

The Russian Virtual Observatory

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Abstract.

International Virtual Observatory (IVO). The RVO has the main goal of integrating resources of astronomical data accumulated in Russian observatories and institutions (databases, archives, digitized glass libraries, bibliographic data, a remote access system to information and technical resources of telescopes etc.), and providing transparent access for scientific and educational purposes to the distributed information and data services that comprise its content.

Another goal of the RVO is to provide Russian astronomers with on-line access to the rich volumes of data and metadata that have been, and will continue to be, produced by astronomical survey projects.

Centre for Astronomical Data (CAD), among other Russian institutions, has had the greatest experience in collecting and distributing astronomical data for more than 20 years. Some hundreds of catalogs and journal tables are currently available from the CAD repository. More recently, mirrors of main astronomical data resources (VizieR, ADS, etc) are now maintained in CAD. Besides, CAD accumulates and makes available for the astronomical community information on principal Russian astronomical resources.

1. Introduction

During recent years the idea of creating of Virtual Observatories (VO) has become one of the principal ideas of modern astronomy. We understand the VO as observations of the virtual sky with a virtual telescope, where the virtual sky consists of archival data sets of space-borne and ground-based observatories, the catalogues of multiwavelength surveys, and the virtual telescope is metadata standards, query services, data mining applications, and computational resources.

The principles of the structure of the projects announced by NVO, AVO, AstroGrid and other national initiatives are certainly well known. The International Virtual Observatory Alliance (IVOA) was formed in Garching in June 2002 to coordinate common efforts in this direction.

Among the projects participating in IVOA, there is also the Russian Virtual Observatory (RVO) proposed by the Centre for Astronomical Data (CAD) of the Institute of Astronomy of the Russian Academy of Sciences (INASAN) and the Special Astrophysical Observatory (SAO) of the Russian Academy of Sciences (RAS).

This is very natural because the Centre for Astronomical Data has 20-years experience of activity as a regional data center and, among other Russian institutions, has the largest experience in collecting and distributing astronomical data. CAD also fills the function of coordinator of the Section 13 “Databases and Informational Environment” of Scientific Council of Astronomy of the RAS and represents the Russian astronomical community in the Library Council of the RAS.

SAO has the largest optical and radio telescopes in Russia and extensive data archives.

The RVO project has already attracted attention of the astronomical community in our country, and its presentation was included in the programs of several conferences: those that were carried out in St-Petersburg (“All-Russian astronomical conference” in August 2001), in Moscow (“Euro-Asian Astronomical Society VI congress” in May 2002) and in Nizhnij Archyz, SAO (“Informational systems in fundamental science” in July 2002), and those that will be held in Dubna (“Digital Libraries”, October 2002).

2. RVO principles

As we understand it, the RVO has 3 principal goals:

1. To provide the Russian astronomical community with a convenient access to the world data grid,
2. To take part in developing software, techniques, standards, and formats necessary for the establishment of the IVO,
3. To unite Russian and former Soviet Union (fSU) data, to make them available to the rest of the world and integrate them into the IVO, and to strengthen education and public applications of world astronomical data.

Further, our activity on development of these principles is discussed.

2.1. Providing the Russian astronomical community with a convenient access to the world data grid

The functions of CAD in this kind of service are as follows:

- CAD now holds the mirrors of VizieR from CDS and of ADS - in addition to the ADS abstracts, in the immediate future we will have a complete version of this informational system.
- CAD also maintains the INES (IUE Newly Extracted Spectra) “National Host”-level mirror installed at INASAN.

- CAD also has some other functions:
 - To keep archives, catalogues, and software on CD,
 - To fulfill browsing and visualization of catalogues,
 - To provide reviewing and expert evaluation of data sets,
 - To make data translations: DLT, DDS, ADR, CD, MO,
 - To make an analysis of user requests.
- The staff of CAD has also significant experience in construction of astronomical catalogues. Some of them are:
 - Observational data in galactic star-forming regions,
 - Stellar mass catalogue,
 - Stellar polarization bibliography,
 - Catalogue of astrophysical parameters of binary systems,
 - Masses and ages of stars in open clusters,
 - Low-mass binaries database and others.

2.2. Taking part in developing software, techniques, standards, and formats necessary for the establishment of the IVO

A special collection of links to useful astronomical Internet resources, named Internet Resources in Astronomy (IRinA) is compiled by CAD staff. This collection includes

- Original, multi-level, classification scheme,
- Reviews and expert analysis,
- Comprehensive lists of national resources,
- Bilingual resource descriptions,

and is supplied with search facilities.

The methods developed by the CAD staff allow data visualization and cross-identification of the catalogues.

We also intend to construct interoperability tools, particularly for national observational archives.

2.3. Uniting Russian and fSU data, to make them available to the rest of the world and to integrate them into the IVO

In collaboration with Russian observatories CAD carries out the following activities:

- Providing convenient direct access to on-line resources,
- Distributing off-line resources,

- Providing access to electronic tables published in the main Russian astronomical journals,
- Producing machine-readable versions of catalogues, glass libraries, and printed papers,
- Consultations and technical support to authors,
- Standardization and unification of information for provided resources,
- Construction of catalogues and databases.

Collection of astronomical resources of Russia and FSU

After the disintegration of the SU almost all the observational facilities turned out to be in other countries. In Russia there are now only about 30 astronomical institutes and other organizations. Many of them maintain extensive data archives. But the main value of Russian astronomical observational data is their large time scale of observation. Russia is the most extended country in the world in longitude - there are 11 time zones in Russia, and it is situated almost on the opposite side of the globe from most of the world's astronomical observatories. This allows, for instance, obtaining an uninterrupted sequence of observations for variable objects.

As was already mentioned, CAD coordinates the activity of Section 13 "Databases and Informational Environment" of the Scientific Council of Astronomy of the RAS. The main goal of this section is to collect the principal Russian astronomical data and make them available to the world astronomical community. We sorted all recourses according to types of observed objects or spectral range and their availability.

- *Stellar systems*

Online resources:

- Informational system "Evolution of radio galaxies" (SAO): allows a user to operate with simulated curves of spectral energy distribution for a set of galaxies from the RATAN-600 RC-catalogue. An archive of observations of radio galaxies and bibliography will be added in the near future.
- Database of rich clusters of galaxies (Astronomical Institute of the Saint-Petersburg University [AI SPbU] et al.): Radio and optical sources in the clusters of galaxies.
- Polar-ring galaxies page (AI SPbU et al.): bibliography and images for polar-ring galaxies.
- Catalogue of open cluster proper motions (Shternberg Astronomical Institute [SAI] of the Moscow State University): 324 clusters.
- Bibliographic catalogue of galaxies' rotation curves (SAI): 4165 observations for 2070 galaxies.

- Catalogue of interacting galaxies (SAI): 2014 items.

- *Stars*

Online resources:

- General Catalogue of Variable Stars (SAI + INASAN): about 40000 stars (also regularly issued on CDs)
- Supernovae catalogue (SAI): 1948-2001
- Supernovae light curves catalogue (SAI): 180 light curves
- Database of UV Cet variable stars (Crimean Astronomical Observatory [CrAO] National Academy of Sciences, Ukraine [NASU]): bibliographical database, 460 stars and 3500 references.
- The catalogue of energy distribution in the spectra of late stars (CrAO): 111 stars.
- General catalogue of galactic carbon stars (Astronomical Institute of Latvian State University [AI LSU]): 3rd edition of the Stephenson's catalogue, redone in the AI LSU, 7000 stars.

Resources that are distributed on CD or available by request (off-line):

- Astrographic catalogue (SAI): coordinates for 8.6 million stellar images
- Tycho Reference catalogue (SAI et al.): Tycho positions, proper motions, and photometry for 1 million stars.
- FONAC (Main Astronomical Observatory NASU [MAO NASU]): positions, proper motions and photometry for 2 million stars of the Astrographic catalogue.
- Combined catalogue of astronomical data ASCC-2.5 (MAO NASU): compiled catalogue of astronomical data from space missions and ground-based telescopes observations for 2.5 million stars.

Resources that are not yet available in electronic form:

- Catalogues of spectral binaries (Ural State University [USU]): set of catalogues of physical and orbital characteristics of SB stars.

- *Solar System*

Online resources:

- Database of the interstellar magnetic field (Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation of RAS [IZMIRAN] + Space Researches Institute [IKI] of RAS): data from the magnetic measurements of the satellites "Prognoz-6,7,9" and "Interball" in 1977-79, 83-84, 95-96.
- Planetary observations (Fesenkov Astrophysical Institute [FAphI], Kazakhstan): observations of major planets and other Solar System bodies and objects made in Almaty. Images, some science, bibliography etc.

Resources that are distributed on CD's or available by request (off-line):

- System STAMP (Institute of Applied Astronomy [IAA] RAS): system of minor planets ephemeris and software for related calculations (21,000 minor planets).

Resources that are not yet available in electronic form:

- Database of the interstellar magnetic field (addition) (IZMIRAN + IKI): magnetic measurements of the spacecraft “Fobos-2” in 1988-1989.
- Meteor orbits (Astrophysical Institute of the Tajic Academy of Sciences [AphI TAS]): orbits for 20,000 meteors by radiolocation + elements of orbits for 500 meteors by Dushanbe photographs
- Guissar catalogue of geo-stationary satellites (AphI TAS)
- Spectra of asteroids database (SAI)

- *Sun*

Online resources:

- Siberian Solar Radio Telescope (Irkutsk Institute of Solar-Terrestrial Physics, Siberian Branch of RAS [ISTP]): database of solar observations.
- Siberian Solar Radio Telescope (ISTP): daily images of the Sun at 5.2 cm wavelength.
- Siberian Solar Radio Telescope (ISTP): short-term forecasts of solar activity.
- Solar Telescope for Operative Prediction (ISTP): archive of solar magnetograms 1997-2000.
- Pulkovo database of sunspot magnetic fields (Main Astronomical Observatory RAS [MAO RAS]): sunspot magnetic fields, statistics, images (24,000 measurements).
- Combined database of sunspot magnetic fields (MAO RAS et al.): sunspot magnetic fields etc. (queries on-line; the complete version of the database is available at CDs)
- Solar data 1996-2001 (MAO RAS): Synoptic maps of active features, activity information for 1996-2001.
- RATAN-600 solar observations (SAO): daily one-dimension, high-resolution scans of the Sun in radio wavelengths since May 1997.
- Solar activity forecast (IZMIRAN): daily forecast in real time.
- Sunspot magnetic fields (CrAO): 1998-2000.
- Solar images in lines (CrAO): 1996, and since 1999 (HeI+H α)
- Large Solar Vacuum Telescope (Baikal Observatory of ISTP): archive of Sun images at H α .

Not yet available in electronic form:

- CORONAS project database (IZMIRAN et al.): helioseismology, neutrino astronomy.

- *Radioastronomy*

Online resources:

- Database of catalogues CATS (SAO): wide sample of astrophysical catalogues and relevant software, with emphasis on radio catalogues.
- RATAN (COLD) catalogue (SAO): Radio sources spectra
- 230 Milky Way supernova remnants (SAO): 230 radio spectra
- UTR-2 catalogue (Kharkiv Radioastronomy Institute of NASU [KhRI]): Low-frequency survey for celestial radio sources.
- Pulsar database (Puschino Radioastronomical Observatory [PRAO] of RAS, et al.): pulsar timing results. The complete archive is available on CDs.

- *Cosmic Rays*

Online resources:

- Cosmic ray database (ISTP): monthly, daily and hourly data since 1958, 1-minute data: 1989-1991 and since 1994.
- Monitor of cosmic ray activity (IZMIRAN): data of hourly measurements, real-time and archived since 1958. The complete archive is available on CDs.
- Database of the cosmic ray department (IZMIRAN): archive of the World Net of neutron monitors for 1953-1998.

- *Educational and public resources*

Online resources:

- Reference resources (SAI, AI SPbU, IAA).
- Educational resources (SAI, USU, ISTF, AI SPbU).
- Popular scientific resources (SAI, IAA, Kazan State University [KSU], ISTF, Odessa Astronomical Observatory [OAO], FAphI).
- Observatories publications (CrAO, SAO, PRAO, INASAN, OAO).

- *Glass plate libraries and spectroscopic data archives*

An enormous volume of observational data is maintained in the glass plate libraries and spectroscopic data archives of observatories. We have collected principal (but of course not absolutely complete yet) information about these repositories.

- Glass plate libraries

- OAO: 104,000 plates, 1957 - 1998 (7-camera astrograph). The catalogue with complete information about every plate is accessible via ftp (Log on-line)
- SAI: about 100,000 plates (including glass library of the variable stars department). Plates digitalization is in preparation.
- MAO RAS: 55,000 plates (various telescopes). The catalogue is in preparation and is completed for 37,000 of the plates.
- CrAO: plates taken since 1960s (various telescopes). Catalogue is in preparation.
- MAO NASU: Catalogue is under preparation, plate digitalization is planned.
- KSU: plates taken since 1900s. Catalogue is in preparation.
- AphI TAS: 64,000 plates (Sky service observations of variable stars).
- AI LSU: Plate digitalization is supposed to be underway.
- FAphI: Mainly planetary and lunar observations.

- Spectroscopic data archives

Data on-line:

- SAO: archive ASPID of spectrophotometric and interferometer data observed with the 6m telescope since 1989.

Log on-line:

- CrAO: 43,000 spectra, 1984-1991, processed CCD-spectra observed with the 2.6m telescope, under preparation for on-line presentation.
- CrAO: 44000 spectra, since 1991, register of CCD-spectra observations with the 2.6m telescope + unprocessed spectra.
- CrAO: register of observations made with various instruments at various times.

The list of Russian and FSU astronomical resources is compiled for the first time and will be kept up to date. This list (as well as other CAD services) is available on high performance CAD-servers connected to the internet through 2 x 2Mb fiber optic channels and back-up radio channels at:

<http://www.inasan.rssi.ru/cad>

3. Conclusions

The information hub of the RVO will be made available via Internet for the scientific community and for the public, the scientific methodological and technical aspects and results of the project will be presented to the community.

RVO will be merged into the IVO, and it means, in particular, that RVO will require collaboration with other institutions facing similar challenges.