WIDE FIELD IMAGING AND PHOTOMETRY WITH 2k x 2k CCD

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ABSTRACT. The Ford Aerospace 2048 x 2048 CCD with UV coating is used at the BAO 60/90 cm f/3 Schmidt telescope focal plane, giving a field-of-view of about one square degree and spatial resolution of 1.67 arcsecond per pixel. The paper reviews the following topics:
1) basic performance of the system;
2) anti-blooming technique for a large field CCD;
3) flat fielding for a large field CCD;
4) photometric properties of compressed images.

1. Introduction

With the development of large format and mosaic CCD techniques, CCDs now become competitive with the photographic plates in doing wide-field imaging as well as photometry. Recently, several Schmidt type telescopes have started to use CCDs as detector. We have used the Ford Aerospace 2048 x 2048 CCD mounted at the Schmidt telescope of Beijing Astronomical Observatory to carry out the Beijing-Arizona-Color (BAC) Sky Survey by using 17 narrow band filters for 500 fields selected from a high galactic latitude region. In this paper, the technical part of the system with the emphasis on the problems related to the large format CCD is presented. The BAC survey will be reported in another paper in these proceedings.

2. Basic Performance of the System

The Ford Aerospace 2048 x 2048 CCD with 15 micron pixel size is mounted on the focal plane of the f/3 60/90 cm Schmidt telescope at the Beijing Astronomical Observatory (BAO). The field covered by the CCD is about 1 square degree. The pixel size of the CCD corresponds to 1.67 arcsecs on the sky. We have to dictate a trade-off between the field size, the spatial resolution and the data flow which we can handle. Though the pixel scale is slightly under-sampling compared to the average seeing disc of about 2 arcsecs of our site, the observations show that the spatial resolution is comparable to and is even slightly better than the POSS I. Since the survey is mainly for extragalactic objects at high galactic latitude where the number density of objects is not so high with the limiting magnitude that the survey can reach under reasonable integration

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times and the size of the telescope, we rather like to have a larger CCD field. The CCD is UV coated to provide uniform quantum efficiency from UV (0.18 in Q.E.) to near-IR (0.4 in Q.E.) with readout noise of 3 electrons. The peak-to-peak fluctuation of the whole system noise, including noise from the electronics is 6 electrons. To achieve such a low level of system noise needs very careful treatment of the system grounding, especially to isolate electrically the CCD from the telescope. The readout time is 64 seconds when using 2 amplifiers readout mode. The 17 narrow band filters are mounted on a typewriter-like filter changing device, which, unlike the filter wheel device, can allow all the filters on line with no obscuration in the light path of the telescope. The data taking and handling system consists of 5 SUN SPARC work stations with total disk space of 15 GB.

3. The Anti-Blooming

For CCD fields as large as 1 square degree, it is very hard to avoid some bright stars to be included in the CCD frame even at high galactic latitudes. The blooming of the saturated stars blurs those regions of the CCD which are in the direction of charge-transfer of the bright stars. It influences for both imaging as well as photometry. The anti-blooming technique based on the multi-phase CCD is used. The software is changed to allow clocking of two phases back and forth during the integration of an image to ensure that the photon collection and photometric data are not affected. The degree of anti-blooming can be adjusted by the anti-blooming parameter. The highest one can allow for 1000 times over the full-well electrons with a slight increase in dark current.

4. The Flat Fielding

One of the most serious problems for a CCD to achieve high accuracy of photometry is the flat field correction. Normally, people use twilight or dome flat field image to correct for the small scale (pixel to pixel) Q.E. fluctuation and use the supersky flat field, which is built from many night sky exposures, to correct the large scale gradient in Q.E. of CCD. From our experiences, we found that it is very difficult to get uniform illumination from supersky for sky area of 1 square degree. The night sky varies from place to place, and time to time. Even at zenith direction, the supersky flat field images built from different photometric nights can be different by 2%. When using twilight flat field exposure for small scale Q.E. correction, the period of suitable brightness provided by each day twilight is very short, and the readout time for large format CCD is relatively long. It prevents one from obtaining enough twilight exposures for flat fielding, especially when observations with multi-colour photometry are carried out in a single night. Moreover, the shutter effect also becomes serious for large format CCDs. To reduce the shutter effect down to 0.1%, the exposure time can not be shorter than 10 seconds.

Dome flat fielding has advantages. Images can be obtained with very high signal to noise ratio and can be done in day time. The problem is that one can hardly get very uniform illumination. Therefore, it is important to improve the current dome flat fielding technique in order to use it for corrections for both small scale fluctuation in Q.E. as well as large scale gradient of illumination. In our case, in addition to the dome screen providing uniform illumination, we put another diffuser just in front of the Schmidt corrector plate. The diffuser used is the same as the diffuser used for plate copying. The light from the lamp is firstly reflected by the dome screen and then passes through the diffuser to give uniform illumination for the CCD. In many cases, the large scale gradient after dome flat fielding correction can be as small as 0.1 to 0.2%. We have tested the accuracy of the photometry by repeating observations of the same sky field. It shows that by using the dome flat fielding, the accuracy of photometry can reach the accuracy dominated by the photon statistic noise.

5. The Image Compression

About 1 GB of raw data is accumulated each day with the 2k x 2k CCD. Image compression becomes urgent for archiving data. The technique used to compress the image data needs to satisfy the following criteria:

1) high fidelity of image geometry;
2) high fidelity of photometric property;
3) high ratio of compression.

Three methods have been tested:

1) Binary Morphological Skeleton Transformation;
2) Grey-tone Morphological Skeleton Transformation;
3) H-Transformation.

The results from the test of CCD data show that the factor of compression depends strongly on the threshold above which the data are extracted. The H-Transformation can have better fidelity of photometric property but with lower compression ratio, with the first two transformations vice versa.

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