



ИЗУЧЕНИЕ ОБЪЕКТОВ
ОКОЛОЗЕМНОГО ПРОСТРАНСТВА
И МАЛЫХ ТЕЛ СОЛНЕЧНОЙ СИСТЕМЫ

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SCIENTIFIC COLLABORATION BETWEEN SHANGHAI AND NIKOLAEV ASTRONOMICAL OBSERVATORIES

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1. Past collaboration (1996—2002)

The field of this collaboration was “Reference frames in Astronomy” with topic: “Refinement of linking optical and radio reference frames on the base of CCD observations”. The first scientific agreement between ShAO and NAO was signed in December of 1996, which was valid from October 1, 1996 till December 31, 1999. The following research was covered by the agreement:

- 1) Joint observations of extragalactic radio sources (ERS) and the second reference stars at the telescopes of ShAO and Axial meridian circle (AMC) of NAO;
- 2) Reduction to the accurate positions of ERS;
- 3) Development and setting up a complex program for observation of stars, radio stars and ERS;
- 4) Investigation of modern methods of catalogue compilation;
- 5) Comparison and compilation of catalogues obtained in ShAO and NAO.

After some years the collaboration has become an international Joint Project for China, Russia, Turkey and Ukraine. Active participants of JP were Z. Aslan and I. Khamitov in Turkish National Observatory TUG, Turkey; R. Gumerov in Kazan State University, Russia; W. Jin, Zh. Tang, Sh. Wang in Shanghai Astronomical Observatory, China; G. Pinigin, N. Maigurova, Yu. Protsyuk, A. Shulga in Nikolaev Astronomical Observatory, Ukraine.

In June 1999 Prof. Wenjing Jin and Dr. Shuhe Wang visited NAO and took part in the International Conference “Research of the Solar System Bodies by CCD-Methods”. During the visit, astronomers of both sides looked back the collaboration and discussed the scientific results of the collaboration. Also future collaboration was discussed. A new agreement between ShAO and NAO was signed in June 1999. Some new research interests were included in the agreement, such as “the linkage between various reference frames like optical, radio and dynamical references” and “the special stars like variable, double, multiple stars and so on will be observed and the stellar kinematics will be studied”.

In June 2000, Drs. Zhenghong Tang and Shuhe Wang of ShAO visited NAO. A detailed discussion on the scientific and technique problems in the collaboration was carried out during the visit. Extension of the collaboration to other research fields was also discussed. Both sides decided to collaborate in the development and usage of the CCD systems in future.

In February 2001 Drs. Alexander Shulga and Yuri Protsyuk of NAO visited ShAO. Three lectures were presented by Ukraine visitors during the visit. Scientific collaboration program since 1996 was reviewed and observational data were exchanged. Both sides expressed satisfaction in precise observational results obtained with AMC and Chinese telescopes. The extension of the jointed

research project such as establishing astrometric calibration regions, identifying of new variable stars, research of near-Earth objects (NEOs), etc. in future were also mentioned in the discussion.

During this period some results were received [6,7]:

- 1) Joint observations of ~300 extra-galactic radio sources (ERS), $\delta: -40^\circ \sim +75^\circ$, mag: 12 ~ 23

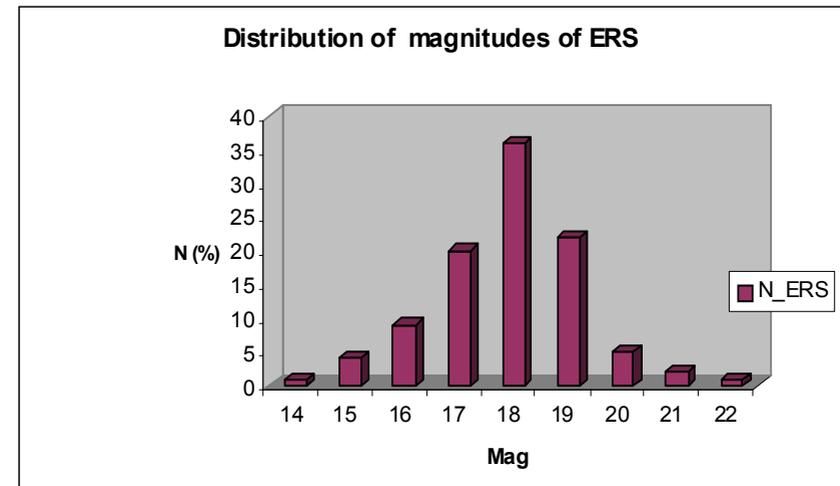


Fig. 1. Distribution of magnitudes of ERS

- 2) The catalogue of optical positions of 213 ERS ($\sigma: \sim 37\text{mas}$)

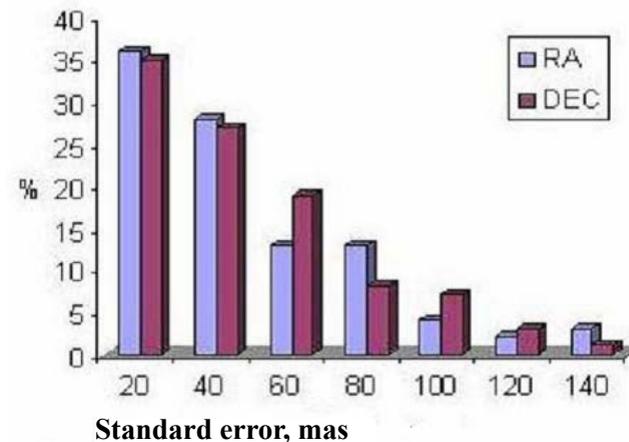


Fig. 2. Distribution of position standard errors for 213 ERS (by using the UCAC2 reference catalogue)

3) Determination of the angles between Optical and Radio Reference Frames [3]

Table 1. Optical-radio rotational parameters

Mode	ω_x (mas)	ω_y (mas)	ω_z (mas)	σ_1 (mas)
Joint Project1, 142 ERS, UCAC2	-4.1±6.1	1.9±5.8	12.4±4.9	46
Joint Project2, 234 ERS, UCAC2, with Assafin et al. [2]	-1.7±4.4	5.2±3.8	9.1±3.3	39
ERL CAT, 318 ERS, Zacharias et al. [8]	-0.2±3.9	-5.4±3.9	-2.5±3.9	58

where $\omega_{x,y,z}$ are rotation angles with their standard errors; σ_1 — error of unit weight.

2. Ongoing collaboration (2003—2006)

The main field of this collaboration is “CCD astrometry in drift-scan mode” for development of electronic hardware for CCD camera in drift-scan mode, development of methods and software for reduction of drift-scan CCD observations [1,4,5]. Active participants of this research were three engineers of ShAO, Drs Zheng Yijin, Cao Kai and Mao Yingdun, five scientists and engineers of NAO, Drs. A. Shulga, Yu. Protsyuk, A. Kovalchuk, Eu. Kozyrev and Eu. Sibirjakova.

In November 2003, Drs. A. Shulga and Yu. Protsyuk of NAO visited ShAO. During this visit summary of the past collaboration, results of observations for NEOs with CCD drift-scan technique and topics for future collaboration between two observatories were discussed. Ukrainian astronomers presented a lecture “Observation of satellites with CCD drift-scan technique” during the visit. Collaborated groups exchanged with information about new results of angles refinement between optical and radio references frames. Both sides recognized that CCD in drift-scan mode is preferable for observing NEOs, natural and artificial satellites, Koiper belt objects, etc. Both side agreed to collaborate specially in the development of CCD drift-scan technique. A new agreement was sign on December 12, 2003.

According to the agreement between ShAO and NAO (2004-2006), Drs. Zhenghong Tang and Jun Tao visited NAO in June of 2004. The results of the collaborated project on the References System were reviewed and exchanged. During the visit both sides discussed in details the new collaborating project “Manufactory, Installation and Application of CCD Drift Scan Technique”, and the draft of the agreement and contract of this project were signed before Chinese visitors went back.

According to the special Agreement, engineers of ShAO, Prof. Yijing Zheng, Kai Cao, and Yindun Mao visited NAO from October 12 till December 28, 2004. They took part in the manufacture of the drift-scan CCD cameras and finished two suits of the drift-scan CCD cameras.

From May 22 till June 22, 2005 Drs. A. Shulga, Yu. Protsyuk and A. Kovalchuk of NAO visited ShAO with a purpose to help Chinese colleagues to install the drift-scan CCD cameras at the telescopes of ShAO. In the results of one

month, the camera has shown good observational data of geostationary satellites (GSS). From June 16 till July 16, 2005, engineers of NAO, Drs. Eu. Kozyryev and Eu. Sybiryakova visited ShAO and took part in the observation of GSS with drift-scan CCD cameras (see Table 2). Also they helped Chinese observers to use the upgraded software for observation of star coordinates in drift-scan mode, and to observe rectangular coordinates and record observational time for synchronous satellites.

During November 21—30, 2005 Prof. G. Pinigin and Dr. A. Shulga were invited to visit ShAO according to the agreement and contract between ShAO and NAO within the Joint Project “Manufactory, Installation and Application of CCD Drift Scan Technique”. There are several purposes for this visit, as to analyse the work on the linkage between radio and optical reference frames, to discuss the results of observation in CCD drift-scan technique, to discuss the future collaboration between two observatories. During this visit Prof. G. Pinigin and Dr. A. Shulga presented three lectures. The collaborated groups exchanged with information on the observations of optical counterparts of radio sources and final results of linkage between optical and radio reference frames. Both sides agreed to publish a joint paper about the final results. The future cooperation projects between two observatories were discussed during the visit. A new agreement was signed by Directors of ShAO and NAO on November 30, 2005, which covers some new research fields:

- 1) development of electronic hardware for CCD camera in drift-scan mode;
- 2) development of methods and software for reduction of drift-scan CCD observations;
- 3) joint observations of GEO satellites and space debris, synchronal observations using the basis method for distance determination;
- 4) research for faint and unknown objects in geo-stationary orbit;
- 5) exchange of results and experience of data reduction, especially automatic data reduction procedure.

Table 2. Some GSS observed by drift-scan CCD

NO.	NO Catalogue.	NORAD International NO.	Name	Owner
1	23649	1995-043A	JCSAT 3	Japan
2	25010	1997-062A	TELSTAR 10	China
3	25404	1998-044A	SINOSAT 1	China
4	25473	1998-052A	PAS 7	USA
5	25657	1999-013A	ASIASAT 3S	Asia-sat Corp
6	26766	2001-019A	PAS 10	USA
7	28364	2004-024A	TELSTAR 18	China

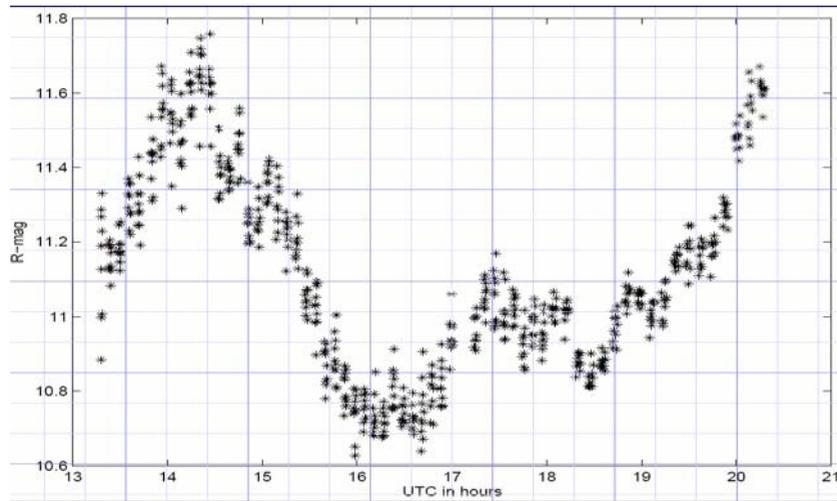


Fig. 3. Change of magnitude of one GSS during one night observation

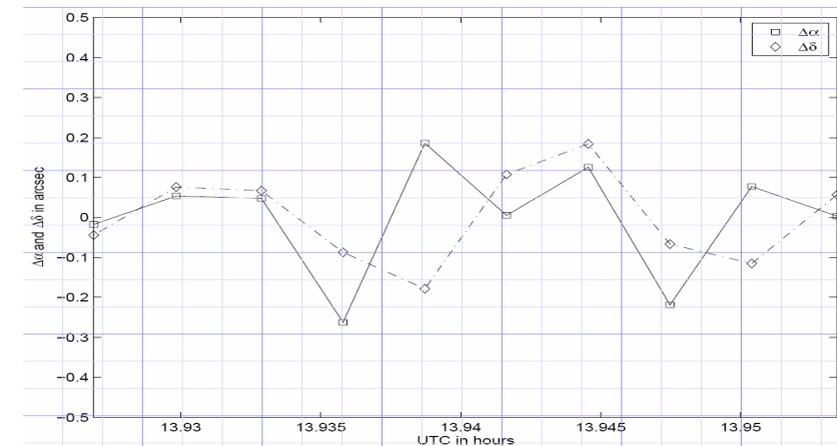


Fig 4. Residual of positions of GSS after orbit fitting

Table 3. Sample results of GSS(25404) observation

Date	UTC	RA(hhmmss.sss)	DE(ddmmss.sss)	TA(deg)	DE(deg)	R-mag
2006-07-29	13:55:36.817	17 37 19.0196	-05 03 43.849	12.84213	-5.06218	11.427
2006-07-29	13:55:47.429	17 37 29.6733	-05 03 43.782	12.84207	-5.06216	11.448
2006-07-29	13:55:58.386	17 37 40.6651	-05 03 43.847	12.84205	-5.06218	11.459
2006-07-29	13:56:08.894	17 37 51.1844	-05 03 44.069	12.84213	-5.06224	11.671
2006-07-29	13:56:19.401	17 38 01.7525	-05 03 44.193	12.84199	-5.06228	11.535
2006-07-29	13:56:29.909	17 38 12.2799	-05 03 43.957	12.84203	-5.06221	11.557
2006-07-29	13:56:40.416	17 38 22.8276	-05 03 43.893	12.84198	-5.06219	11.619
2006-07-29	13:56:50.926	17 38 33.3495	-05 03 44.099	12.84205	-5.06225	11.653
2006-07-29	13:57:01.433	17 38 43.9143	-05 03 44.056	12.84193	-5.06224	11.572
2006-07-29	13:57:12.390	17 38 54.9105	-05 03 43.757	12.84189	-5.06215	11.555
2006-07-29	14:01:43.747	17 43 27.2231	-05 03 43.828	12.84101	-5.06217	11.465
2006-07-29	14:01:53.912	17 43 37.4348	-05 03 43.309	12.84093	-5.06203	11.544
2006-07-29	14:02:04.419	17 43 47.9783	-05 03 43.804	12.84089	-5.06217	11.621
2006-07-29	14:02:14.926	17 43 58.4933	-05 03 43.917	12.84098	-5.06220	11.548
2006-07-29	14:02:25.433	17 44 09.0182	-05 03 43.660	12.84103	-5.06213	11.635
2006-07-29	14:02:36.391	17 44 20.0361	-05 03 43.218	12.84090	-5.06200	11.605
2006-07-29	14:02:46.898	17 44 30.5783	-05 03 43.365	12.84088	-5.06205	11.349
2006-07-29	14:02:57.406	17 44 41.1016	-05 03 43.826	12.84093	-5.06217	11.496
2006-07-29	14:03:07.916	17 44 51.6432	-05 03 43.329	12.84092	-5.06204	11.518
2006-07-29	14:03:18.423	17 45 02.1894	-05 03 43.306	12.84088	-5.06203	11.529
2006-07-29	14:07:49.782	17 49 34.1218	-05 03 44.114	12.84158	-5.06225	11.512
2006-07-29	14:08:00.394	17 49 44.7161	-05 03 44.122	12.84178	-5.06226	11.462
2006-07-29	14:08:10.908	17 49 55.2466	-05 03 44.460	12.84183	-5.06235	11.410
2006-07-29	14:08:21.420	17 50 05.7940	-05 03 44.232	12.84180	-5.06229	11.524
2006-07-29	14:08:31.927	17 50 16.3009	-05 03 43.506	12.84192	-5.06209	11.420
2006-07-29	14:08:42.437	17 50 26.8329	-05 03 43.700	12.84195	-5.06214	11.598
2006-07-29	14:08:53.394	17 50 37.8057	-05 03 44.118	12.84201	-5.06225	11.468
2006-07-29	14:09:03.902	17 50 48.3164	-05 03 43.740	12.84212	-5.06215	11.403
2006-07-29	14:09:14.409	17 50 58.8305	-05 03 43.734	12.84221	-5.06215	11.290
2006-07-29	14:09:24.916	17 51 09.3496	-05 03 43.691	12.84228	-5.06214	11.472
2006-07-29	14:13:55.823	17 55 40.8592	-05 03 43.469	12.84286	-5.06207	11.656
2006-07-29	14:14:06.435	17 55 51.4896	-05 03 43.644	12.84290	-5.06212	11.625
2006-07-29	14:14:17.392	17 56 02.4959	-05 03 43.315	12.84282	-5.06203	11.623
2006-07-29	14:14:27.902	17 56 13.0061	-05 03 43.711	12.84294	-5.06214	11.629

3. Future collaboration (since 2007)

During September 19—28 2006 Drs. Zhenghong Tang and Yong Yu of ShAO were invited to visit NAO according to the agreement (2006–2008) between ShAO and NAO. The two purposes of the visit are “Discussion on the results of observation with CCD drift-scan technique” and “Discussion on the topics for future collaboration between two Observatories”. During this visit Drs. Tang and Yu took part in the international conference “Enlargement of collaboration in ground-based astronomical research in South Eastern Europe countries. Studies of the near-Earth and small bodies of the solar system”. The initial common ideas about joint development of rotating drift-scan CCD cameras were discussed between collaborating groups of ShAO and NAO. Dr. Yu stayed in NAO till November 29, took part in the observations of geostationary satellites and discussed with the Ukrainian colleagues the data reduction software.

From November 30 till December 14, 2006 Drs. A. Shulga and Eu. Kozyrev of NAO visited ShAO under the support of Special Collaborating Foundation for China and Russia-Ukraine-Belarus of Chinese Academy of Sciences. During this visit, Drs. A. Shulga and Eu. Kozyrev installed the upgraded software of the drift-scan mode and remote control software, showed data reduction software in TV mode. Cooperative groups exchanged with information on the observations of GEO satellites with drift-scan mode. Both sides recognized the need to mount a CCD camera on a special rotating system for study of space debris in low orbit with drift-scan technique. The future collaboration program was discussed in detail during this visit. Both sides agreed to collaborate in the new project “Development of hardware and software for rotating CCD camera system in drift-scan mode”. A new special agreement was signed for the next year, which covers items, as development, installation, and usage of rotating CCD camera systems in drift-scan mode on telescopes of ShAO; development of methods and software for CCD observations, data processing, and determination of the equatorial coordinates of objects in drift-scan mode with rotating system; joint observations of space debris at the telescopes of the RI NAO and ShAO for experiments of rotating CCD system in drift-scan mode; estimation of orbital elements and analysis of observational data accuracy.

There are so many good scientific achievements obtained so far from the past ten-year collaboration between ShAO and NAO. We hope that the new steps of the collaboration between ShAO and NAO will bring more success in future.

Future research:

1) Joint manufacture of rotational hardware and corresponding software for CCD with drift-scan mode with good images of faint and small space debris in GEO and LEO.

2) Joint development of data reduction software for rotational CCD in drift-scan mode.

Application of rotational CCD in drift-scan mode in comparison with normal observational mode of satellites and space debris (TV, ~40 ms/frame). Drift-scan mode can prolong the exposure time in 10-100 times, which means that it is possible to get 2—5 magnitude fainter objects with the same telescope. Drift-scan mode is very powerful and effective to observe small space debris.

3) Joint observations of space debris and compilation of catalogue for public and peaceful use of space.

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