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Kazan Virtual Observatory

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At the moment, the Center of Space Investigations and Technologies is being created in Kazan [1]. One of the purposes of the Center is the development of digital science which also includes the construction of a virtual observatory. The novelty of the task lies in the fact that in contrast to other virtual observatories of the world, that mainly contain digital data on modern star catalogues, the Kazan Virtual Observatory is going to include digital material on many branches of astronomy and astronomical heritage, including:

- Astrophysical and astrometric observations databases and occultations database;
- Electronic bases of modern catalogues (stars, positions of lunar objects, parameters of meteor showers, gravimetric observations, etc.);
- Digital databases in the field of UNESCO astronomical heritage (archaeoastronomical objects, databases on astronomers, space flights historical heritage databases). There has been no database of this kind previously.

Keywords: Astrometry, astrometric catalogues, virtual observatory, photographic plates, astronomical heritage

1 Introduction

Currently, digital science is being actively developed. This fully applies to astronomy and is confirmed by the fact that the pivotal countries have been launching their virtual observatories. Virtual observatories include archives of astronomical and astrophysical data in various ranges of the spectrum and the tools to work with them [2, 3]. This paper presents a concept of the Kazan Virtual Observatory development which is going to include an electronic database in the field of astronomical heritage by UNESCO along with astrometric and astrophysical catalogues.

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2 Modern astronomical virtual observatories: methodology

In 2001, the Russian Academy of Sciences approved the initiative on the launch of the Russian Virtual Observatory [4]. The main purposes of the system were the aggregation of Russian astronomical archives in order to become integrated into the International Virtual Observatory, the development of electronic educational materials in astronomy, and to provide the access for Russian researchers to the international resources. The main advantage of the Russian astronomical archives is the presence of long-term series of observations; the geographical position of Russia allows for the production of continuous series of variable objects' observations. The concept of virtual observatories lies in the provision of tools for determining, providing access and processing various data [5]. Here, we should mention USVOA (US Virtual Observatory Alliance) launched at the beginning of 2000s after the announcement of astrophysics decade in the United States [5]. It is well known that all the images and spectra produced during the NASA major projects are stored in archives, and the significant part of the information presented in the images is not processed. Usually, the data belong to researchers that have worked on a project for a year, and then become available for the general public. Each archive has its own system of access to data and the tools to work with them, which may interfere with conducting quality studies. The task of USVAO is to overcome these barriers by developing common user interfaces and standards by which the information is sorted in the archives. USVAO includes the data from organizations and surveys, such as National Optical Astronomy Observatory, National Radio Astronomy Observatory, Sloan Digital Sky Survey, and Two Micron All-Sky Survey. Besides, it also contains the data produced by Hubble and Spitzer space telescopes, Chandra X-ray Observatory, etc.

Observations of the starry sky have been taken for centuries. From the nineteenth century to the twentieth, images of areas of the sky were produced on photographic plates that formed glass libraries and are the key components of virtual observatories now. The main feature of astronomical data is that observations do not become irrelevant over time but, on the contrary, may acquire even greater value providing some unique information on an object under certain, unrepeatable conditions. In this connection, the problem of providing access to the collected materials is relevant and modern, which is confirmed by the creation of virtual observatories in the world's leading countries.

The virtual observatories ensure access to modern astronomical databases, provide new powerful tools for analysis and visualization within these systems and also set the single standard of publishing the existing information, and therefore the implementation of such systems should be based on standardization of data, metadata, and methods of interchange and exchange of information as well as on the available services register with user manuals. This is about some structure allowing for databases to provide competing information rather than a certain software package. Thus, a set of tools for study and visualization as well as user manuals are formed. The main purpose of the world's virtual observatories is the development of some standardized structure that will provide a single working principle to deal with the entire range and variety of astronomical data.

3 Kazan Virtual Observatory

The Kazan Virtual Observatory is based on the software infrastructure system. In contrast to other virtual observatories, the Kazan Virtual Observatory is multidisciplinary. It includes information on many fields of astronomy and astronomical heritage:

- Diverse observations databases, both astrophysical and astrometric;
- Star catalogues, positions of lunar objects and meteor showers catalogues, gravimetric observations;
- Digital databases in the field of astronomical heritage under the aegis of UNESCO [6]. In 2003, UNESCO launched a project aimed at conservation of objects of archaeoastronomical and astronomical cultures. In 2009, during the international conference "Astronomy and World Heritage: Across Time and Continents", which was held in Kazan, UNESCO accepted the declaration [7] saying these are observatories as "scientific monuments"; results of astronomical observations; building, architectural and urban constructions relating to applied astronomy and/or astronomical information storage; astronomical tools; astronomers. There has been no database of this kind before and the work on its development is being performed for the first time.

By now, within the project of the creation of the Kazan Virtual Observatory, the Astronomical Heritage Center has been founded. In 2017, the first monograph [7] relating to astronomical heritage was released; currently, the works on history of astronomy popularization are being carried out. In 2018, upon the decision of the Scientific Council on Astronomy of the Russian Academy of Sciences, a bibliographic reference book containing the information on most famous Russian astronomers was published.

The glass library of the Engelhardt Astronomical Observatory is the basis on which the Kazan Virtual Observatory is developed and contains more than 12,000 astronomical photographs. A description of the structure of the Kazan glass library is given in Table 1.

Photographic observational material is one of the key components of the Kazan Virtual Observatory and has more than a century of history and is currently being digitized. Until the middle of the 2000s automatic measuring machines were used to convert images into the digital form, but the high cost of the tools, long scanning time, and loss of useful information (traces of asteroids or comets were discarded as noise in some cases) made it difficult to use them when dealing with a large number of objects. The optimal tools of digitizing astronomical photographs are multimedia complexes that include high resolution scanners and the corresponding software. At the Engelhardt Astronomical Observatory, in particular, A3 Microtek ScanMaker 1000 XL plus with a resolution of 2400×4800 of a measured image of astronegative on a glass carrier and optical density of 3,8D is used.

Table 1 Positional photographic observations of celestial bodies taken at the Engelhardt Astronomical Observatory and Zelenchuk Station.

No	Object	Number of photographic plates
1	Eros asteroid (Schmidt telescope)	53
2	Asteroids (Schmidt telescope)	1534
3	Comets (Schmidt telescope)	616; 190 of them are Comet Halley
4	Moon with stars (horizontal telescope)	612
5	Venus (Schmidt telescope)	139
6	Mars	301
7	Jupiter	222
8	Saturn	410
9	Uranus	65
10	Neptune	63
11	Pluto	18
12	Mars moons	122
13	Jupiter moons	30
14	Saturn moons	181
15	Northern Sky Photographic Survey (FON), 30×30	1746
16	Southern Sky Photographic Survey, 30×30	1800
17	Galactic radio sources (Schmidt telescope)	184
18	Extragalactic radio sources (Schmidt telescope)	69
19	Selected Kapteyn areas (Schmidt telescope)	1500
20	Variable stars (Schmidt telescope)	350
21	Novas and supernovas (Schmidt telescope)	300
22	Random objects (Schmidt telescope)	250
23	Selected Kapteyn areas in 3 colour filters	2130
	Total	12695

4 Conclusion

The development of Kazan Virtual Observatory in association with the Institute of Astronomy of the Russian Academy of Sciences will allow for conservation of the unique observations that have been taken by Kazan astronomers for a number of decades. The creation of the database on notable Russian astronomers will provide an opportunity for foreign colleagues to become acquainted with the founders of Russian astronomy. The Astronomical Heritage Center has allowed for Kazan astronomy to achieve a new level of international cooperation, which is confirmed by the launch of several joint projects with European, Japanese and American colleagues.

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