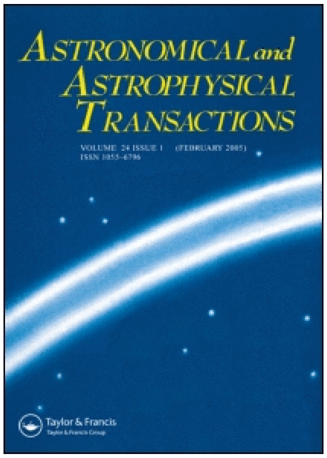

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Scientific and technical collaboration between Russian and Ukranian researchers and manufacturers on the development of astronomical instruments equipped with advanced detection services

Vishnevsky; Galyatkin; Dalinenko; Vydrevich; Zhuk; Iblyaminova; Kossov; Levko; Nesterov; Rivkind; Rogalev; Smirnov; Gumerov; Bikmaev; Pinigin; Shulga; Kovalchyk; Protsyuk; Malevinsky; Abrosimov; Mironenko; Savchenko; Ivaschenko; Andruk

Online Publication Date: 01 January 2003
To cite this Article: Vishnevsky, Galyatkin, Dalinenko, Vydrevich, Zhuk, Iblyaminova, Kossov, Levko, Nesterov, Rivkind, Rogalev, Smirnov, Gumerov, Bikmaev, Pinigin, Shulga, Kovalchyk, Protsyuk, Malevinsky, Abrosimov, Mironenko, Savchenko, Ivaschenko and Andruk (2003) 'Scientific and technical collaboration between Russian and Ukranian researchers and manufacturers on the development of astronomical instruments equipped with advanced detection services', Astronomical & Astrophysical Transactions, 22:4, 777 - 786
To link to this article: DOI: 10.1080/1055679031000154256
URL: http://dx.doi.org/10.1080/1055679031000154256

Astronomical and Astrophysical Transactions
Vol. 22, Nos. 4–5, August–October 2003, pp. 777–786

SCIENTIFIC AND TECHNICAL COLLABORATION BETWEEN RUSSIAN AND UKRANIAN RESEARCHERS AND MANUFACTURERS ON THE DEVELOPMENT OF ASTRONOMICAL INSTRUMENTS EQUIPPED WITH ADVANCED DETECTION SERVICES

G. I. VISHNEVSKY[a,*], I. A. GALYATKIN[a], I. N. DALINENKO[a,†], M. G. VYDREVICH[a], A. A. ZHUK[a], A. F. IBLYAMINOVA[a], V. G. KOSSOV[a], G. V. LEVKO[a], V. K. NESTEROV[a], V. L. RIVKIND[a], Yu. N. ROGALEV[a], A. V. SMIRNOV[a], R. I. GUMEROV[b,‡], I. F. BIKMAEV[b], G. I. PINIGIN[c,§], A. V. SHULGA[c], A. V. KOVALCHYK[c], Yu. I. PROTSYUK[c], S. V. MALEVINSKY[d], V. M. ABROSIMOV[d], V. N. MIRONENKO[d], V. V. SAVCHENKO[d,‖], Yu. N. IVASCHENKO[e,¶] and V. M. ANDRUK[e]

[a]'Electron-Optronic' Research & Production Company, St Petersburg, Russia;
[b]Kazan State University, Kazan, Russia;
[c]Nikolaev Astronomical Observatory, Nikolaev, Ukraine;
[d]National Center of Space Facilities Control and Test, Evpatoria, Ukraine;
[e]Andrushivka Astronomical Observatory, Ukraine

(Received September 24, 2002)

The paper presents the possibilities and a list of tasks that are solved by collaboration between research and production companies, and astronomical observatories of Russia and Ukraine in the field of development, modernization and equipping of various telescopes (the AMC, RTT-150, Zeiss-600 and quantum-optical system Sazhen-S types) with advanced charge-coupled device (CCD) cameras. CCD imagers and ditital CCD cameras designed and manufactured by the 'Electron-Optronic' Research & Production Company, St Petersburg, to equip astronomical telescopes and scientific instruments are described.

Keywords: Position astronomy; Astronomical instrumentation; Charge-coupled device (CCD) imagers; Digital CCD cameras

1 INTRODUCTION

Both telescope parameters and recording methods play an important role in the expansion of the range of artificial and natural observed objects in the near-Earth and deep space, and in particular those with a low intensity in the optical spectral band.

* Corresponding author. E-mail: vish@silar.spb.ru
† E-mail: dalin@silar.spb.ru
‡ E-mail: rustem.gumerov@ksu.ru
§ E-mail: pinigin@mao.nikolaev.ua
‖ E-mail: nkay@eec.crimea.com; sav@seavenue.net
¶ E-mail: yurets@gluk.org

ISSN 1055-6796 print; ISSN 1476-3540 online
DOI: 10.1080/1055679031000154256

2 DETECTORS AND DETECTING SYSTEMS

At present the majority of astrophysical and astronomical telescopes are equipped with charge-coupled device (CCD) image sensors. A photosensitive CCD array offers significant advantages over a photographic plate or photomultiplier; the observation of faint celestial objects in various recording modes (drift scan, stare mode and combined mode), the large dynamic range and the capability of digitizing the output signal all provide the possibility of using different data-processing techniques and, as a result, improving the effectiveness and accuracy. Two modes of the CCD operation are used in astronomical observations: drift scan or time delay and integration mode, when detected objects move in the telescope field of view, and stare mode, when the observed stars have a fixed position within the telescope field view (under the condition that the angular movement of the telescope tube is equal to the Earth's diurnal rotation speed).

2.1 'Electron-Optronic' Research & Production Company Charge-Coupled Devices

St Petersburg 'Electron-Optronic' Research & Production Company currently designs and manufactures more than ten CCD models of different types for ultraviolet (UV)–visible–near-infrared (IR) spectral bands (0.2–5.5 μm) (Vishnevsky et al., 2001).

The class of virtual phase CCDs, which is traditional for the company's production line, includes seven CCD models with formats from 386 × 298 to 1300 × 1225 pixels. They all possess frame transfer organization and are made with the help of two-phase polycrystalline silicon technology in the image section. These devices feature high UV (up to 25% at 250 nm) and overall (up to 65% at maximum) quantum efficiency, low photoresponse non-uniformity (1.5–3%), and low readout noise figures (8–10 electrons rms at 1 MHz readout rate). For the ISD-017AP CCD a readout rate of fewer than four electrons at 50 kHz has been achieved.

Three-phase polycrystalline silicon CCDs are obtained by two devices with 512 × 512 and 1024 × 1024 formats. These devices have a fibre-optic input window and are intended for direct coupling with the output screen of the image intensifier tube. The 512 × 512 has frame-transfer architecture, a 22 μm × 22 μm pixel, a quantum efficiency of up to 45% at 600 nm, 500× antiblooming and a full well of 350 000–400 000 electrons.

All CCDs are available both in a non-cooled version and in a Peliter-cooled version in gas-filled vacuum-tight housings.

The company carried out research and development work on thinned CCDs for operation in the electron-bombarded mode. Electron-bombarded CCDs of 520 × 580 and of 1024 × 1024 formats are available.

For the mid-IR imaging in the 3–5.5 μm spectral band, interline Schottky-barrier CCDs with 256 × 290 pixels are available, and 480 × 320 devices are under development at the moment.

2.2 S1C Charge-Coupled Device Cameras

In the field of the slow-scan digital CCD cameras a new-generation camera, namely the 14 bit compact CCD camera of monoblock design S1C, has been developed and is manufactured in small lots. This model features dual-mode (draft and fine) readout, variable CCD exposure time (within the 1 ms–3000 s range) and a wide variety of image pre-processing built-in functions.

The S1C series can be used for all-digital video signal processing (CDS, black-level restoration, etc.). Camera operation and signal display are controlled with the help of a personal computer (PC). The camera design consists of the monoblock (100 mm × 80 mm × 90 mm) with a remote power supply unit. The basic interference to the PC is serial; the distance to the PC is up to 15 m. The specialized PC interface adapter used to connect the camera with the PC allows real-time image displaying.

The main performance characteristics of the S1C camera series are as follows:

(i) support of CCDs of different formats;
(ii) flexible control of the operation modes of CCDs;
  (a) readout frequency range, 200 kHz–5 MHz;
  (b) horizontal binning, up to 8×;
  (c) vertical binning, up to 32×;
  (d) different algorithms of CCDs dump;
  (e) exposure time range, 1 ms–3000 s;
  (f) trigger mode;
  (g) drift scan mode;
(iii) synchronization of the CCD with the internal pulse light source;
(iv) two easily switched CCD readout modes;
  (a) draft mode (read-out rate, 5 MHz;);
  (b) fine mode (read-out rate, less than 1 MHz);
(v) dynamic range (depending upon the CCD model and readout mode), 4000–16 000;
(vi) CCD cooling system with the stabilized CCD temperature down to −40°C with the accuracy not worse than 1°C; force-air circulation cooling of the Peltier-cooler hot-plate;
(viii) optical interfaces with F and C mounts.

All cameras of the S1C series can be easily configured for different applications; the choice of the image formats and CCD operation regimes (clock diagrams, operating voltages levels and exposure time), as well as built-in functions of the image pre-processing can be controlled from the PC continuously. Besides the basic set-up, parameters can be written into the camera by default.

The cameras are implemented on the basis of the Analogue Devices 14 bit analogue-to-digital converter (ADC) and reprogrammable Altera logic. The built-in Atmel microcontroller serves to control all camera modes of operation. The image processing is all digital.

The cameras of the S1C series do not have a built-in video buffer. The signal transmission is fulfilled synchronously with the CCD readout. The data flow interface is of a serial type based on FlatLink Ser/Des integrated circuits with LVDS drivers with a maximal data transfer speed of 30 MBytes s^{-1}.

The software is running under Windows® 95/98 and provide the following:

(i) control of the camera operation parameters;
(ii) display of the image on the PC monitor (with adjustable zoom, brightness, contrast and gamma);
(iii) saving of the images on the PC HDD;
(iv) image pre-processing functions: dark-field correction; flat-field correction; smear correction; defects correction; digital automatic gain control (AGC); digital frame integration; construction of sections and histograms; a low-level delay lock loop is available.

2.3 Sony ICX249AL Charge-Coupled Device Camera

A low-cost digital CCD camera has been developed on the basis of the Peltier-cooled ICX249AL (Sony, Japan) for amateur astronomy. When the CCD chip is cooled $-20\,^{\circ}$C it reduces the dark current drastically and, together with the CCD antiblooming capability, allows the camera to have a wide range of exposure times (256 μs–20 min). Original design of the housing allows us to use a two-stage Peltier cooler, which results in a temperature drop of up to 60°C between the CCD chip and the ambient (Peltier-cooler consumption power, 5–7 W). The CCD camera is especially effective when used to observe inactive and fixed objects under low lighting levels.

The main camera specifications are given in Table I.

The software includes the following:

(i) camera operation control: exposure time, ADC mode, Peltier-cooler and fan control, start of the integration and electrically erasable programmable read-only memory control;
(ii) data readout into the PC;
(iii) display of the image with the possibility to switch between different fields;
(iv) horizontal profile of any line of the image superimposed on to the displayed image;
(v) frame difference calculation;
(vi) image capture into bit-map files;
(vii) calculation of the mean value and rms variation over any arbitrary image zone and construction of histograms;
(viii) indication of the CCD chip and ambient temperatures;
(ix) customized software available.

2.4 Digital 12 bit Intensified Charge-Coupled Device Cameras

The company has developed and manufactured a new class of CCD cameras, namely digital 12 bit intensified CCD cameras for operation in a pseudotelevision mode (with a frame rate up to 20 Hz) in the 10^{-4}–10^{+3} faceplate illuminance range with a digital AGC system. The

TABLE I Main Camera Specifications.

CCD imager	Sony CCD ICX249AL mounted into vacuum-tight gas-filled housing with a single-stage Peltier cooler (two-stage Peltier cooler as an option)
Optical format	$\frac{1}{2}$ in (8 mm diagonal)
Effective number of pixels	752 (horizontal) × 582 (vertical)
Pixel dimensions	8.6 μm (horizontal) × 8.3 μm (vertical)
Scanning mode	2 : 1 interlaced with charge integration in one or two elements
Exposure times	256 μs–20 min with 256 μs step (software controlled)
Frame readout time	0.16 s
Frame rate	maximum 6 Hz
ADC resolution	12 bit
Readout noise	<30 electrons rms
S/N ratio	>58 dB (one-element integration mode) >62 dB (two elements integration mode)
Camera control	By the software via the COM port
Main PC interface	Parallel
Data input	Via the digital frame grabber (supplied with the camera) installed into the PC interface slot

camera detector consists of a Gen II image intensifier with a 18 mm photocathode, directly coupled via the fibre-optic plate with the 512×512 CCD.

2.5 Modified TVC200ML Thermovision Charge-Coupled Device Camera

New modifications of the TVC200ML thermovision CCD camera for imaging in the 2–5.5 μm spectral band are being developed. These cameras are based on the 256×290 Schottky-barrier IR CCD. Detector cooling is attained with the help of the refilled liquid-nitrogen cryostat with a hold time from 6 to 32 h. At present an IR CCD camera with a Stirling-type CCD cooler is under development.

3 ASTRONOMICAL TELESCOPES AND INSTRUMENTS

Let us consider several astronomical instruments in order to evaluate the effectiveness of the use of some products of the 'Electron-Optronic' Research & Production Company (Tab. II).

3.1 Nikolaev Axial Meridian Circle Instrument

This instrument was made in the Nikolaev Astronomical Observatory and began regular observations in 1995 (Kovalchuk et al., 1997).

3.1.1 Performance Characteristics of the Axial Meridian Circle Instrument

These were as follows:

(i) main tube with an objective diameter of 180 mm and a focus distance of 2480 mm;
(ii) universal CCD camera (UCC) of the main tube; ISD017AP CCD imager (1040×1160, 16 μm × 16 μm pixel); $1''.33$ pixel^{-1}; FOV, $23' \times 26'$ (Kovalchuk, 1999);
(iii) observation mode:
  (a) drift scan; exposure time, 103 s; sec δ; scan width in declination (δ), $23'$;
  (b) stare mode for the stationary objects in the FOV;
(iv) fixed autocollimator with an objective diameter of 180 mm and a focus distance of 12 360 mm; CCD camera with a FPPZ-13M CCD imager (256×288; 24 μm × 32 μm pixel); $0''.40$–53 pixel^{-1};
(v) drive: positioning accuracy $\pm 4''$;
(vi) automatic control system provides observations of about 7000 stars per hour in the 8.5–16 magnitude range.

The UCC made in the Nikolaev Astronomical Observatory will now be briefly described.

The UCC is a multimode digital CCD camera with a 16 bit ADC and low-noise performances. The built-in thermostatically controlled generator provides a high stability of time features of operating diagrams; therefore, the influence of environmental temperature changes is eliminated. The application of ultralow-noise amplifiers, double-correlated sampling and low frequency of the signal read-out allows us to minimize the noise of the camera.

The UCC operation and viewing of the video information is carried out with the help of a computer. The camera consists of a mechanical module with a CCD chip and pre-amplifier, remote control, processing block and the supply unit. A parallel interface with the computer is used. The distance to the computer under the standard configuration is up to 20 m. The ISA adapter is used for connection to the computer.

TABLE II The Comparative Performance Characteristics of Several Telescopes Equipped with the same CCD Imagers of the ‘Electron-Optronic’ Research & Production Company.

Parameter	Value for the following instruments			
	AMC[a]	Zeiss-600[c]	QOS Sazhen-S[d]	RTT150[b]
Design	Refractor	Reflector, Cassegrain	Reflector, Cassegrain	Reflector, Cassegrain
D (mm)	180	600	500	1500
F (mm)	2480	7500	8200	11,600
Installation	Meridian	Parallactic	Parrallactic	Parrallactic
CCD camera with ISD017AP	Universal CCD camera	S1C Digital CCD camera	S1C Digital CCD camera	DinaCam CCD camera
1040×1160 CCD ($16\times16\,\mu m^2$ pixel)	1.″33 $pixel^{-1}$	0.″44 $pixel^{-1}$	0.″40 $pixel^{-1}$	0.″28 $pixel^{-1}$
Mode	Drift scan, stare	Drift scan, stare	Drift scan, stare	Drift scan, stare
Stare mode, (exposure time $\tau \approx 600$ s)				
FOV[e]	$23' \times 26'$	$8' \times 9'$	$7' \times 8'$	$5' \times 5'$
Magnitude	11.0–16.0–17.5	12.0–18.0–19.5	12.0–18.0–19.5	14.5–19.5–21.0
σ[f]	0.″02–0.″04–0.″20	0.″01–0.″0.2–0.″10	0.″0.1–0.″0.2–0.″10	0.″005–0.″01–0.″0.5
Drift scan mode exposure time				
τ (sec),	103	37	34	22
mag:	10.0–14.0–16.0	10.0–15.0–17.0	10.0–15.0–16.5	11.0–16.0–17.5
σ[f]	0.″02–0.″04–0.″20	0.″01–0.″02–0.″10	0.″01–0.″02–0.″10	0.″005–0.″01–0.″05

[a]AMC, axial meridian circle of the Nikolaev Astronomical Observatory (NAO), Ukraine.
[b]RTT150, Russian–Turkish telescope of the Turkish National Observatory.
[c]Zeiss-600 of the Andrushivka Astronomical Observatory, Ukraine.
[d]QOS Sazhen-S, quantum-optical system of the National Center of Space Facilities Control and Test, Evpatoria, Ukraine.
[e]FOV, field of view indicated for the stare mode only; there are no restrictions on the right ascension for the drift scan mode.
[f]The lower limit of the calculated accuracy is indicated for the maximal magnitude, and the best accuracy is for objects 1.5–2 magnitudes brighter.

The main characteristics of the digital UCC are as follows:

(i) Support of different formats of CCD chips;
(ii) flexible regulation of the CCD working modes by software:
  (a) exposure time, 1 ms–5000 s;
  (b) stare mode;
  (c) drift scan mode;
  (d) read-out frequency of output register, 50 kHz;
  (e) minimal discretization of time transfer for a single line under drift-scan mode, 750 ns;
  (f) frequency transfer number, 4×10^{-9};
  (g) gain range, 10–2550.

The software, written in PASCAL, includes the procedures of operating, viewing and processing of the signal.

Two UCCs for the AMC were made at NAO based on the ISD 017AP (‘Electron-Optronic’ Research & Production Company) and FPPZ-13M (‘Electron’ National Research Institute). Later, the same UCCs were installed into the zone astrograph at NAO (Ivantsov et al., 2000) and the meridian axial circle of the Main Astronomical Observatory, National Academy of Sciences of Ukraine, and the Astronomical Observatory, Kiev National University (Lazorenko et al., 2001). At present all these UCCs are used for regular observation.

3.1.2 Observation Programmes at the AMC (Completed, Running and Scheduled)

These are as follows.

(i) From 1996 to 1998, observations of intermediate reference stars in the 12–15 magnitude range in selected areas near 190 extragalactic radio sources were made. The stars from the USNO-A2.0 catalogues, HC and TC, were used in the observations list. The AMC catalogue was presented in 2000. It contains 14 400 stars with accuracy $\varepsilon_\alpha \cos\delta = \pm 0''.07(\sec Z)^{0.20}$ (magnitude-7)$^{0.43}$; $\varepsilon_\delta = \pm 0''.09(\sec Z)^{0.10}$ (magnitude-7)$^{0.31}$. The catalogue is available at http://www.mao.nikolaev.ua/ARC/amc1b.zip.
(ii) Observations of the selected minor planets were made according to the list of the Applied Astronomy Institute (St Petersburg).
(iii) Observations of the bright ERS up to magnitude 16 were made in order to specify the connection between optical coordinate reference frame HCRF and radio coordinate reference frame ICRF; the second epoch of the observations of the intermediate reference stars from the AMC catalogue, were also obtained.
(iv) Observations were carried out for the extension and confirmation of the Hipparcos catalogue.
(v) Large astrometrical calibration areas were created in the selected fields of the celestial sphere.
(vi) Observations of the Solar System objects were carried out:
  (a) observations for determination of masses of selected asteroids;
  (b) observations of selected minor planets for determination and refinement of their orbital parameters;
  (c) observations of bright near-Earth orbit NEO asteroids approaching the Earth, for determination of their position and magnitudes;
  (d) long-term observations of outer planets and the majority of their satellites in the ICRF system for improvement in their ephemerides.
(vii) Long-term observations of the variable stars were made.

3.2 The Russian–Turkish Telescope (RTT150)

The 1.5 m telescope RTT150 was manufactured by the well-known optical–mechanical company Lomo (St Petersburg) in 1995 (Gumerov et al., 1999). By 1998, work on the telescope's assembly and installation in Antalya, Turkey, was completed in the framework of the Cooperation Agreement between the Kazan State University (KSU), the Space Research Institute, Russian Academy of Sciences (SRI RAS), and the Turkish National Observatory. The optical scheme of the well-known CIS telescope of AZT-22 type has a set of the optical schemes (F/3, F/8 and F/16 for the Cassegrain focus and F/48 for the Cude focus). In addition, the telescope is equipped with two guides, namely Ritchey–Chretien telescopes with mirrors of 360 mm diameter, which can be used independently. The full FOV in the Ritchey–Chretien variant with the corrector installation is 80′ (300 mm). For the small fields limited by the CCD size a corrector is not necessary.

The telescope is equipped with a PC control system developed at KSU and SRI RAS which allows observation to be performed in two modes:

(i) batch mode, when the list of objects (coordinates, start of exposure and exposure time) is prepared in advance and loaded into the control PC for further orientation of the telescope;
(ii) via the remote terminal (PC), connected with the control PC (and with the Internet) via a local network.

The telescope is equipped with an ST8 CCD camera (from SBIG, USA) for comparatively short exposures (up to 10 min). For extended exposure times the new digital CCD camera DinaCam with liquid-nitrogen CCD cooling is used. This camera was developed in the advanced research laboratory headed by Dr S. Markelov of the Special Astrophysical Russian Academy of Sciences. In addition to the extreme noise figures, the camera provides several modes of the charge storage: stare mode, drift scan, forward–backward and their combination. The last feature provides new possibilities for the connection of investigated objects with the reference objects.

Table III demonstrates the performance characteristics of the DinaCam CCD camera equipped with the ISD-017AP CCD. It is planned to use this camera for observation of faint objects with the RTT150.

The main task of the RTT150 telescope is astrophysical research: observations of far objects (quasars, galaxies and clastersions, micro-lensing objects, etc.), near galaxies and objects in Milky Way. The astrometry programme includes observations of the ERS optical counterparts and stars around them for refinement of the connection between optical and radio coordinate systems. Observations of minor objects in the solar system (of 16–21 magnitude) is also scheduled: selected minor planets and asteroids, including trans-Neptunian objects with the aim of determining their positions, masses and spectrum.

3.3 Zeiss-600 Telescope

In January 2002, the Zeiss-600 telescope (main mirror diameter, 600 mm; equivalent focus, 7500 mm; Cassegrain focus FOV, 20′; secondary mirror diameter, 183 mm) of the Andrushivka Astronomical Observatory was equipped with the S1C CCD camera. In February–March of the same year, test observations of selected astronomical objects began with the goal of obtaining their coordinate and photometric parameters (Ivaschenko et al., 2001). The MIDAS/ROMAFOT software package is used for image processing. In the present author's opinion, the preliminary test results have proved that star images of up to 21

TABLE III Characteristics of the DinaCam CCD Camera.

Parameter	Value
ADC quant, e^-/ADU	
Output channel A	
Gain, 1	3.33
Gain, 4	0.82
Output channel B	
Gain, 1	3.06
Gain, 4	0.75
Read-out noise, e^-	
Output channel A	
Gain, 1	6.30
Gain, 4	3.80
Output channel B	
Gain, 1	6.70
Gain, 4	3.80
Full charge, e^-	165 000
Dynamic range	
Gain, 1	28 000
Gain, 4	10 000
Dark current, $e^-/s \times$ pixel	0.001
Charge transfer efficiency (per one transfer)	
Output channel A	
In register	
In image section	0.999 88
Output channel B	0.999 95
In register	
In image section	0.999 89
	0.999 95

magnitude can be obtained with a 10 min exposure time. The expected accuracies of the single determination of position and photometry are about 0.″05 and 0.04 respectively. Realization of the Vilnius variant of the symmetrical photometric system is planned to determine the parameters of celestial objects.

3.4 Quantum-Optical System Sazhen-S

The QOS Sazhen-S is intended for high-accuracy measurements of (Mironenko et al., 2001) the following:

(i) inclined range for space vehicles (SVs) equipped with an angle reflector by the time-pulse technique;
(ii) angular coordinates of the SV measurements corresponding to the reference stars (by the respective technique) for further recalculation in the required coordinate systems;
(iii) SV photometry characteristics in the optical wavelength range.

The inclined range measurement mode for the SV is the main operational regime of the QOS Sazhen-S during its performance, as it allows ballistic and navigation tasks to be performed with the required accuracy.

In the course of the current modernization of the QOS Sazhen-S an upgrade of the system with the advanced instruments is being carried out, with the goal of providing multifunctional usage, including near-Earth space control, investigations of space debris problems, observations of Solar System minor objects, and research of the approach of NEO asteroids to the Earth.

The QOS Sazhen-S consists of the following subsystems:

(i) astronomical mirror telescope (D = 500 mm; F = 8200 mm);
(ii) pavilion and support-rotating system;
(iii) driving system;
(iv) inclined range measurement system;
(v) set-up for the observations of near-Earth space objects: recording television camera and rotation platform (NAO) and digital CCD camera S1C (‘Electron-Optronic’ Research & Production Company);
(vi) control–computer centre.

4 CONCLUSION

(i) At present, the ‘Electron-Optronic’ Research & Production Company is the only manufacturer of CCD image sensors and high-performance digital CCD cameras for a wide range of scientific and applied tasks at CIS.
(ii) When the performance level of the CCD devices and CCD cameras from this company is evaluated according to the totality of the performance characteristics (accuracy, sensitivity, reliability, price, etc.), these instruments are competitive with similar instruments worldwide, which makes it possible for Russian and Ukranian astronomers to participate in advanced research projects in astrophysics, positional and near-Earth astronomy.
(iii) The scientific and technical cooperation between the manufacturers and astronomical observatories has proveed how efficient this can be for a sample of different telescopes equipped with advanced CCD cameras.

Acknowledgement

This paper was partly supported by the Russian Foundation for Basic Research under Grant 02-02-17076a.

References

Gumerov, R. I., Kovalchyk, A. V., Pinigin, G. I., Protsyuk, Yu. I. and Shulga, A. V. (1999). In: Yatskiv, Y. S. (Ed.), Kinematics and Physics of Celestial Bodies, Supplement 1. Main Astronomical University, National Academy of Sciences of Ukraine, Kiev, pp. 79–83 (in Russian).

Ivantsov, A., Kovalchuk, A., Martynov, M., Pinigin, G., Pyshnenko, V., Pozhalova, Zh., Shulga, A., Chernetenko, Yu., Shor, V., Rapaport, M. and Vieteau, B. (2000). In: Yatskiv, Y. S. (Ed.), Kinematics and Physics of Celestial Bodies, Supplement 3. Main Astronomical University, National Academy of Sciences of Ukraine, Kiev, pp. 225–226.

Ivaschenko, Yu. M. and Andruk, V. N. (2001). In: Pinigin, G. I. (Ed.), Extension and Connection of Reference Frames using CCD Ground-based Technique. Nikolaev, Atoll, pp. 224–230 (in Ukranian).

Lazorenko, P. F., Karbovsky, V. L., Andruk, V. M., Telnuk-Adamchuk, V. V., Molotaj, O. A., Babenko, Yu. G., Vertipoloch, O. Ya, Kasjan, S. M., Ivanova, M. M. and Kovalchuk, O. M. (2001). Extension and Connection of Reference Frames using a CCD Ground-based Technique. Nikolaev, Atoll, pp. 287–290 (in Ukrainian).

Kovalchuk, A. (1999). Kinematics and Physics of Celestial Bodies, Supplement 1. Main Astronomical University, National Academy of Sciences of Ukraine, Kiev, pp. 97–100 (in Ukrainian).

Kovalchuk, A. V., Pinigin, G. I. and Shulga, A. V. (1997). In: Vondrak, J. and Capitaine, N. (Eds.), Journees 1997 Systemes de Reference Spatio-Temporels, September 22–24, 1997, Prague, pp. 12–14.

Mironenko, V. N., Savchenko, V. V., Serbin, B. M. and Tsyukh, A. M. (1999). In: Pinigin, G. I. (Ed.), Research of Characteristics of Solar System Bodies by CCD, Nikolaev, June 20–24, 1999, pp. 9–12 (in Russian).

Vishnevsky, G., Vydrevich, M., Galyatkin, I., Dalinenko, I., Zhuk, A., Iblyaminova, A., Kossov, V., Levko, G., Nesterov, V., Rivkind, V., Rogalev, Yu. and Smirnov, A. (2001). In: Pinigin, G. I. (Ed.), Extension and Connection of Reference Frames using a CCD Ground-based Technique, Nikolaev, Atoll, pp. 238–241 (in Russian).