FULL-DISK SOLAR DOPPLERGRAMS OBSERVED WITH A 1024 X 1024-PIXEL CCD CAMERA

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ABSTRACT. We present here the first full-disk solar Dopplergram 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. This Dopplergram has a spatial resolution of 2.2 arcseconds and was obtained in less than one minute of time. The Dopplergram was 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) esperiment which is currently being designed at JPL for the joint NASA/ESA Solar and Heliospheric Observatory (SOHO) mission.

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 orignally 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.

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Hence, a single frame can be read out in 1.3 seconds. For the images employed to create the Dopplergram 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 actually employed a shutter cycle of 15 seconds and hence it took us 30 seconds to acquire each of a series of Dopplergrams.

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). Figure 4 shows the first solar Dopplergram ever obtained with the MOF and camera combination, while Figure 5 contains an enlargement of one quadrant of Figure 4.

2. REFERENCES

Rhodes, E. J., Jr., Bursch, T. K., Ulrich, R. K., and Tomczyk, S. 'A one megapixel image acquisition and processing system for Solar Oscillation Studies,' to appear in Proceedings of Instrumentation in Astronomy VI, SPIE, in press, 1986.

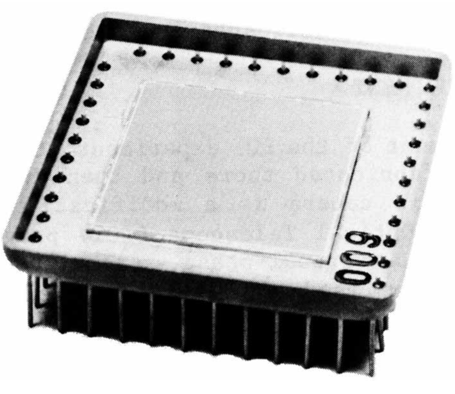

Figure 1. Close-up photograph of Texas Instruments' 1024 x 1024-pixel virtual phase CCD array. The array is shown in its 43-pin socket. The array is illuminated from the top of the figure.

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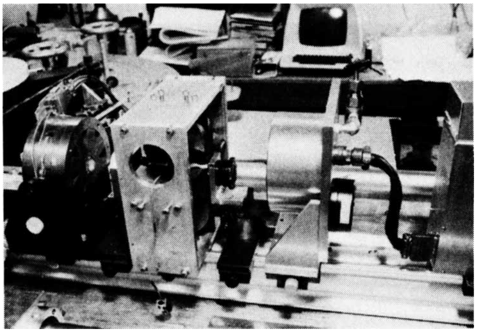

Figure 2. Installation of CCD camera at Mt. Wilson 60-foot solar telescope. The CCD array is contained within the round aluminum enclosure near the center of the picture, while the signal chain, the timing circuitry, and the control electronics are located within the rectangular box at the right. The magneto-optical filter includes the 6000-Gauss and 2000-Gauss magnet assemblies at the left.

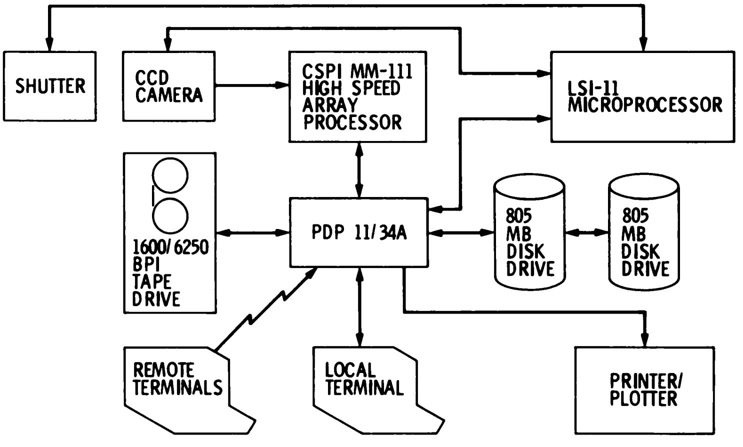

Figure 3. Schematic diagram of the entire data acquisition and processing system.

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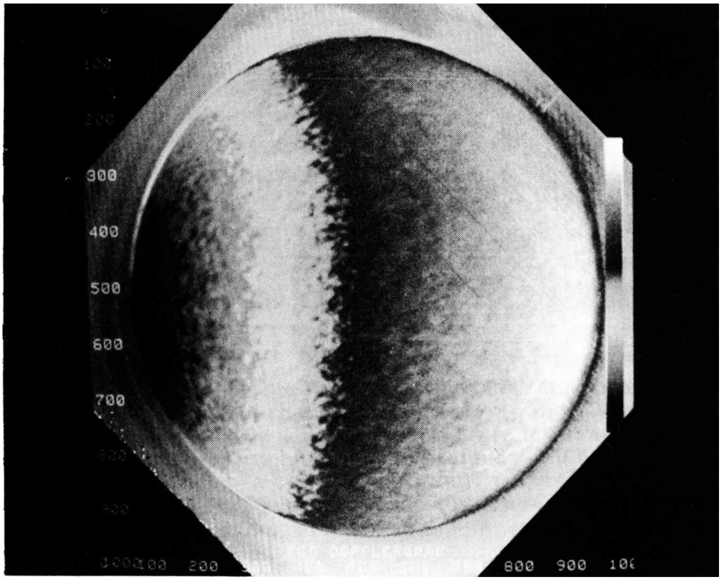

Figure 4. First of five full-disk Dopplergrams obtained with the CCD camera and the Na magneto-optical filter on April 10, 1986. This Dopplergram was obtained by differencing two filtergrams which were taken 15 seconds apart. The solar disk covers about 900 x 900 pixels and has been rotated in order to place the equator in the horizontal direction. Solar rotation is visible as the systematic change in shading across the disk; due to the resolution limit of the television monitor only 512 x 512 pixels are actually displayed.

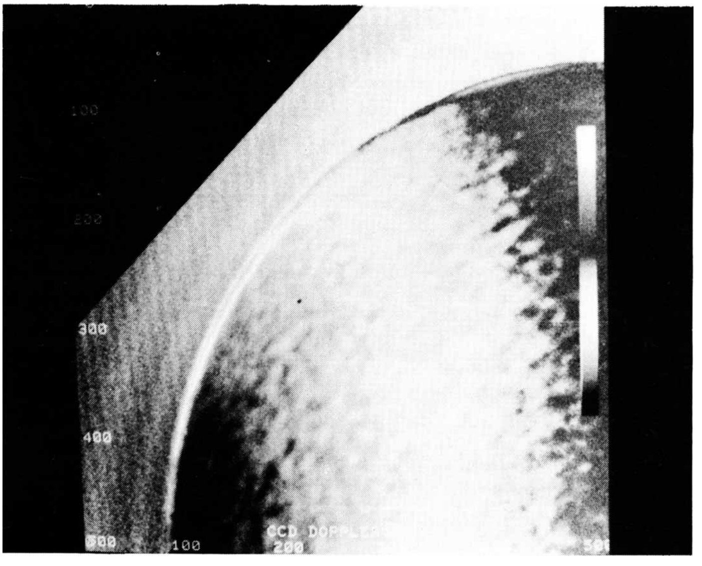

Figure 5. Enlargement of one quadrant of Dopplergram shown in Figure 5. Here every pixel within a 512 x 512 pixel area is displayed to accentuate the detail of the small scale features.

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