FULL-DISK SOLAR DOPPLERGRAMS OBSERVED WITH A ONE-MEGAPIXEL CCD CAMERA AND A SODIUM MAGNETO-OPTICAL FILTER

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ABSTRACT. We present here the first two full-disk solar Dopplergrams obtained with the new 1024 x 1024-pixel CCD camera which has recently been installed at the 60-Foot Tower Telescope of the Mt. Wilson Observatory. These Dopplergrams have a spatial resolution of 2.2 arcseconds and were obtained in a total of one minute of time. The Dopplergrams were obtained with a magneto-optical filter which was designed to obtain images in the two Na D lines. The filter and the camera were operated together as part of the development of a Solar Oscillations Imager (SOI) experiment which is currently being designed at JPL for the joint NASA/ESA Solar and Heliospheric Observatory (SOHO) mission. We also include here two difference images obtained by subtracting two pairs of the Dopplergrams from the initial time series.

1. DESCRIPTION OF EQUIPMENT

As part of the development of the SOI experiment at JPL, a 1024 x 1024-pixel CCD camera was fabricated there and then installed at the Mt. Wilson Observatory. This camera is a modification of one originally designed for the Solar Optical Telescope (SOT) program. It is based upon a Texas Instruments virtual-phase, front-side illuminated CCD array. This array is comprised of 1,048,576 pixels each 18.3 microns on a side. Hence, it has an active area of 18.7 mm square.

Each pixel of the array has a full-well depth of 200,000 electrons, while the complete camera noise floor is about 50 electrons. Hence, a maximum signal-to-noise ratio of 4000 to 1 is possible in a single exposure. To take advantage of this SNR, the A-to-D converter digitizes the analog video signal to 12 bits. The camera electronics has been designed to allow a readout rate of 800,000 pixels per second.

Hence, a single frame can be read out in 1.3 seconds. For the images employed to create the Dopplergrams shown here, an exposure time of about 0.64 seconds was required. Therefore, the combined exposure and readout time for each filtergram was about 2 seconds. Since two filtergrams were needed for each Dopplergram, the minimum time needed to acquire one Dopplergram was only 4 seconds. However, in these initial tests we employed a shutter cycle of 15 seconds and hence the two Dopplergrams shown here were actually separated by 30 seconds.

Figure 1 contains a close-up photograph of the T.I. CCD chip itself, while the completed camera is shown as it is now installed at Mt. Wilson in Figure 2. The sunlight is passed through the two magneto-optical filter (MOF) cells located to the left of the camera in Figure 2 before it forms an image on the chip near the center of the Figure. A schematic diagram of the data acquisition and processing system which is now in operation at the 60-Foot Tower Telescope is shown in Figure 3. A key part of this system is the high-speed, floating point array processor from CSPI. This processor contains a custom-designed interface port which allows us to store each CCD image directly in a 2-megabyte array during the 2-second exposure and readout interval of the subsequent frame. The array processor can then numerically integrate or subtract the subsequent frames from the first. The data are transferred from disk to tape daily. The camera and the data acquisition system were described in more detail in Rhodes, et al. (1986). Figures 4 and 5 show the first two solar Dopplergrams ever obtained with the MOF and camera combination, while Figure 6 contains an enlargement of one quadrant of Figure 4. Figure 7 shows the image obtained when we subtracted the first and second Dopplergrams, while Figure 8 shows the result of differencing the first and third Dopplergrams. Figure 9 shows an enlargement of one quadrant of Figure 8.

2. REFERENCES