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First Results for CCD Observations with the 70 cm Meniscus Telescope

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Abstract. From the middle of 1993, a ST-6 CCD Camera (375 × 242 array with 23 × 27 microns pixel size) was mounted at the Newtonian focus (f/3) of the 70 cm meniscus telescope of the Abastumani Observatory. The photometer is now equipped with various sets of narrow-band interference, intermediate and wide band standard filters. Some pilot observations were carried out in direct imaging mode and in combination with an 8° objective prism (166 Å mm^{-1} at Hγ). Spectrophotometric standard stars with absolute calibrations were observed in the 8° mode to determine the CCD spectral response. Some other observations were performed with a prism-interference filter combination to estimate the observational mode efficiency.

1. Introduction

At the beginning of 1993, following a decision by the European Astronomical Society Emergency Fund Committee, a Model ST-6 Professional CCD Imaging Camera was donated to the Abastumani Observatory. The camera was mounted at the Cassegrain focus (f/13) of the 125 cm RC telescope and at the Newtonian focus (f/3) of the meniscus telescope. This paper reports the first CCD observations taken using the meniscus telescope.

We describe the telescope CCD-Camera photometer system (section 2), first results of observations in several modes, estimation of main parameters discussed by Djorgovski (1984), Fort (1985), Gudehus (1990), Pogge (1992), Vigroux (1985), Wagner (1992), Walker (1990) and Winkler et al. (1990), and future plans (section 3).

2. The Telescope CCD-Camera Photometer System

2.1. The Telescope

The Abastumani Observatory 70 cm meniscus telescope uses the meniscus system of D. D. Maksutov. The meniscus has a diameter of 70 cm with a main mirror diameter of 98 cm. The primary focus (F = 2102 mm) of the telescope provides a wide field-of-view of 4.8° × 4.8° and secondary (F = 10050 mm) with 20 arcmin × 20 arcmin and 40 arcmin × 40 arcmin fields. For spectral observations the telescope is equipped with several objective prisms: 8° (166 Å mm^{-1}), 4° (660 Å mm^{-1}), 2° (1250 Å mm^{-1}) and 1° (2500 Å mm^{-1}). All dispersions correspond to Hγ.

2.2. The CCD Camera

The Model ST-6 Professional CCD Imaging Camera was made by Santa Barbara Instrument Group, Santa Barbara, California. The camera system itself consists of a camera head, IBM PC XT-type CPU and software. The camera head contains the CCD chip, two stage thermoelectric cooler and 16-bit analog-to-digital converter.

The CCD chip is a thinned, back-illuminated 375 × 242 array with a pixel size of 23 × 27 microns. The chip has a readout noise of 30 e^-. A thermoelectric cooler provides cooling of the CCD chip to -50 C and the temperature regulation has an accuracy of 0.01 C. Experience shows that the temperature regulation is reliable when the CCD temperature is set to a value about 40 C below the ambient temperature.

The ST-6 CCD camera operates in conjunction with the IBM PC Computer through a serial RS-232 port with a maximum baud-rate of 115.2 Kbd. The ST-6 operating software provides various service capabilities such as capturing the image with exposure times from 0.01 s to 1 hr, a focussing mode, a track and accumulation mode for automatic guiding and long exposures, dark frame and flat field corrections, temperature regulation, some initial image processing and so on. The image can be saved to a hard or floppy disk in several formats (uncompressed, compressed, TIFF, FITS).

2.3. The Photometer

The ST-6 CCD camera is now attached to the 70 cm meniscus telescope through a prime focus photometer which is mounted at Newtonian focus of the telescope and equipped with a focussing system and filter wheel. Six filters can be set at a time. Currently CCD mounting devices are being constructed for the 125 cm RC telescope with a transfer lens providing a scale of 0.64 arcsec per pixel which is well optimized to a mean seeing of 1–1.5 arcsec at Abastumani. For the secondary focus of the meniscus telescope, a transfer lens will provide a scale of 0.96 arcsec per pixel, or 0.5 arcsec per pixel without the lens. The following wide, intermediate and narrow band interference filters (*BVRI*, Gunn System, Hα, β_1, β_2, Hγ, Hδ, HK 3950, OIII 5007, HeII 4686, SiII 6725, OII 3733, OI 6300, BaII 4554, 6450, 6000, 5400, 4600, HeI 5870) are either already manufactured or are being processed at the Abastumani Observatory. They are all of imaging quality.

3. Observational Results

The critical parameters of our CCD Camera System are a pixel size of 2.46 arcsec on the sky and a CCD readout noise of 30 e^-. The gain is equal to about 6 e^- per analog-digital unit (ADU). A typical twilight flat-field frame, taken with the 125 cm RC telescope, has a best rms over the whole image of 0.7 % of an ADU. Probably due to the high focal ratio, it is practically impossible to get good flat fields at the prime focus of the meniscus telescope; rms reaches 2 % of an ADU.

In order to estimate the ST-6 CCD spectral response, several bright stars (β Tri, 12 Per, ι Per, ζ Per) with absolute spectral calibrations were observed in the 8°mode. Three separate frames were taken for each star to cover the wavelength range from about 3500 Å to 1 micron. Each star was observed at different zenith distances for determination of selective atmospheric extinction. Corrections for transmission of the telescope optics and objective prism can be measured.

Preliminary reduction of the observational data shows that the CCD is sensitive to a wavelength range from 3500 Å to 1.2 micron, with a maximum efficiency at 7400 Å. There is a secondary maximum at 6000 Å. Further processing of the data to determine the absolute quantum efficiency as a function of wavelength is in progress.

For the determination of limiting magnitudes, a few open and globular cluster frames were obtained. All the images are under-sampled due to a scale of 2.5 arcsec per pixel. It became clear that limiting magnitudes are improved by at least 2.5 mag, relative to earlier photographic observations, for both direct and spectral observing modes. Moreover, the CCD exposure times were five times shorter.

Observations of galactic and extragalactic objects, namely, planetary nebulae, supernova remnants, elliptical and S0 galaxies, double and interacting galaxies, taken using interference and intermediate band filters, show that they are reasonably visible on our frames in comparison with photographic observations on larger telescopes.

The limiting magnitude reached allows us to identify a few faint blue horizontal branch (BHB) stars in distant globular clusters and to classify faint carbon stars detected in the Abastumani deep extensive survey of the Milky Way (Kurtanidze and Nikolashvili 1989; Kurtanidze & Nikolashvili 1994) into C and RN subclasses. Due to the absence of image processing systems such as MIDAS at Abastumani, we are unable to consider the results of our observations in more detail. The PC version of MIDAS will be installed on the Abastumani IBM PC AT-486 soon.

Taking into account the preliminary results of the observations carried out at the Newtonian focus of the 70 cm meniscus telescope we plan the following observational programs:

1. Galactic objects

- A detailed study of the structure and morphology of planetary nebulae and supernova remnants using diagnostic emission lines.
- Classification of carbon stars detected in the Abastumani survey into C and RN systems. Detailed spectrophotometry of bright C stars.
- Identification and subsequent study of BHB stars in globular clusters.
- A deep spectral survey of selected regions in the Milky Way for identification of faint (distant) carbon stars and peculiar A stars in galactic windows, where the reddening is known from distant objects (clusters of galaxies). This survey complements regular photographic (Kodak IIIa-J, F or IV-N) surveys made at Abastumani.

2. Extragalactic Objects

- A survey of double and interacting galaxies with intermediate band filters and in Hα.
- Determination of magnitudes, colours, diameters, mean ellipticities, position angle, mean surface brightness and morphological classification of early type galaxies.
- Hα survey of galaxies in clusters and in the field. A few of these clusters were studied photometrically at Abastumani (Kurtanidze & Richter 1987; Kurtanidze 1994).
- Photometry of the central regions of selected cD clusters of galaxies in the Gunn System.

Presently under consideration is the construction of a two-channel type CCD photometer producing two images of a field in different wavelength bands on the CCD.

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