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The methods and facilities of astrophysical experiments support in the SAO RAS

Short review of the problems

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Abstract. This paper opens new heading — "The methods and facilities of astrophysical experiments support" and defines a general subject of future publications in this theme.

Key words: Automation – Astrophysical experiment

1. Introduction

The acquisition of the most reliable data on various astronomical objects is the main goal of astrophysical experiments carried out at any observatory. In so doing astronomers use different methods and facilities, depending on the field and character of researches. One can consider the combination of such methods and facilities as a system of astrophysical experiment automation. The efficiency of automation system operation is the most important factor influencing the professional activity of astronomers.

Historically we have a situation when the researches automation problems are not duly represented in periodicals, though they acquire the greater significance in the extensive observatory activity. But many observing astronomers are interested in such informational publications. A part of information about the automation is given in the SAO Report of 1993–94.

Beginning with this issue of the "Bulletin of the Special Astrophysical Observatory" the publications under the heading "*The methods and facilities of the astrophysical experiments support*" have been resumed. This paper defines the principal trends in this field, and also the subjects of the future articles.

The automation of astrophysical experiments is a complex multiaspect problem. On the one hand it is connected with the observational process which consists of separate stages. Each stage has its own specific features and this is displayed in the employment of different functionally orientated components. On the other hand obtaining of the final astrophysical results depends on the use of different procedures of further observational data processing. The character of these procedures is defined by a field and methods of researches, interest of individual astronomers, final goals of data processing, structures of experimental data, etc.

Taking all these points into consideration, we think that publication of the most important aspects of the astrophysical experiments automation is the main task coming under the new heading. We hope that it will facilitate more intensive exchange of experience between astronomers and system designers.

Attention should be drawn to the fact that SAO, being one of the largest astronomical centers in the world, is a great software elaborator at the same time. The introduction of new computer technologies at the observatory does make the part played by software still more important.

2. Terminology

In the home and foreign literature both the generally accepted and special terminology is used. The generally accepted terms are usually applied without explanation. At present every observer must have knowledge about the widespread concepts such as *FITS* — Flexible Image Transport System — international format of observational data exchange between astronomical centers (Wells et al., 1981; Greisen and Harten, 1981; IAU, 1983), *AIPS* — Astronomical Image Processing System, created in the NRAO and generally used in radio astronomy (AIPS, 1989), *MIDAS* — Munich Image Data Analysis System — the astronomical data processing system, created in ESO (Banse et al., 1983), *IRAF* — Image Reduction and Analysis Facility — the data processing system created in the NOAO and applied, as *MIDAS*, mainly to optical data (Tody, 1986).

At the same time the authors of papers coming under the new heading are free to introduce their own special terminology provided that all special concepts are strictly defined and uncontradictory.

3. Technological sequence of obtaining astrophysical results

The technological process of obtaining astrophysical results includes a series of interconnected stages (Fig. 1):

1. Astrophysical problem formulation.
2. Scheduling of telescope time.
3. Preparation of observations.
4. Telescope and receivers control.
5. Registration and observational data collection.
6. Archiving of observational data.
7. Data processing.
8. Transportation of observational and auxiliary data.
9. Publication of obtained results.
10. Astrophysical interpretation of results.

The stages enumerated above are used for the telescopes of SAO: RATAN-600, 6 m and 1 m. Moreover stages 2–9 are supported by the system of astrophysical experiments automation, and stages 4–5 are connected immediately with carrying out observations. Stage 8, transportation of observational data, can be joined to other stages if necessary. It can also provide connection of SAO with other scientific centers.

4. System of automation of astrophysical experiments

Revealing the essence of the automation system, it is necessary to show its basic components. First of all, it is *SOFTWARE*, including the SAO original products and external programs. Without software, providing friendly interface, on the one hand, and independence (or vice versa — dependence on) of the human factor, on the other hand, it is impossible to make a serious physical experiment. Software is leaned on the computer base. It is clear that the greater intellectual work is desired to be trusted to software, the more powerful *HARDWARE* is needed. At the same time hardware defines a possibility of choosing a particular basic instrumental medium of programming, primarily an operating system and its environment, which immediately has an influence on software servicing the experiment, although the modern open systems and the most universal one, OS UNIX, are operative practically on any hardware platform.

It is necessary to elaborate appropriate *NET FACILITIES* (Chernenkov, 1995) to provide automatic observations unattended by the observer, data exchange with remote users or preparation of the next observations.

Another important component of automation system is *METHODS* and *ALGORITHMS* of data processing, which facilitate mathematically effective access of the user to the data and enable an accurate astrophysical result to be promptly obtained. The quality of the applied methods defines the quality of final result.

And, finally, when an astronomer needs, for example, to store his own primary or processed observational data or to transfer them to colleagues from some other institute, the question of *FORMATS* of data recording arises.

All the components mentioned are described in details below.

4.1. Software

By the software is implied primarily the basic instrumental facility as the tool of the operating system extension. These are libraries of programs and text scripts of universal use. Secondly, it is a set of final products in the form of different telescope control systems, data collection, transmission, processing and archiving systems, realized in the algorithmic languages and used by astronomers in the process of astrophysical research. These are both the widespread systems operating at SAO (e.g., MIDAS, PC VISTA, etc.) and used for data collection and processing (Kniazev and Shergin, 1995) and those worked out at SAO (e.g., MCOSS, ODA, FADPS — collection, archiving and processing systems respectively (Vitkovskij et al., 1989; Kononov, Evangely, 1991; Verkhodanov et al., 1993)). Besides, this component includes various mathematical packages and database management systems, distributed quickly in the research centers.

It should be noted that all these functionally orientated systems represent to a particular degree individual stages of the technological sequence and are interrelated in this sense. Therefore, here we have a problem of optimum interaction of the systems, which has a methodological aspect as well (Kononov, 1995a).

4.2. Hardware

We do not aim at describing all standard equipment necessary for the telescopes of SAO to be operated. Nevertheless, the original facility of development of hardware, allowing unique astrophysical data to be obtained, will undoubtedly be interesting not only to engineers but also to astronomers. Information about the architecture, design, and parameters of apparatus and computer systems permits critical evaluation the limits of reliability of astrophysical data being obtained and points out the ways of their improvement.

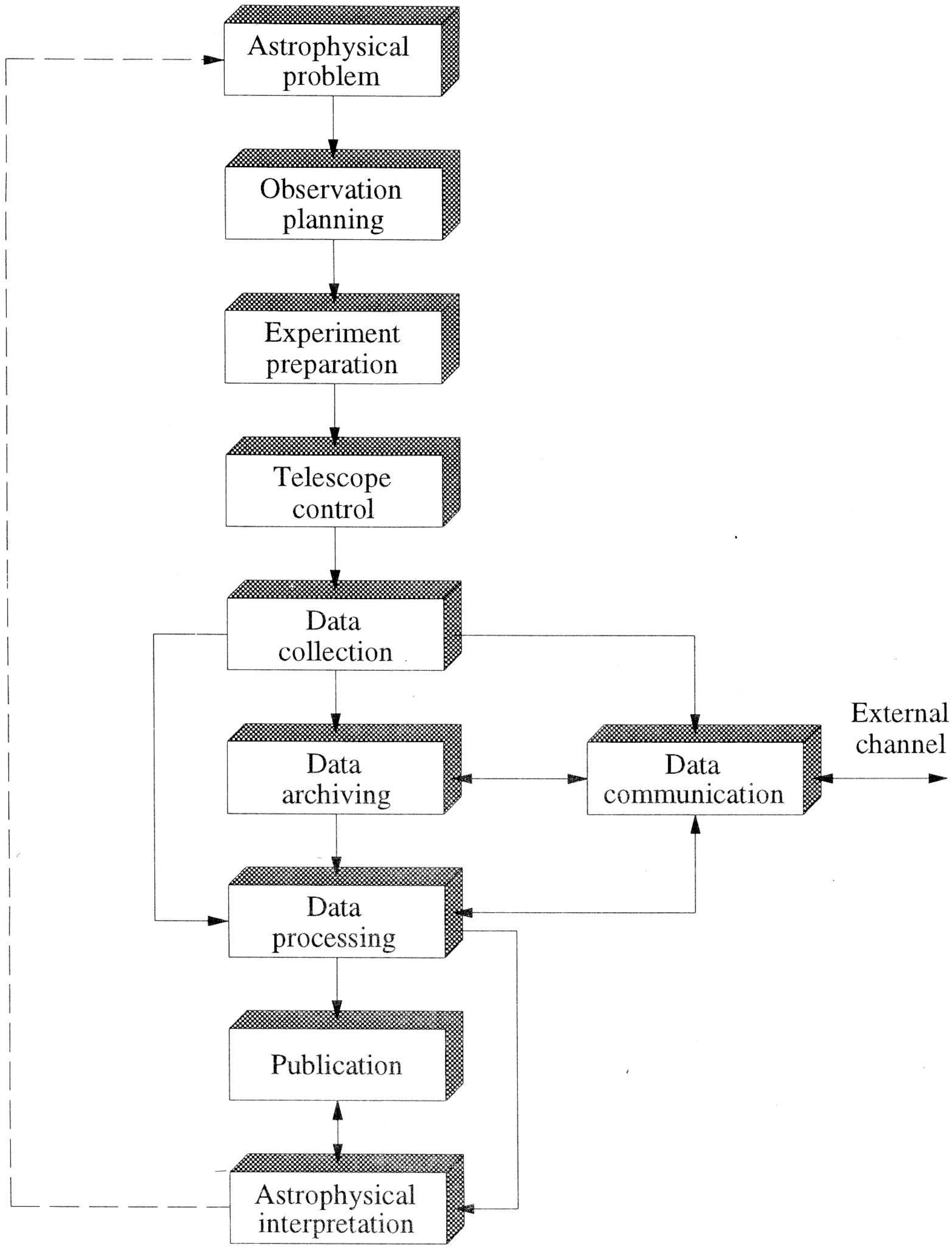

Figure 1: *Technological sequence of obtaining astrophysical results.*

4.3. Net facilities

Considering the net facilities, we have to take account of the operating environment where they function. As the basic operating system for the servers of SAO the OS UNIX in its non-commercial version, Linux, is chosen. It has the natural UNIX net facilities: UUCP, TCP/IP, FTP, NFS, X Window, etc. The users' net workstations operate not only in UNIX-like OS Linux, Sun OS, Solaris but also in MS–DOS/MS–Windows, which have no developed built-in net functions. Therefore, special software packages are used for their net support. These are UUPC, PC–TCP, PC–NFS, Telnet and other systems, including the X-window emulating systems. The basic protocol of the SAO net is TCP/IP. At the same time the systems NTS and Demos are realized with a sufficiently simple facility of Kermit type.

The principal trend in developing the net facilities of SAO in the nearest future is the integration of the main information resources on the basis of the hypertext servers called World Wide Web (WWW) technology in the Internet.

4.4. Methods and Algorithms

Another important aspect, defining capabilities of the automation system, is the collection of methods and algorithms being applied. The concept of method (in the broad sense) can be used as a characteristic of any other component — hardware, software, etc. Here one may point, e.g. to the methods of designing individual apparatus, computers and software, organization of communication between different subsystems, calculation methods, methods of data access and organization of data processing.

Algorithms are connected primarily with the software field and usually display the realization of software of any mathematical medium or logical design of data transformation. It should be noted that it is exactly astronomy (and particularly radio astronomy) that has created fast and powerful facilities, e.g. the *CLEAN* algorithm of image restoration (Högbom, 1974), which are a standard now in mapping with the application of the interferometric systems.

4.5. Data formats

The concept of data format representation on the machine mediums is immediately associated with the problem of information storage and transfer. It is related to experimental data and to other categories, e.g. to astronomical catalogs and different documents.

The existence of the large number of various collection systems at the SAO causes strongly different structures of observational data, and hence their formats. It is expedient to bring the heterogeneous forms of data representation to a common format on the basis of certain standards (e.g. FLEX standard of the SAO — FLexible EXchange (Kononov, 1995b)) for the software unification and simplification. It is natural to use the generally accepted FITS format with its possible variants for the observational data exchange with other astronomical centers.

A similar problem is associated with astronomical catalogs also. Here it is sufficient to use a wealth of international experience.

On the other hand, the data formats are also defined by the software components, which are used in the process of the stage-by-stage information transformation. These are the data processing systems, archiving systems, database management systems, editing systems, etc. One should note that formats can be transformed to each other. That means the use of the interface systems, when it is needed.

5. Subject-matter of the heading

Under the heading come:

- methods and algorithms of observational data access and processing;
- packages and systems of observational data processing;
- systems of observation preparations, registration and data collection;
- systems of telescope and receivers control;
- journalizing the astrophysical experiments;
- archiving and database management systems;
- systems of astronomical catalogs and documentation support;
- data structures and formats, and interface systems.

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