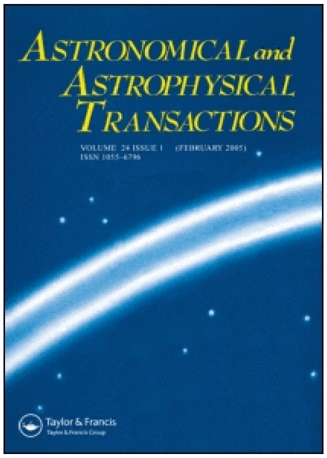

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THE RUSSIAN VIRTUAL OBSERVATORY: INFORMATION HUB

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The Russian Virtual Observatory (RVO) will be an integral component of the International Virtual Observatory, which will link the archives of all the world's major observatories into one distributed database, with powerful tools to optimize the extraction of science from the data. As a result, data from all the world's major observatories will be available to all professional astronomers, and to the public. The information hub of the RVO has the main goals of integrating resources of astronomical data accumulated in Russian observatories and institutions and providing transparent access for scientific and educational purposes to the distributed information and data services.

One of the general-purpose data centres for astronomy is the Moscow Centre for Astronomical Data (CAD). CAD has been systematically collecting and distributing astronomical data for more than 20 years. The CAD staff will carry out the activities on construction of the information hub of the RVO.

Keywords: Virtual observatories; Data analysis; Data dissemination; Catalogues; Databases; Surveys

1 INTRODUCTION

A virtual observatory (VO) is a collection of interoperating data archives and software tools that utilizes the Internet to form a scientific research environment where astronomical research programs can be conducted. The VO consists of a number of data centres each providing unique collections of astronomical data, software systems and processing capabilities.

One can consider a VO as the instrument for observations of the virtual sky with a virtual telescope, where the 'virtual sky' is a collection of archival data sets of space-borne and ground-based observatories, and the 'virtual telescope' is metadata standards, query services, data mining applications and computational resources.

The need for the development of a VO is driven by two key factors. Firstly, there has been an explosion in the size of astronomical data sets delivered by new large facilities. The processing and storage capabilities necessary for astronomers to analyse and explore these data sets will greatly exceed the capabilities of the currently available types of desktop systems. Secondly, there is a great scientific gold mine going unexplored and underexploited because

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large data sets in astronomy are unconnected. If large surveys and catalogues could be joined into a uniform and interoperating ‘digital universe’, entire new areas of astronomical research would become feasible.

In the past months, three major international projects (NVO, AVO and ASTROGRID) and a number of smaller projects have been funded to develop and realize the vision of using astronomical data repositories as virtual observatories. The scope of these efforts is not limited to national boundaries but rather extends over the range of space and ground facilities utilized by the international astronomical community. Each project seeks to empower astronomers as they face the challenges of carrying out data-intensive scientific research in the twenty-first century. Each project also wishes to tap into the underutilized scientific potential of existing and future astronomical data repositories. The number of VO projects continues to grow as more and more communities of astronomers realize the challenge and opportunity before them.

Recently the Scientiflc Council on Astronomy (Russian Academy of Sciences) strongly endorsed the Russian Virtual Observatory (RVO) initiative with the Centre for Astronomical Data (CAD) (INASAN) and Special Astrophysical Observatory as co-ordinators. The RVO will be an integral component of the International Virtual Observatory (IVO), which will link the archives of all the world’s major observatories into one distributed database, with powerful tools to optimise the extraction of science from the data. The IVO alliance was formed in 2002 to facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures required to enable the international utilization of astronomical archives as an integrated and interoperating VO.

Another reason for construction of the RVO is that Russian astronomy is deprived of almost all observational facilities after the disintegration of the Soviet Union: the majority of southern Soviet observatories turned out to be in other countries, that is former Soviet republics. The best (and cost-effective) solution for Russian astronomy is an integration into the international data grid.

The Russian contribution will be in the following areas:

(i) to provide Russian astronomical community with a convenient access to the world data grid;
(ii) to unite Russian and former Soviet Union data, to provide them to the rest of the world and to integrate them into the IVO;
(iii) to take part in the development of software, techniques, standards and formats necessary for the establishmnent of the IVO;
(iv) to use Russian instrumentation to provide observational data in remote mode when needed;
(v) to strengthen education and public applications of world astronomical data.

The CAD contributes mostly to points (i)–(iii) and these will be described below.

2 PROVIDING WORLD DATA FOR RUSSIAN ASTRONOMERS

The main activity of CAD, as an information hub of the RVO and as a national data centre, is to install and maintain mirrors of principal world astronomical databases. CAD holds now the mirrors of the largest astronomical electronic library ADS (Eichhorn et al., 1993) and the most complete database of astronomical catalogues and data tables VizieR (Ochsenbein et al., 2000). CAD also serves as a National Host of the IUE Newly Extracted Spectra database INES. One of advantages of this activity is that for many Russian institutions domestic Internet traffic is cheaper than the international one.

We continue our activity on the mirroring of databases. Among others, we plan to mirror Vienna Atomic Line Database (VALD) (Piskunov et al., 1995) and the Database of the Belgrade Astronomical Observatory (BELDATA) (Milovanovic et al., 2000).

Some data resources that are not available on line (mostly observational archives, catalogues and software) are kept on CD and distributed upon request.

Another activity of the CAD is to read modern media currently supported by data archives and to distribute the data on lower-capacity media.

CAD also fulfils some other functions: browsing, visualization and cross-identification of catalogues (Malkov, 1986; Malkov and Smirnov, 1994, 1995, 1997, 1999; Pasian et al., 1998; Smirnov and Malkov, 1999; Dluzhnevskaya et al., 2000; Malkov et al., 2000); review and expert evaluation of data sets (Malkov, 2002); analysis of user requests.

3 RUSSIAN DATA TO BE INTEGRATED INTO THE INTERNATIONAL VIRTUAL OBSERVATORY

There are about 30 astronomical institutes and organizations in Russia. Many of them maintain extensive data archives, but the main value of Russian astronomical observational data is the large time scale of observations. Russia is the most latitude-extended country in the world; there are 11 time zones in Russia, and it is situated almost on the opposite side of the globe to the most of the world's astronomical observatories. This allows, for instance, to obtain a continuous set of observations for variable objects.

CAD coordinates the activity of the Section 13 'Databases and Informational Environment' of the Scientific Council on Astronomy of the Russian Academy of Sciences. The main goal of this section is to collect principal Russian astronomical data in order to make them available to the world's astronomical community. The first stage of this programme involves the organizations situated in the European part of Russia.

We collect information about all available (both Russian and some former Soviet Union) resources and classify them according to types of observed object, namely stellar systems, stars, Solar System, Sun, radioastronomy and cosmic rays or spectral range. Figure 1 presents

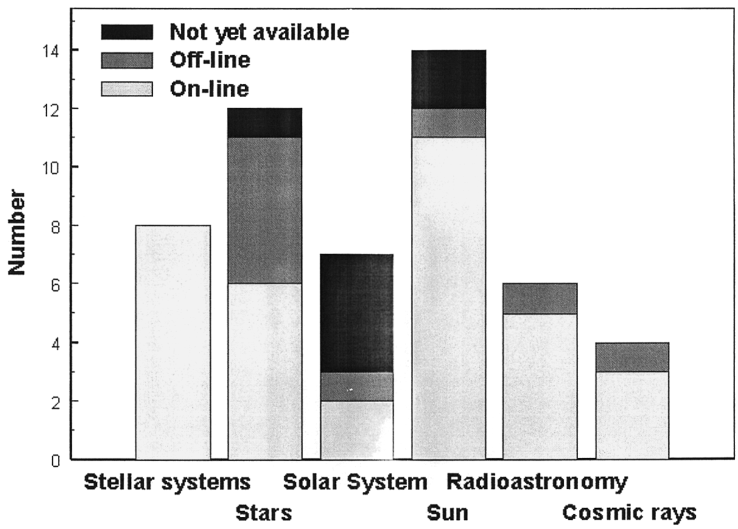

FIGURE 1 Main Russian and former Soviet Union astronomical data resources.

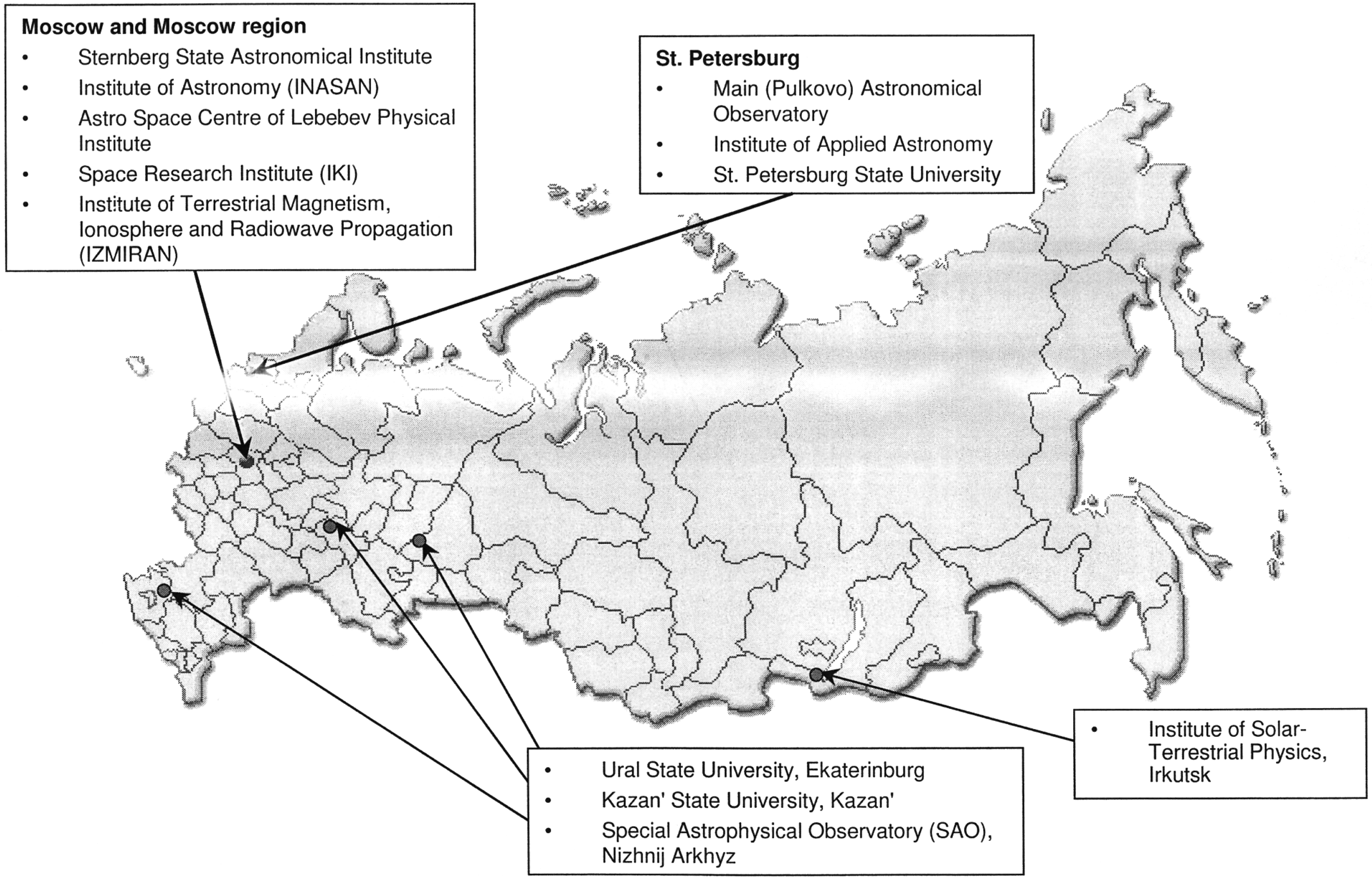

FIGURE 2 Main Russian astronomical organizations holding astronomical data resources.

the distribution of the resources, kept in a dozen Russian (see Fig. 2) and some former Soviet Union (Ukraine, Latvia, Kazakhstan and Tadjikistan) astronomical organizations, according to the types and to the degree of availability.

The list of Russian and former Soviet Union astronomical resources (Dluzhnevskaya et al., 2002) is compiled for the first time and will be kept up to date. This list of resources (as well as other CAD services) is available on high-performance CAD servers at www.inasan.rssi.ru/eng/cad connected to the Internet through 2 × 2 Mbit fibreoptics channels and back-up radio channel. We provide a convenient direct access to on-line resources and distribute some off-line resources.

CAD provides an access to electronic tables published in main Russian astronomical journals.

CAD (in collaboration with Russian astronomical organizations) produces machine-readable versions of catalogues, glass libraries and printed papers.

Another CAD work is the construction of catalogues and databases. The staff of CAD has significant experience in this field. Some of them are the following:

(i) observational data in galactic star-forming regions (Avedisova, 2002);
(ii) stellar mass catalogue (Belikov, 1995);
(iii) stellar polarization bibliography (Belous, 1996);
(iv) catalogue of astrophysical parameters of binary systems (Malkov, 1993);
(v) masses and ages of stars in open clusters (Piskunov, 1980; Myakutin et al., 1984);
(vi) low-mass binaries database (Shpil'kina and Malkov, 1995).

This experience allows us to provide scientific and technical support to authors of catalogues.

4 STANDARDS AND FORMATS DEVELOPMENT

Each VO project shares common needs and seeks access to common ground. There is, therefore, a need to define this common ground and to find ways of meeting the needs as an international astronomical community seeking to realize a VO with global capabilities. Each of the existing national and international efforts will have its own particular set of science drivers, technology interests and metrics for success. While this diversity is beneficial to the success of an IVO, there are also elements of the international effort that must be common and agreed upon if the IVO is to become an operational reality. Most of these common elements have to do with standards for data and interfaces. Other common or shared elements may be in the form of software packages, source code libraries and development tools. Some others have to do with issues of policy, funding and securing international support at governmental levels.

The RVO project started a couple of years later than other principal VOs and, therefore, should follow interoperability standards of various kinds already established. We must enable information to be openly exchanged and must share our experiences with other VO projects.

To provide users with convenient links to Internet astronomical data resources a special collection of links, called Internet Resources in Astronomy (IRinA), has been compiled by CAD staff. This collection is based on an original multilevel classification scheme (see Fig. 3), supplied with search facilities and will include reviews and expert analysis, comprehensive list of national resources and bilingual resource descriptions.

One of CAD's immediate tasks in the framework of this project is standardization and unification of information on national resources (resource identifications, object names,

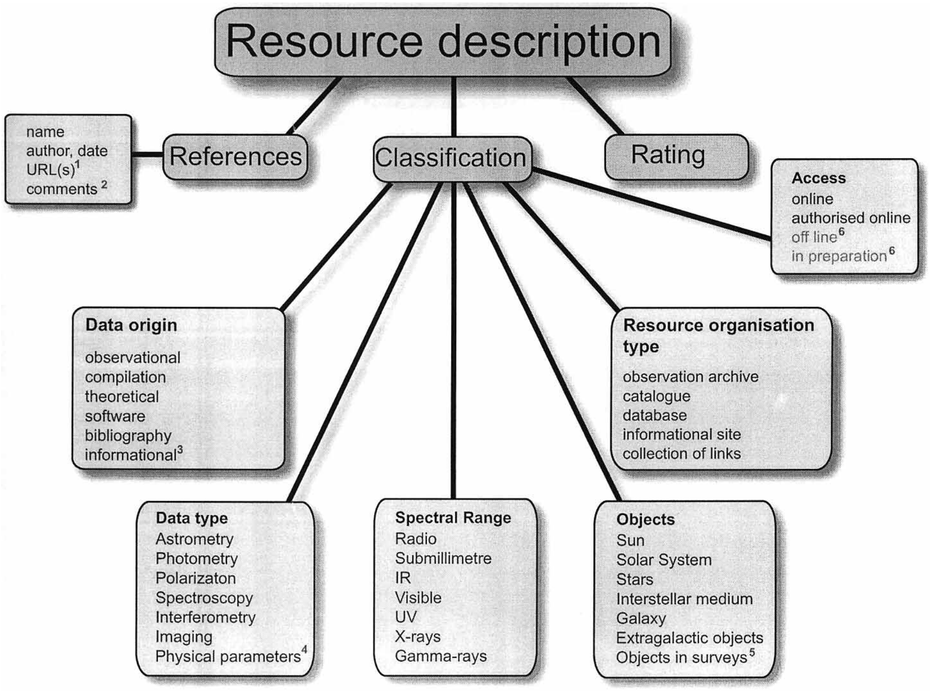

FIGURE 3 Scheme of resource description: [1], in the case of resource mirroring; [2], volume, content, etc.; [3], organizations, conferences, personnel, projects, etc.; [4], mass, radius, age, etc.; [5], all objects, satisfied given coordinate and magnitude limits; [6], used only for Russian resources description.

units, etc.), their rating and completion of a (meta)database of Russian astronomical resources. This work is also an approbation for the classification scheme (Fig. 3).

Another future goal is to construct interoperability tools, particularly for national observational archives.

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