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A SCANNING CCD DETECTOR FOR SOLAR ECLIPSE OBSERVATIONS

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ABSTRACT

A wide-field CCD detector for solar eclipse observations is discussed. The CCD is supposed to be of a moderate size, and the image of the corona is obtained by scanning the field of view. Results of the 1995 solar eclipse observation are shown which have been made with a prototype of the scanning CCD detector.

Key Words : solar eclipse, CCD observations, solar corona

Using CCDs for observations of the solar corona is very attractive because these detectors have a dynamic range which is much wider than that of photographic plates. In addition, one may record the image in an electronic form and check them just after the eclipse. This sometimes is rather important because a photographic laboratory may be not available in the conditions of the solar eclipse expedition.

But CCDs have two disadvantages: lower resolution in comparison with photographic emulsion and a rather small field of view. Even for a telescope with a moderate 1-meter focal length one should cover at least 4 x 4 square centimeter field of view in order to detect full image of the corona.

So, a relatively large focal length telescope and a high resolution CCD detector are to be used. A mosaic of CCDs may help in covering wide fields of view. But in order to simplify the expedition equipment one may cover the large field of view by scanning it with a small high resolution CCD camera which has pixels as small as, for example, 6 – 8 microns.

A simple two-coordinate carriage driven with a screw and stepping motors could cover the telescope field of view during a rather short duration of the solar eclipse. Using stepping motors is important because afterwards the observer may know position of each elementary frame in order to combine correctly these frames.

One could make observations without a radial filter due to wide dynamic range of CCDs. But in order to get better photometry of the inner corona it is still very useful to put a radial filter into the focal plane of the telescope. In this case an additional relay optics is necessary to project the filtered image to the detector plane.

The CCD is to be read very fast (with a readout time less than 0.2 – 0.5 second per frame) in order to be able to detect full image of the solar corona during the short period of the eclipse. A rather large memory (a few tens Megabytes) is also necessary. But in order to simplify the process of observation one may use a normal video recorder, and enumerate the images afterwards.

A testing observations of the solar corona with a scanning CCD device have been made by the author together with Prof. Valentine Makarov (Pulkovo Observatory) during the total solar eclipse of October 24, 1995 at Neem Ka Thana (India).

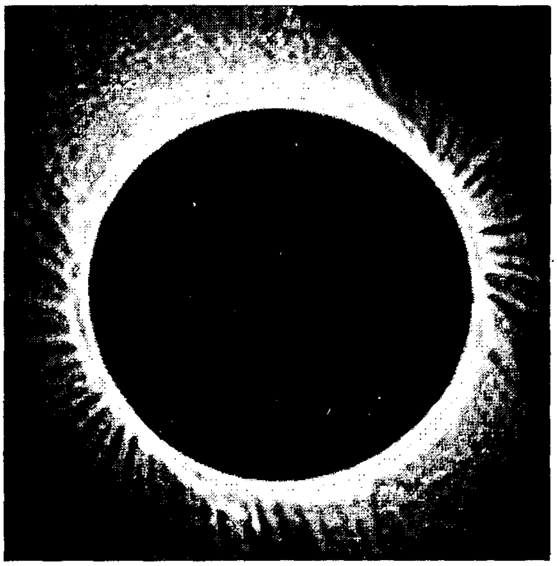

Fig. 1.— CCD scans of the solar corona, October 24, 1995, Neem Ka Thana, India.

A small CCD camera coupled with a 15-cm Maksutov telescope (one meter focal length) has been used used. The camera has $6 \times 8\mu^2$ pixels covering a $4 \times 5mm^2$ field of view. It is quite sensitive (the minimal detectable light is about 0.05 lux), but more sensitive CCD cameras are available which have higher resolution, larger field of view, and, which are still not very expensive. Cooling was not necessary for the camera because it works in the standard CCIR television mode (each frame is readout during 40 ms).

Scanning was implemented by simple movements of the telescope around its R.A. and Declination axes during the 37 seconds of the totality phase of the eclipse (this technique is admittable for small telescopes, but the position of each frame is known only approximately, and lunar limb with its irregularities is to be used in order to reconstruct the full image).

Approximately 1000 frames obtained during the totality phase were recorded on a magnetic tape. Afterwards, the best images were digitized, stored in the computer memory, and combined in a complete image of the corona. It is shown on Fig.1. The image is of the size of approximately 3×4 partial frames, but totally about 30 frames were used in the reconstruction (many of them are overlapping). One may apply also more complicated technique of averaging all 1000 partial images in order to reduce noise and achieve higher resolution. Unfortunately, the image being printed do not demonstrate achieved resolution of $\approx 3 - 4''$ per pixel, but the structure of the "polar plumes" is seen quite well.

The nature of these structures is not well known yet, but they might be related to the global solar magnetic field. The authors intended to reveal these structures because they might be used in order to check some models of the inner magnetic field of the Sun. The discussion of this question will be published soon. The structure of the "polar plumbs" has been underlined by a special two-dimensional filter aimed at edge enhancement. Such filters are usually incorporated in many image processing software packages (the author have used *Photostyler 2.0* for this purpose).

A mechanical two-coordinate carriage us under construction now, and a larger telescope of 3-m focal length is planned to be used in the nearest future for observations of the solar eclipses in Siberia (1997) and France (1999).

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