CCD ASTROMETRY WITH WIDE-FIELD ASTROGRAPHS

V.S.GUBANOV
Institute of Applied Astronomy
8, Zhdanovskaya st., St.-Petersburg
197042, Russia

O.E.SHORNIKOV
Central Design Bureau "Foton"
Ind.Assoc."The Kazan Opt.-Mech. Factory"
2, Stantionnaya st., Kazan, 420018, Russia

ABSTRACT. A principle of a CCD-Tracking System for wide-field astrographs is proposed. This system can be used for precise relative positioning of fixed and moving, bright and very faint optical objects with respect to reference stars. Estimates of the positioning accuracy are given for objects of the 10÷20th magnitudes when observing with the K. Zeiss wide-field astrographs.

One of the actual astrometric problem is high-precision positioning of quasars and other superfaint celestial objects whose optical brightness (near the 20th magnitude) is much fainter than that of photographic reference stars ($m \simeq 10$ mag.) and even below the limit for direct photography by means of typical wide-field astrographs such as the K. Zeiss-Yena (D=400mm, F=2 or 3m). For overcoming this trouble a two-stage photographic procedure is used. The superfaint objects are first photographed with the astrophysical telescope ($D \geq 1000$ mm) against a background of intermediate very faint stars. The positions of these stars are observed with an astrograph in the reference catalogue system. Three or more such stages have to be used for very faint objects. All this cannot but negatively affect the accuracy of the final results.

We propose a more effective procedure for observations of superfaint objects with ordinary wide field astrographs such as the Zeiss. The observed object is registered not on a photoplate, but on a more sensitive CCD-matrix. Thus, the penetrative force of the astrograph, quite sufficient in regard to reference stars, will increase $n=Q/q$ times in regard to the object, where Q and q are quantum outputs of the CCD and plate, respectively. Taking into account the positioning of such moving objects as major and minor planets, comets, highorbital satellites and others, it is feasible to include the CCD into the Tracking System (TS), thus compensating the motion of objects. The principal scheme of the TS is shown in Fig.1.

I.I. Mueller and B. Kołaczek (eds.),
Developments in Astrometry and Their Impact on Astrophysics and Geodynamics, 125–127.

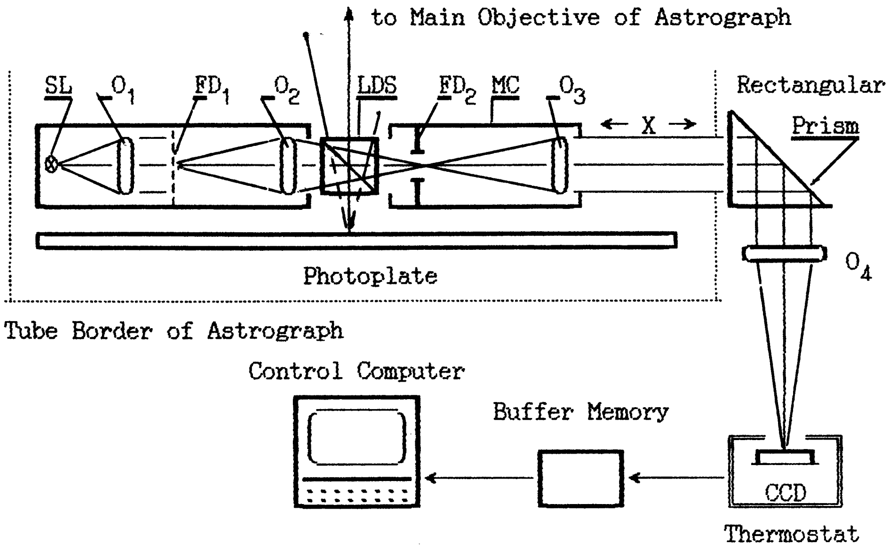

Fig.1. Principle of the CCD-tracking system.

The main element of TS is the movable carriage MC capable of motion in two orthogonal directions X and Y parallel to the plate. The light-dividing cube LDC secured on the carriage case MC is mounted above the focal image of the object and keep it by means of movement of the whole carriage along axes X and Y. Light beams from the object are nearly fully reflected by the LCD diagonal side and focused in the plane of the field diaphragm FD_2. The relation between reflectance and transmission of the LCD diagonal side is selected approximately equal to n=Q/n. The flash source of light SL with the help of collector O_1 uniformly illuminates the continuous diaphragm FD_1 having a few small holes with a diameters of about 30 mcm. Their images, with the help of the objective Q_2 and the same cube LDC, are constructed on the photoplate and in the plane of the diaphragm FD_2 together with object, whereupon the main part of light concentrates on the photoplate. The images of the object and light marks are transferred by the reversing and increasing system O_3-O_4 and the rectangular prism to the CCD-matrix which may be found outside the cassette case. The prism is secured on the platform bearing the guides on which the carriage MC moves in the X-axis direction, while the objective O_4 and the CCD-matrix are secured on the cassette case. In this way, during the movement of the carriage MC along the X or Y axes the images of the light marks will not be displaced relative to the CCD-matrix. If this movement also compensates the motion of the object accurately enough then its image will be also fixed on this matrix.

By turning the whole cassette the X-axis should be first set by the position angle so that it is parallel to the direction of motion of the object among stars for which the cassette should be fitted with a corresponding counting device. A small movement of the carriage MC in the orthogonal direction Y is necessary for the compensation of curvature of the trajectory of the object.

During the movement of the carriage MC along both axes following the object, the latter is continuously exposed on the same pixels of the CCD matrix. At the same time the light source SL flashes periodically and the file of light marks is exposed on the photoplate and simultaneously projected onto the same pixels of the CCD-matrix.

On the completion of the object exposure, charges of the CCD-matrix are read out in a numerical code and entered into a buffer memory connected with a control computer. This computer processes the data and determines the coordinates of the object relative to the light marks whose positions in the reference stars system are found as usual by measuring their relative coordinates on the photoplate.

Numerical simulation of observations through a turbulence atmosphere with the Zeiss-400 astrograph (F=2m) using an ordinary CCD-matrix (pixels 30×30 mcm^2, limit charge 700000$\bar{e}$, Q=30%, noise 20$\bar{e}$, light loss 25%) and a 10 times TS optical magnification showed (Gubanov, Kumkova and Malakhov (1990)) that it is possiple to obtain positioning accuracy of objects within 10÷20 magnitudes with respect to:

single reference star	0.″10÷0.″15,
the AGK3 reference stars	0.05÷0.10,
the HIPPARCOS reference stars	≃0.05.

REFERENCE:

Gubanov, V., Kumkova, I. and Malakhov, E. (1990), 'Precision estimate of positional CCD observations', Kinematics and Physics of Celestial Bodies, Allerton Press, New York (English translation), 6,No.2, 83-90.