosen this language. As a result, a set of IDL programs was developed to provide these capabilities:

- looking through records and viewing data in various representations;
- measurement of a radio source size, flux, and location on the solar disk;
- building high-sensitivity 1-D images from a number of single scans;
- transformations of solar maps, such as rotation within the plain of the sky and around the polar axis of the Sun; and
- viewers and conversion programs for special and standard files, etc.

An example display from one of the programs is shown in Figure 1.

2. Program Features

To program more effectively, we have been trying to follow some guidelines:

Widget-based interface, a few graphics windows. Most programs are provided with a widget-based graphical interface. By presenting a few graphical windows, reflecting various aspects of the data and different processing stages, the researcher gains a comprehensive overview of the situation, and can interactively and simply select an object, control the procedure, and supervise intermediate and final results. It allows him to expedite data processing and to monitor progress. The programs are especially convenient for rapid data analyses.

Combining SSRT data with optical or X-ray images. To obtain a thorough picture of the event, it is useful to view and process SSRT data in combination with optical or X-ray images. By means of the global network, it is now possible to obtain the required images from various observatories. After appropriate preprocessing, these images could be imported into a program to be viewed together with the SSRT data.

Providing the programs with supporting tools. For convenience and efficiency, we provide the user with various supporting tools: (*i*) a calculator; (*ii*) an program displaying current SSRT parameters; (*iii*) coordinate conversion between various solar coordinate systems (heliographic, Carrington's, normalized in the plane of the sky); (*iv*) color palette adjustment (XLOADCT); (*v*) an interactive array viewer for looking at data in various representations (wire-mesh surface, shaded surface, halftone image, contour, and their combinations); and (*vi*) temporary exit into the shell.

Use of the library worked out by our group. The unique features of the SSRT influence the programming needs of all of our researchers. For this reason we have developed, supplemented, and corrected some routines from the IDL library, resulting in our own library. This library contains special routines for our use, as well as routines which could be of common interest and applicability (Konovalov et al. 1997). The widget-based data processing programs use this library extensively.

3. Implementation

Our widget-based programs are complex: a typical size ranges from 10 to 50 kB. Each program consists of three to six routines and uses some dozens of local variables having different types and dimensions. Because it is unlikely that a user would run two or more copies of such a program simultaneously, most of them exchange variables by means of common blocks. These variables are collected into structures. When the program is terminated, and the respective widget dies, the memory is freed by setting all these variables into scalar values.

IDL does not provide for retaining the scaling in graphics windows; therefore, when working with a few windows, one has to save the state of the system variables !X, !Y, !Z, !MAP for all the graphics windows being in use, and restore them when the cursor is placed onto a particular window.

Besides completely widget-based programs, we have also developed a hybrid program using both widgets and conventional graphics windows. This approach makes it possible to use the IDL library routines (such as PROFILES, ZOOM, etc.) in a straightforward way, and expedites program development.

All the programs can be run under IDL 3.0.1 or later versions. We welcome any interest and cooperation.

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