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Advance in observational data archiving technology at SAO RAS. Historical aspect

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Abstract. The development of archiving technology of observational data obtained with the radio telescope RATAN–600 and the 6 m optical telescope during a period of 25 years is discussed. Particular stages are described, which are associated with different approaches in the area of experimental information storage. Examples of implementation of some versions of archive systems based on computers of different generations are given.

Key words: methods: data analysis –astronomical archives – methods: numerical

1. Introduction

Archiving of results of astronomical observations began to take shape in the 1970s in the process of doing major orbital astronomical experiments. The expenses for the establishment and support of digital archives accounted for a considerable part of the costs of space projects, and the thesis of accessibility of the archives was to justify the total expenditures for extraatmospheric explorations. In ground-based astronomy, where the lifetime of a telescope is by at least an order of magnitude longer than the average time of performance of a space instrument, the attitude to archiving was quite different since in ground astronomy permanent updating of both the devices themselves and appropriate systems of recording and acquisition of data. In the 1990s a common approach began to form, when the expenses for establishing and supporting archives of experimental information came to be included in the costs of new ground projects. The problem of archiving results of the observations made with already existing telescopes was also viewed in a different light. Here is an example. At the Conference devoted to appraising the prospects of development of ground- and space-based astronomy in the XXI century, it was noted that there was no programme of construction of new ground-based telescopes in Russia (Boyarchuk, 1994). It was emphasized that little was known to the astronomical community about the data obtained with about 10 4-meter class telescopes and over 50 telescopes of the 2-meter class, except for the results published, meanwhile the archives of the space-borne telescopes are open to researchers interested in them. A suggestion follows from this that having no means for the creation of new astronomical instruments, one should concentrate on the formation (or bringing to order) of archives of the observations already made. Guided by this, we will attempt to give a background look on the archiving of observational data at the Special Astrophysical Observatory and, taking into account good fortune and mistakes, to assess the prospects of this undertaking.

The problem of storing experimental data of SAO sprang as early as the 1970s, concurrently with the first observations at the telescopes RATAN–600 and BTA. During the 25-year period of the observatory development, the instruments themselves underwent changes, new astronomical devices and receiver complexes were designed, a number of computer hard- and software generations superseded one another, the observing techniques and the reduction procedures were improved. All this had an effect in a natural fashion on the observational data archiving technology (Kononov, 1996a).

The evolution of the archives at SAO may be viewed as consisting of several stages (Fig. 1). This division into stages is not purely conventional: it reflects real processes responsible for the formation of particular approaches and introduction of specific programmes at certain time intervals. Gradual accumulation and generalization of experience in the sphere of experimental data storage made it possible to create different archive systems and their versions. First of all, this refers to the centralized systems which supported one or more astronomical facilities and were independent of observing programmes. The development of each of such systems had an ideology of its own and relied on the computer base and operation environment existing at that time. From the present-day point of view the archiving systems created previously had certain constraints and demerits. However, it is their long-term usage that provided eventually a possibility of forming a common view on the problem of long-duration storage of observational information and automated access to the data for subsequent processing or archive statistics collection.

Here we present a brief review of the observational data archiving technology at the observatory and results of introduction of specific versions of archive systems.

2. Analog and digital forms

The major factor that had a principal effect on the establishment of archives of two different generations was the form of representation of data at the output of the acquisition system — *analog* and *digital.*

The first observations in the radio range were made with the feed No. 1 of RATAN–600 using the broad-band radiometers in 1974. The output data were recorded on paper tape. In so doing, as many as 6 recorders operated concurrently which were switched to appropriate radiometers (channels) via an automatic recording device (UAR). Further reduction of astronomical data on the computers was performed after preliminary manual digitization of paper records.

Optical observations with BTA were started in late 1974 after the first 6 m mirror was installed and tested. The observations were carried out mostly by photographic techniques:

- direct photography at the BTA prime focus;
- photographic recording of spectra with the Main Stellar Spectrograph and, to a lesser extent, with the spectrographs SP-124 and SP-161;
- photographic imaging in combination with image intensifier tubes (spectrographs UAGS and SP-160).

The first digital methods were supported by the electrophotometer (EFIR) and, beginning in the late 1970s, by the photoelectric magnetometers and the scanner of BTA (Balega et al., 1979). Results were presented in the analog (plates, records) and digital (punched tapes) forms. In 1978, digitization of photographic plates with the domestic automatic microdensitometer was initiated (Grishin et al., 1976; Nazarenko, 1981; Burenkova et al., 1982; Korovyakovskaya and Korovyakovskij, 1983). This work, however, would never end in conversion of most of the photographic spectrograms to a digital form.

In the early 80s the BTA prime focus electrophotometer was used both in the classical mode and for recording of the moments of arrival of individual photons (Pimonov, 1983). The data acquisition system had a "dead" time of 300 ns and was operated on line with the computers M-222 and SM-4 with a limiting load of 70 kHz and 35 kHz, respectively. Later on, the method was based on the hard- and software complex which provided loss-free recording of fluxes up to 150 kHz (Plokhotnichenko, 1992).

A number of BTA scanner improvements resulted in creation of prerequisits for realization of a dynamical spectroscopy technique with a temporal resolution of 32 ms (Somov, 1988). A two-processor complex created made it possible to divide the tasks performed in the process of spectral investigation between two computers, Elektronika-60 and SM-4.

Thus the analog form of output data at the initial stage determined the character of *nonautomated* archives of the first generation, which used to be a mere collection of paper records in the radio range and glass plates in the optical range.

The introduction of standard digital recording devices at RATAN–600 in the late 1970s and somewhat later, early 1980s, at BTA made it possible to establish *automated* second-generation archives — databases on computer media. The entire further advance of archiving techniques is associated exactly with the digital form of output data representation of different data acquisition systems. From the very beginning of operation of the SAO major telescopes up to the present moment the radio telescope RATAN–600 has been the leader in systematizing and storage of experimental data. This is evidenced not only by lack of publications on optical data archiving in the 1980s, but also by the results of comparison of the current state of the archives of the optical and radio ranges.

3. General characteristics of the stages

The whole preceding period of development of data archiving technology can be divided into four stages (Fig. 1):

I. The distinction of the first stage that began in 1975 is the intensive substitution of digital methods of recording for analog. This process referred only to observations in the radio range and was implemented at RATAN–600 by way of introduction at the feeds of analog-digital converters and appropriate updating of the acquisition systems.
In the optical range the analog form of data recording persisted.
Attempts were made at that time to realize the first versions of automated observational data archives of the radio range on the basis of the second-generation computer M-222.

II. The beginning of the second stage dates back to 1980. Only digital recording techniques were applied in radio astronomy, while in the optical range, along with digital methods, photography was applied (the statistics of the techniques employed at BTA can be found in Panchuk (1998)).

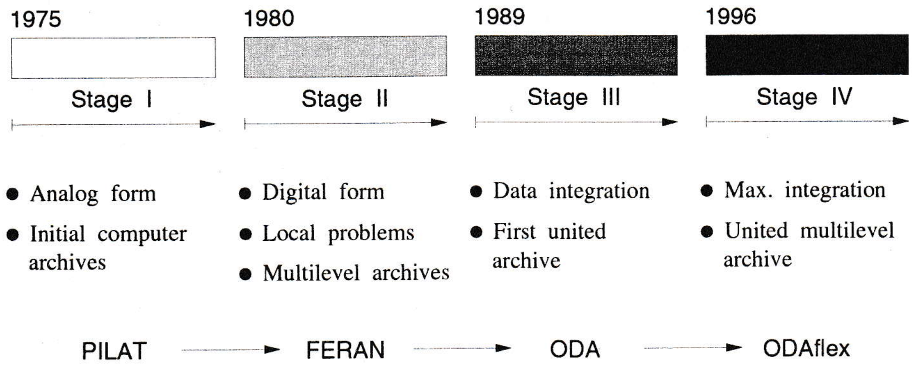

Figure 1: *Stages of development of archiving technology of observational data in SAO.*

Based on the versatile third-generation computers M4030 and ES-1035 (IBM/360/370), full-fledged archive systems of different type radio data came to be developed. These systems used to be integrated with specialized systems of initial reduction, and the tasks of formation of archives themselves were treated as local tasks of the SAO departments.
Multilevel archives on computer media appeared which reflected different stages of data reduction.
The problems of creation of automated archives in the optical range had begun to be formulated by as late as the 1980s, when computers of SM (PDP-11) type, which were introduced directly in BTA observations, became common at the observatory.

III. The third stage of the archiving technology development, which began in 1989, is characterized by the introduction of the first version of the integrated archives system supporting the archives of both radio and optical data.
In that period the digital recording methods became predominant, and the problem of experimental information storage aggravated for many observatory subdivisions.
A new approach — the conception of a *unified* archive of observational data — formed the basis of the developments in the field of archiving. The approach was implemented through integration of several types of archives based on computers of SM series.

IV. The fourth stage reflects the current state of development in observational data archives.
Based on the analysis and generalization of experience of establishing the previous versions of archive systems, the idea of the unified archive of the observatory received further prosecution.
A maximum integrated, as to different types of observational data and systems supporting them, open and flexible system of data archiving is considered most promising from the point of view of efficiency and storage of experimental data. Here the open system is one that is readily adaptable to new types of experimental data and its flexibility provides for a maximum degree of meeting various requests of astronomers.
Such a system, based on the present-day computer technologies: IBM PC, Unix-like operational environment, net facilities including realization of external communication channels via Internet, is currently being worked out and introduced.

4. Original automated archives

The first work over the creation of a logically finished archive system at the observatory was started in 1976 for the broad-band radiometric data of the feed No. 1 at RATAN–600. The computer M-222 located at the BTA site, 40 km away from the radiotelescope, was used as the basis.

4.1. Collection and transport of data

The acquisition system of the feed No. 1 was a receiving-measuring complex including 6 cm-wavelength radiometers and a 6-channel automatic recording device UAR-6 with a tape puncher PL-20 (Fridman, Cherkov, 1975) connected to the output. The number of channels was later increased to 9, and the recording was executed with the device UAR-9. Results of multifrequency observations were output to an 8-track tape.

Three general remarks have to be made right away:

- Concurrently with placing in service of the first digital acquisition systems a need for definition and fixing of two notions — ***structure of output data*** and *format* — arose.
- Since these systems were operated without the local computer support or such a support was rather limited, the structures of output data and their formats represented directly the specific character of the acquisition process.
- In this connection the archive and/or processing systems were loaded with extra functions of data decoding which are unusual to them.

The information output of the primary acquisition system of broad-band radiometers was a collection of numerical arrays obtained in the modes of calibration and recording of the object. These arrays contained sets of the so-called "cycles of polling" of individual channels — some mixture of counts. Results of observations of discrete and extended radio sources were thus accumulated for several days, and then communicated manually to the computer M-222 as rolls of punched tape for further archiving (Fig. 2).

Somewhat later, a unified data acquisition system for several feeds was installed at the radio telescope RATAN-600 (Fridman, Cherkov, 1975; Petrov, 1986). The data were transmitted to the small computer Electronika K200 by communication lines, where they were buffered on a 9-track magnetic tape (MT) with preserving the initial formats determined by the receiving-measuring complexes of the feeds. Thus a new variant of transport of observational results with the aid of MT reels, which was more convenient and reliable, appeared.

4.2. The archive system PILAT

The system PILAT was put into operation in 1977 and represented a package of programmes developed in the language Autocode BM-4/220 in the environments OSPO for the computer M-222; the package is independent of the processing systems. Taking into account the planned updating of the feed No. 1 acquisition system, PILAT was realized successively in the form of three versions:

1.0 — 6-channel punched-tape input;
1.1 — 9-channel punched-tape input;
2.0 — 9-channel input with a buffer MT.

For every observation the system performed the following:

- input of initial data from the buffer with the aid of the punched-tape reader FS-1500 or the magnetic tape recorder NML-67;
- decoding of service information;
- correction of detected malfunctions;
- sorting over channels;
- reduction of calibrations;
- recording of data into the archive on MT of M-222;
- journalization of recording to the archive;
- drawing of data from the archive for subsequent processing.

The system programme components for fetch of data from the archive were incorporated in the processing systems SON, SON-2 and SON-4.

4.3. Data archives of the system PILAT

As the archive media, the only suitable for this purpose 35-mm magnetic tapes of the computer M-222 were used at that time. Data of radiometric channels corresponding to different wavelengths, single-frequency arrays, were recorded on MT as separate files in blocks of fixed length of 430 45-bit words.

The archive media were filled successively as data arrived in *pseudochronological* order. This order of archive information was conditioned by the fact that the data would usually be transmitted after the completion of observing programmes (or their parts), which alternated frequently. This manifested mostly when a punched tape was used as the buffer media; with the change over to MT, the order of recording into the archive became practically *chronological.* It should also be noted that not all the data arriving from the data acquisition system (although the greater part of them) were transmitted for archiving, but only those which were to be processed by SON systems. This is why, results of some individual observations, which fail to get into the archives, remain in the possession of astronomers and eventually get lost.

Identification of archive data was provided for in two ways:

1. With the aid of file descriptors, which included such parameters as *the number of the series of observation, the date of observation, the time of observation begins, the number of the channel* etc.
2. Based on the archive catalogue formed by the system as a listing in the process of data recording into the archives. In addition to the parameters from the file descriptors, the catalogue contained the numbers of archive volumes and blocks indicating the location of files on the media.

The automated identification and recognition of archive volumes were not used. The identification of radio sources was made by the series number or by the date and time of observation.

The object of drawing from the archives is a file — a single-frequency array. The catalogue was mainly of illustrative character, that is why, the procedures of drawing demanded explicit indication of the file coordinates on a medium in the form of the numbers of the first blocks.

The archive of the system PILAT in the logical respect is the simplest single-level observational data archive, which was supported by elementary automated servicing in conjunction with a large number of manual operations. The whole archive was located on 47 volumes of MT and contained *dozens* of Mb of experimental data. Because of the shortage of media, no copies of the archive volumes were made.

Despite the multi-stage character of data conver-

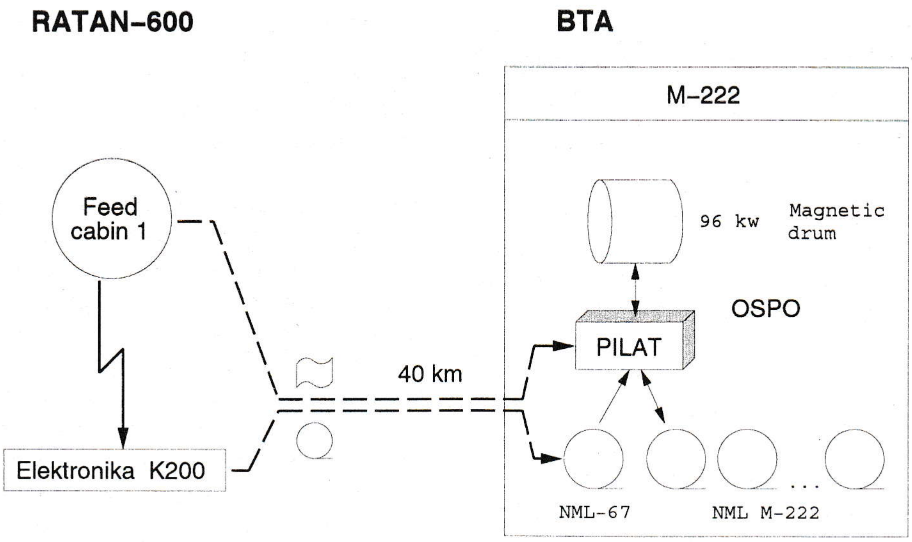

Figure 2: *A scheme of archiving radiodata in late 70s.*

sion and the remoteness of the recording and processing stations, the established archive system PILAT functioning during the years 1977 and 1978 together with the processing systems SON, SON-2, SON-4 became a standard technological element in the observing cycle of the radio telescope RATAN–600. It appeared helpful in archiving and processing of *hundreds* of observations of radio sources in the continuum of the radio wavelength range.

In that period, certain work associated with archiving, but, first of all, with mathematical reduction of observations was done for other types of radio data (for instance, the system MOSN, radio spectroscopy laboratory, feed cabin No. 2), however, it was of a slightly different character. In particular this was conditioned by the fact that the main body of observational data came exactly from the feed cabin No. 1, but not from the feed cabins No. 2 and No. 3. That is why, the archive of the PILAT system characterizes the distinctions of the **first** stage of development of the archive technology at SAO.

5. Multilevel archives on a new computer base

The major factor that determined the shift of the archiving systems to a qualitatively new level was the introduction of various computing facilities at RATAN–600 in the late 1970s and early 1980s. The use of the new computer technology manifested itself both in the designing of data acquisition systems and in the creation of new data processing systems.

In 1979-1980 the acquisition of radio data was mainly supported by the centralized system on the basis of the computer Elektronika K200 located in the laboratory building. This referred to all three directions of investigations carried out at the radio telescope: continuum observations, spectral and solar observations with the feeds No. 1, No. 2 and No. 3, respectively (Petrov, 1986; Venger et al., 1982; Bogod et al., 1985). However, the small resources of the computer Elektronika K200 itself, the failure to conduct concurrent observations with different feeds utilizing that level of centralized accumulation led to a development of local (autonomous) acquisition systems at the feeds on the basis of mini- and micro-computers M-400, Elektronika-100I, Elektronika-60, and MERA-60. Later on, at the beginning of the 1980s, these systems, providing local data acquisition and buffering on magnetic tape with the aid of the NML-67 and IZOT-5003, became the main sources of different types of experimental data (Larionov et al., 1981; Bogod et al., 1982; Alferova et al., 1986; Shatilov, 1987; Venger et al., 1982; Petrov, Shatilov, 1985; Ivanov et al., 1982a,b; Zhelenkov, 1982).

On the other hand, placing in service at RATAN–600 of the multipurpose third-generation computers M4030 in 1978 and ES-1035 at the Lower Scientific Site of SAO somewhat later offered quite new possibilities for designing of advanced archiving and data processing systems. Having considerable advantages in memory, speed of the central processor, range of external devices, rate of exchange with external memory and capacity of the media over the second-generation computer M-222, these computers became the basis for the development and implementation of various problem-oriented programme systems under support of powerful environment OS ES and DOS ASVT.

The development of fully independent acquisition systems at the feeds in the early 1980s as well as the capabilities of computers of the third generation in establishing special-purpose data processing systems led to a higher level of autonomization of different areas of research at RATAN-600. In particular, this had an effect on the solution of the problem of observational data archiving.

Experience gained in the establishment and performance of the first archive system PILAT made it possible to initiate development of a new system FERAN on the computer M4030 in 1979. This system was intended to support continuum observing in the radio range with the feed No. 1.

5.1. Acquisition and communication of broadband radiometer data

In 1980 the last version of centralized collection on the basis of the small computer Elektronika K200 was used for the observational data of the feed No. 1 radiometers.

In the course of observations the information was accumulated and buffered with the aid of the tape recorder NML-67 on a 9-track magnetic tape. The data had the same structure and nearly the same format as in the period of operation of the 9-channel version of the system PILAT 2.0. Then the buffer MT was manually transferred to the computer M4030, accomodated in the same laboratory building, for subsequent archiving and processing (Fig. 3).

The buffer medium initial data were recorded with a density of 16 bit/mm (400 bpi), which is not regular for M4030. For this reason, the stage of main reduction was preceded by an auxiliary stage of data recording with the aid of an autonomous programme Packer operating without the operation system (OS): data of all observations were read from the buffer tape, converted and copied by means of standard drives ES-5012 on another MT volume, but having already a standard density, 32 bit/mm (800 bpi). The information obtained after such a transformation was considered as initial for FERAN.

5.2. The system FERAN for initial processing and archiving

The system FERAN was essentially an archiving system integrated with the package of programmes for initial processing similar to the SON type for M-222. All the FERAN software, numbering over 100 components, was developed in the languages of Assembler, FORTRAN–IV and PL/1 and functioned under control of the operation system OS ES (OS/360).

The system was implemented as two versions:

- 1.0 — archiving and a minimum set of reduction procedures;
- 1.1 — archiving and an extended set of reduction procedures.

The former version was tested with observational data in late 1979 and placed in service in February 1980 before the first long-term experiment "Cold" was started. The latter was realized in late 1980 after modification and extension of the basic set of procedures.

Taking into account that for the continuum radiometers the old data acquisition system with the established (though not quite convenient) data structure and format was used, the system FERAN, as well as PILAT, had to perform some extra functions of data decoding. This resulted in complication of the system architecture, which, as it was, had a multilevel logical organization based on maximum modularity.

For every observation FERAN provided:

- input of initial data from the buffer medium via the magnetic tape recorder ES-5012;
- decoding of service information;
- recovering from error conditions;
- sorting over the channels;
- reduction of calibrations;
- primary processing of initial records;
- location of data on archive MT of M4030;
- correction of contents of the catalogue of the archive medium;
- journalization of processing;
- drawing of data from the archive for subsequent processing.

The system was controlled with the aid of standard macroprocedures formed as jobs in the language JCL (Job Control Language) of the OS ES.

FERAN had the following distinguishing features:

1. The job for the processing was formulated by the astronomer in a definite standard form.
2. Any stage of data conversion was interpreted by the system as the accomplishment of a particular procedure.
3. In connection with the fact that any procedure had a standard input and output, the version of processing was chosen by the astronomer and specified as a graph of start of the procedures (of any combination expedient from the observer's point of view). The graph of start of the procedures is part of the job for the processing.
4. Recording into the archives was treated by the system as an ordinary procedure of primary processing.
5. Extensive use was made of the principle of default in both identification of channels (single-frequency arrays) and specification of parameters of particular procedures and the graph itself.

The system procedures incorporated simple mathematical conversions and functions of output of results to different media, the recording into the archives included. Each procedure was identified by

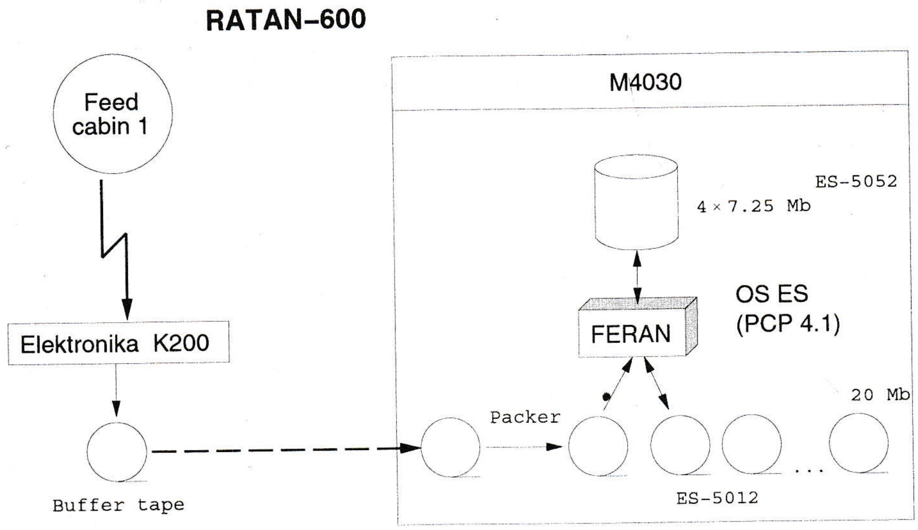

Figure 3: *A scheme of archiving radio data of the feed No. 1 in early 80s.*

a unique two-symbol name, e.g. T1 — correction for the time constant τ, SH — array shrinking; Z1 — linear background subtraction, BF — output to the archives.

Since any procedure could in the general case be specified in the graph many times (the observer was responsible for the correctness of use), the recording into the archive (BF) could formally be performed after any sequence of processing procedures. This made it possible to create *multilevel* archives with the help of FERAN, since the input data for performing some processing could be both the initial data from the buffer MT and archive data of any level (Kononov et al., 1983). In addition, a special procedure — averaging of records of several observations was realized. The input for it was the archive data alone.

5.3. The principles of multilevel archives

The system ideology concerning the combination of procedures and their interpretation in the processing graph offered several possibilities at once:

1. Batch recording (unattended by the astronomers) of initial data into the archives if the graph contains only the invocation of a single procedure BF.

2. Forming the archives on the basis of initial data, but after performing some canonical set of procedures which could be regarded as compulsory reduction:

<reduction procedures> BF

3. The same as 1 and 2, but on the basis of data of a certain intermediate archive.

4. The same as 3, but with an arbitrary set of reduction procedures.

Along with this, one could take account of an additional aspect linked with the archive contents:

- basic archive including all the data of the acquisition system;
- archives of individual observing programmes;
- personal archives.

In this connection the following conventions were adopted:

A. The basic archives is established after the reduction (point 2) that involves two procedures: correction for the time constant τ and shrinking of the arrays of the channels with coefficients proportional to the wavelength λ (allowance for information redundancy and saving of the medium).

B. The archives of major observational programmes (of the type "Cold" (Berlin et al., 1981; 1984a,b)) can be established on the basis of point 3.

C. Private archives are created in view of point 4.

All enumerated above determined the principals of organizing the multilevel observational data archives of the system FERAN (Fig. 4).

5.4. Data archives of the system FERAN

For the archives of any level reeled magnetic tapes 20 Mb in capacity with a density of recording of 800 bpi were used, access to the archives was provided via fast drives ES-5012.

The general organization of volumes was the same: each observation was usually represented as a single file containing several frequency arrays — channel records. It was admitted possible to include several observations in one file. Each array was in the form of one block of variable length (of indefinite length — in terms of the OS ES; the format U). The maximum block size was 32080 bytes. This parameter imposes

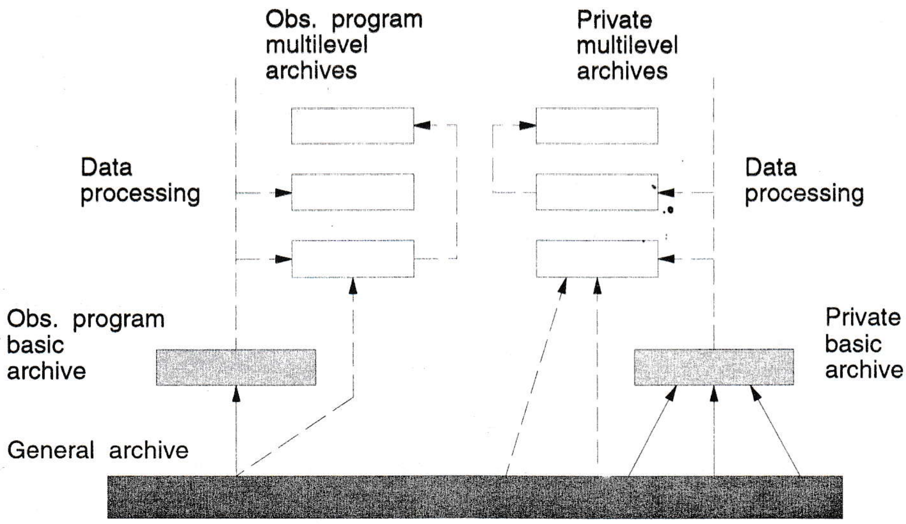

Figure 4: *Multilevel archives of FERAN system.*

a reasonable constraint on the duration of one observation according to the frequency of polling of the channels: 10 Hz — 4^h, 200 Hz — 12^m.

Only magnetic tapes with standard labels (SL type) were used.

The media for the basic archive were filled successively as the data arrived in strictly *chronological* order. The archives of individual programmes were formed after completion of observing cycles and only for the sake of convenience of subsequent processing. The filling of personal archives was under control of the astronomers themselves.

In the general case identification of archive data was provided in two ways:

1. With the aid of the descriptors of single-frequency records, which included such parameters as *the identifier of observation* (concatenation of regular object name and date of observation), *channel identifier* (concatenation of wavelength and Stokes parameter), *record starting time, observing mode, time constant* τ, and also some parameters of the preceding processing. The record descriptors were employed for the archives of all levels.

2. By means of the catalogues of archive volumes developed by the system in the form of special files on the device of direct access ES-5052 in the process of data location into the archives. The catalogues were supported only for the basic archive and archives of the "Cold" experiments and contained the data that optimized drawing of data on the archive media, including automated recognition of volumes.

The subject of fetch from the archive was a single-frequency record which was determined unambiguously by three parameters: *date of observation, radio source name*, and *channel identifier*. The name of the object was specified in the regular form:

$$\mathrm{R}\alpha\alpha\alpha\alpha \pm \delta\delta\delta,$$

where $\alpha\alpha\alpha\alpha$ is the right ascension (hours, minutes), $\delta\delta\delta$ is the declination (degrees and tenth fractions).

Thus, as a result of functioning of the system FERAN, a multilevel archive of data of broad-band radiometers, which included about 5000 observations, was established and supported. Nearly 90 % of the information arriving from the feed No. 1 was stored in the systematized database after its primary processing. The whole archive was located on several *tens* of MT volumes and contained *hundreds* of Mb of experimental data. Due to the shortage of media, the copies of MT were made only for the programmes "Cold".

The system FERAN was a standard system and provided support of observations in the continuum of the radio range for 4 years: from 1980 through 1983. The archive created with its aid became a primary source for establishing secondary archives on another hardware. The observational data processing is still in progress.

5.5. Archiving of spectral and solar radio data

Along with the development of the system FERAN for the continuum data carried out by the group of software of M4030, designing of a system for primary processing and archiving of spectral data (feed No. 2) was under way in the laboratory of radio spectroscopy and solar data (feed No. 3) in the group of solar investigation at RATAN–600.

In 1979 the system MOSN–2 (Alferova, Gosachinsky, 1979; Gosachinsky, Alferova, 1982) was put into operation. The system functioned on the computer M4030 in the environment DOS ASVT. It was used to execute standard processing of spectral radio data, and, as a version of output, archiving of results on MT was provided for.

The archive support of solar observations in 1979–1981 was ensured by the system MONITOR–I–GSO on the computer ES-1035 in the OS ES (Andrianov et al., 1982). Taking into account the new capabilities of recording complexes of the type IKAR, the second version of the system MONITOR–II–GSO was put into operation in 1982. The basic archive of solar data was formed on magnetic tapes (NL type, format F) and contained about 2000 observations covering the period 1979–1989 (Plotnikov, 1991).

In the ideological respect the three systems, FERAN, MOSN–2 and MONITOR–I(II)–GSO, were largely unlike since they took account of the specific character of their types of observational data: their structure, processing, methods of access, identification etc. Nevertheless, the long-term utilization of the systems at SAO resulted in the creation of three to a certain extent automated observational databases. This fact characterizes the main distinction of the **second** stage of the archiving technology development.

6. The first integrated archive of the observatory

In the late 1980s the digital methods of data recording in the optical range already found extensive applications at SAO. The large number of various optical devices available and of the qualitatively new systems evolved from them increased sharply the amount of information in the digital form. A natural consequence of this is that solution of the observational data storage problem became more pressing.

The computers SM (SM-3, SM-4, SM-1420, MERA-125, MERA-685) that were extensively used at that time displaced completely the big general use computers M4030 and ES-1035. The new computers provided the astronomers with more reliable and accessible computing facilities, which, first of all, promoted the development of the receiver-measuring complexes of the telescopes. From the point of view of establishing an archiving systems, the SM computers had essential demerits: small capacity of the media and low rate of exchange with external storage. For instance, the magnetic tape drive IZOT-5003 had an exchange rate of 10 kb/s and utilized a reeled magnetic tape 10 Mb in capacity with a data density of 800 bpi; the magnetic disk cassette-type drive IZOT-1370 — 300 kb/s and 2.4 Mb, respectively.

For these reasons, the most common method of data storage was simple copying (buffering) the data after observations on the storage media (usually magnetic tape) with the aid of the standard facilities of operation systems. The problems of such "archiving" of data were solved within individual departments of the observatory or even by individual astronomers. The predominant decentralization of work concerned with the storage of experimental data led eventually to losses of a considerable part of unique information.

The mid-1980s witnessed the introduction of a TV panoramic recording system QUANTUM (Afanasiev et al., 1987). At the prime focus of BTA the system was used in conjunction with spectrometers realizing medium spectral resolution; the two-dimensional photon counters with these systems were later replaced by CCD (Afanasiev et al., 1995a-c).

For the tasks of stellar spectroscopy at the Nasmyth–2 focus the system QUANTUM was used in combination with the Main Stellar Spectrograph (camera I (Klochkova, Panchuk, 1991a) and camera II) and with echelle spectrometers of moderate (ZEBRA; Klochkova, Panchuk, 1991b) and high (ESPAK; Klochkova et al., 1991) resolution. In 1991 the technique of high resolution echelle spectroscopy was complemented with CCDs (Panchuk et al., 1993; Klochkova, 1995), and in 1993 CCD came to be used with the moderate resolution echelle spectrometer as well. In 1994 camera II of the Main Stellar Spectrograph was fitted with a CCD. In 1996, observations with the BTA prime focus echelle spectrometer were started. That is, the amount of information about stellar atmospheres obtained with BTA over several years increased substantially in the number of spectrum elements transmitted simultaneously (see for details Klochkova and Panchuk, 1991a).

At the same time, a 2×1024-channel TV photon counter (scanner) (Drabek et al., 1986) and a two-channel electrophotometer (Vikuliev et al., 1991) were used to perform the tasks of spectrophotometry of objects at the Nasmyth–1 focus of BTA.

In the middle of the 1980s stepwise introduction of a new generation data acquisition system (MCOSS) for the feed No. 1 at RATAN–600 was initiated. The system was based on a two-level measuring computing complex incorporating the host computer MERA-125 (then MERA-685) and a microcomputer on the feed (Erukhimov, Chernenkov, 1987; Vitkovsky et al., 1988; 1989). The system provided preparation, acquisition and preliminary processing of data and consequently was extended to the level of public use. MCOSS increased sharply the effectiveness of observational process in the continuum: the number of observations with the feed No. 1 was 2000 in 1986 and 3000 in 1987.

Thus, the change of the hardware at SAO, the increase in the amount of experimental information and springing of quite a few local problems of archiving of different types of data called for working out of quite a new approach to the problem of archiving. Such an approach was formulated in 1987 as a conception of *unified* observational data archive at the observatory. This conception formed an ideological basis of the first version of the integrated archiving system ODA, which was placed in service in 1989 and was the first informational system embracing both radio and optical data (Kononov, Evangely, 1991; Kononov, 1996a).

The idea of unified archive contained two major points:

1. A notion of *a local archive* was first introduced, which was associated with a certain type of observational data referring to a particular astronomical facility and its acquisition system.

2. Principles were first elaborated of *informational integration* of different types of experimental data and systems, which made it possible to make use of a common methodology and create software for simultaneous maintenance of any local archives.

6.1. ODA Version 1.0. System environment and computer base

When the system was in the process of development, rather severe constraints allowing for the real conditions under which the system was to be operated, were formulated:

- The acquisition systems whose data are to be archived represent standard soft- and hardware complexes which are in permanent use and cannot be updated essentially in the nearest future.
- The acquisition systems and their associated processing systems run under the environment of OS NTS on SM-type computers.
- The output data structures of the acquisition systems are stable and will not be changed for a certain period of time.
- Magnetic tape is believed to be the most suitable and accessible archive data medium.

Thus the main distinguishing characteristic is the fact that the already existing and operated systems with their established output data structures, formats of their presentation on the media, and communications with the processing systems are considered as original systems. For this reason, the creation of the archive should not have offended the already realized configurations, and the informational integration of the systems was originally restrained and could manifest itself only in:

- similarity in computer media of the local archives' structure;
- application of the common archive format-envelope;
- realization of similar procedures of access to archive data;
- use of a unified user interface;
- application of a common software to support local archives.

All software was originally developed in the environment of the Unix-like OS DEMOS on the computer SM-1420 as model versions. Consequently it was adopted to function under control of the OS NTS on SM-type computers. All programme modules are written in the language C.

6.2. Archiving subsystems

To do the work, 4 standard acquisition systems were chosen (names of devices are given in brackets):

- RATAN–600 broad-band radiometers (Continuum);
- BTA scanner (IPCS 2 ∗1024);
- two-channel photometer (NPh–1) (Neizvestny, 1994);
- BTA fast echelle spectrometer (ZEBRA) (Gazhur et al., 1990; Klochkova, Panchuk, 1991b; Galazutdinov, 1994).

This choice was motivated by both the desire to make use of two different wavelength ranges (optical and radio) and the considerable dissimilarity of the structures of output data of the systems listed above. In addition, a certain pseudo acquisition system whose output was not determined rigidly was considered. This enabled the astronomers an opportunity to establish their personal (working) archives with an arbitrary structure, but having a common organization close to standard, the standard ODA programmes being used.

The system ODA Version 1.0 was implemented as five functionally oriented subsystems, each supporting a particular-type archive:

ODA/R	—	local archive of continuum radiometers of RATAN–600 (Kononov, Evangely, 1990a);
ODA/S	—	local archive of the BTA scanner (Kononov, Evangely, 1990b);
ODA/P	—	local archive of the BTA two-channel photometer (Kononov, Evangely, 1990c);
ODA/E	—	local archive of the BTA fast echelle spectrometer (Kononov, Evangely, 1990d);
ODA/U	—	personal (working) archive of users (Kononov, Evangely, 1990e).

Concerning the architecture, all the subsystems were alike, however, each of them was adjusted to its type of input data (acquisition system output) with the aid of specialized programme components.

Reeled magnetic tapes of 10 Mb with a data density of 800 bpi were used as the archive media. The local archives were disjoint in volumes of their media.

6.3. Formation of local archives

Different local archive subsystems were placed in service sequentially as they were developed during the years 1989–1990, and, in the general case, their introduction did not coincide with the time their associated acquisition systems came to be employed as standard (Kononov, 1993; 1994; 1995a). This is why each local archive covered its time interval. Besides, in the process of gradual filling of the archive with current observational data, the latter were added by the preceding (old) data that had been buffered earlier and stored on the computer media in a nonstandard form. This made it possible to increase the *effective* time of operation of the archiving subsystems and as a result to bring eventually to the "life time" of the corresponding acquisition systems as hard- and software complexes with the fixed information outputs. Full periods of formation of the local archives are given in Fig. 5 (dark areas of the diagram).

The local archive of the BTA scanner was extended owing to old data (since 1983), which were read from buffer disks, reconstructed, ordered and reduced to the ODA archive standard. Because of this, the total time interval spanned by the scanner archive data was 9.4 years.

The operation of the subsystems of optical data archiving discontinued nearly simultaneously in 1993, while with the radio data it lasted until 1995, when the change-over of their associated acquisition systems of RATAN–600 and BTA to the new computer base, IBM-compatible personal computers, took place. Thus the total time of functioning of the system ODA Version 1.0 was 11.4 years.

6.4. Working configurations of the system

The working configurations of the system on a particular computer were defined by disposition of both the acquisition systems and the stations of principal processing of pertinent types of data:

RATAN–600:
Configuration ODA/R + ODA/U on the computers MERA-125 and MERA-685 — archiving and processing.

BTA:
Configuration ODA/S + ODA/P + ODA/E + ODA/U on two computers SM-4 — archiving and processing.

Lower scientific site:
Configuration ODA/S + ODA/P + ODA/E + ODA/U on the computer SM-4 — operative archives and processing.

Thus the local archives were originally distributed over the sites of the observatory, but actually supported by one and the same software (Fig. 6).

6.5. Radio data archiving

Archiving of data of continuum radiometers was accomplished via the subsystem ODA/R over the period November 1989 – May 1995 (5.5 years) (Kononov, Mingaliev, 1996).

The subsystem in its original version was realized at RATAN–600 on the computer MERA-125 in the environment of the OS NTS (Fig. 7). The communication with the acquisition and processing systems was implemented at the level of a buffer disk 2.4 Mb in capacity (cassette-type data drive IZOT-1370). The data recorded in the process of observations with the feeds using the software/hardware complex MIKRAT were transmitted and recorded on the buffer disk of the host computer MERA-125 through a specialized local computer network. The stage including direct recording, primary processing and transmission of data for subsequent archiving was provided for by the acquisition system MCOSS.

The small capacity of the buffer medium actually defined the frequency of starting the procedure of data archiving — once in 24 hours. In the case of intensive observations the round-the-clock data were archived in parts.

The subsystem ODA/R was later transferred to the computer MERA-685, and the disk port Seagate ST-125 of 20 Mb (archive region 10 Mb) came to be employed as the buffer. As a result, the recording of data into the archives came to be executed once in several days. The acquisition and archiving could be performed in synchronism, the data of the current date being disjoint. The tape-recorders IZOT-5003 (MERA-125) and MERA PT-310 (MERA-685), which is greatly superior to the former in rate of exchange and reliability, were used as archival storage base.

As a result of functioning of the subsystem ODA/R throughout the period 1989–1995, a data archive of broad-band radiometers was established, which was located on 78 magnetic tapes. Because of the shortage of data media (with allowance made for their large number) the copies of archive volumes were not supported.

6.6. Optical data archiving

Archiving of optical data of three types was executed by using the subsystems ODA/S, ODA/P and ODA/E in the periods:

IPCS 2 $*$1024	—	December, 1983 – February, 1993 (9.4 years);
NPh–1	—	November, 1989 – February, 1993 (3.4 years);
ZEBRA	—	January, 1989 – February, 1993 (4 years).

In brackets are indicated the total time intervals.

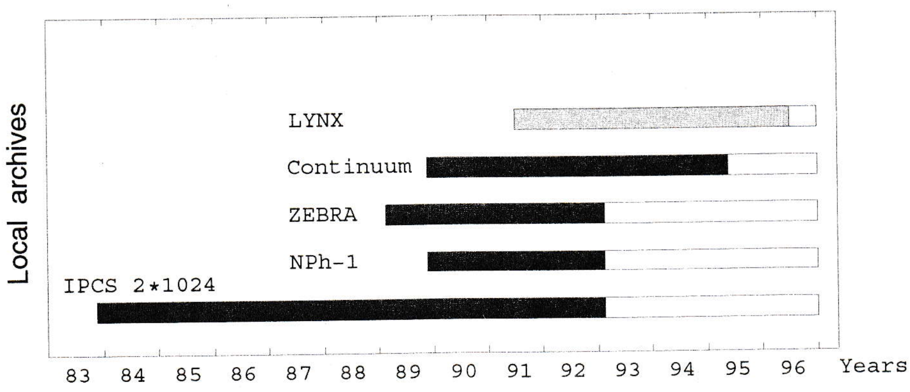

Figure 5: *Periods of generation of local archives.*

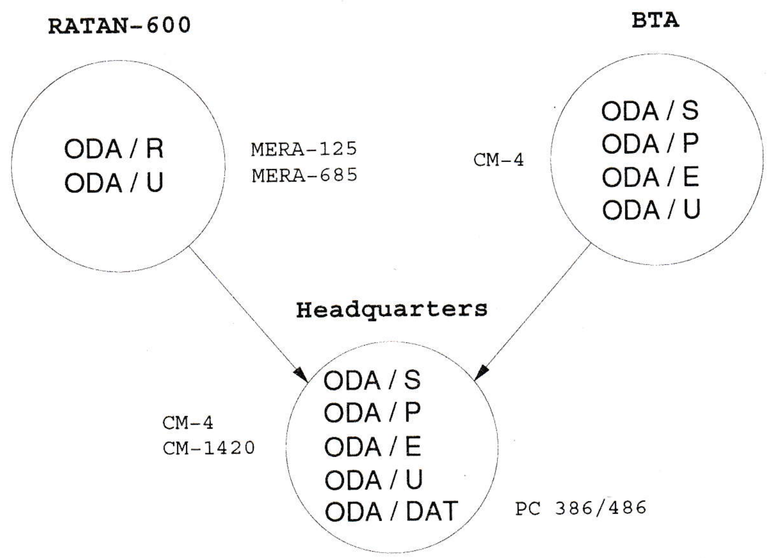

Figure 6: *Working configurations of archives system ODA Version 1.0.*

The three subsystems were implemented at BTA on two computers SM-4 in the environment of the OS NTS (Fig. 8). The informational communication with the acquisition and processing systems was implemented similarly to that of the subsystem ODA/R — at the level of the buffer disk 2.4 Mb in capacity (IZOT-1370).

The considerably smaller bodies of optical data, as compared with the radio range, made it possible to do archiving once in several days or at the end of the observing run. Nevertheless, this procedure was accomplished once in 24 hours. The tape recorders IZOT-5003 were used as data drives.

Taking into account that a great part of optical data processing was performed at the Lower observatory site (LS), and for prompt access of the observers to new information, the data were transmitted to the LS by means of the buffer MT and included in the appropriate *operative* archives after the completion of the observing run. With this end in view, the archive subsystems were implemented on the computer SM-4 of the LS in the environment of the OS NTS, the direct renewal of the operative archives was carried out on the computer SM-1420 in OS Demos.

It should be noted that originally the organization of operative archives was conceived to be the establishment of particular working archives containing data of the latest 2–3 months. However due to the comparatively small amount of optical information, the operative archives actually became copies of the local archives. As a result of operation of the subsystems ODA/S, ODA/P and ODA/E, an optical data archives was created throughout the period 1983–1993, which was located on 20 magnetic tapes (disregarding the copies).

6.7. Personal archive support

The astronomers could make their personal (working) archives with the aid of the subsystem ODA/U which was developed at all sites of SAO, and the users were furnished with unified facilities of data storage

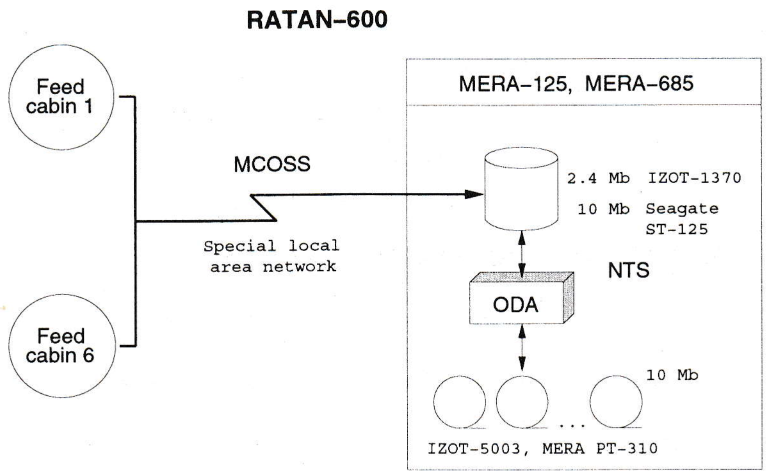

Figure 7: *A scheme of archiving continuum radiometer data.*

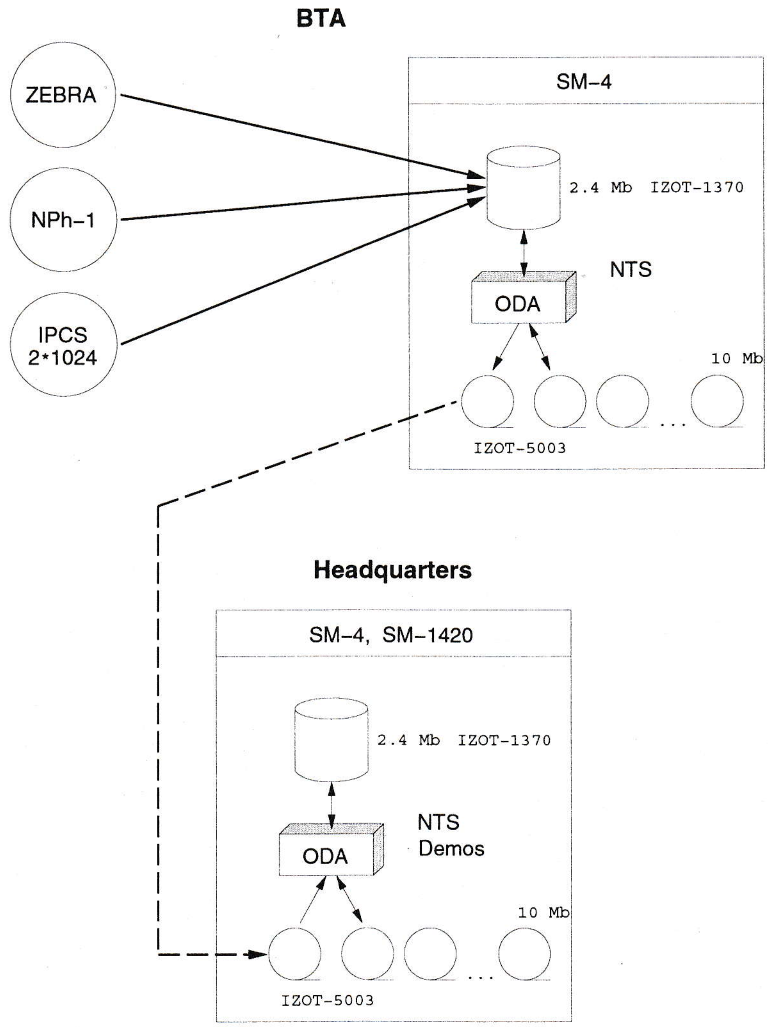

Figure 8: *A scheme of archiving optical data.*

on MT.

The content of personal archives and the order of their filling were defined by the astronomers themselves. These could be both the archives of different-type initial observational data (subsets of the local archives normally associated with particular observing programmes) and the archives of intermediate and/or final processing of results.

In addition, the subsystem ODA/U was used actively for transport of MT-buffered data between the observatory sites, since it supported a convenient form of representation of arbitrary data on the media, which is compatible with the Unix-like OS (*tar*-format).

6.8. Data format and organization of the archive data media

Since the development of all the acquisition systems was practically independent, the structures of observational data and the rules of their identification were essentially different from one another. It is this fact that presented the most severe difficulty in the implementation of unified approach to the task of archiving heterogeneous data. Nevertheless the task was performed through the introduction of special organization of archive data media for all local archives by way of immersing internal formats of the acquisition systems in the *tar*-format envelope of the operation system Unix. In so doing, each original (terminal) file of the acquisition system was formed in the archive as a *tar*-file, and a single *tar*-archive corresponded to a set of round-the-clock files (of night for the optical subsystems). The content of the *tar*-archive for the subsystem ODA/U was defined by the astronomer. The *tar*-format itself was simulated by the ODA system means in the OS NTS environment.

The information was recorded on MT in blocks of 10 kb. The *tar*-archives for each local archive were formed in *chronological* order of data arrival.

Thus the two-level organization of the archive data media represented two types of objects from the point of view of the system ODA: *date of observation* (night) and *terminal file* of the acquisition system.

6.9. Identification of archive files

Identification of archive files as *tar*-files was provided for with the aid of hierarchical names. In the general case, each archiving subsystem used its convention on the structure of names with allowance made for the distinctions of the structure and identification of output data of the corresponding acquisition system:

ODA/R:	$date/object/time/channel/filname$;
ODA/EPS:	$date/object/filname$;
ODA/U:	$date/com_1/com_2/com_3/filname$;

where

date	—	date of observation (*yymmdd*) (for ODA/U — date of creation of the *tar*-archive);
object	—	name of the object (up to 14 characters);
filname	—	name of the original file of the acquisition system;
time	—	discrete time of the beginning of observation (*hhmm*);
channel	—	channel identifier (concatenation of wavelength in cm and Stokes parameter);
com_i	—	comments (up to 14 characters);
/	—	delimiter character.

The parameters *date* and com_i are optional for the subsystem ODA/U: for instance, the name of the archive file could be one simple name $filname$, or else a particular truncated combination of parameters.

Examples are found in:

ODA/R:	910522/SS433/1143/7.6_I/SS4322.516
ODA/S:	921013/AM_HER/A50106.000
ODA/U:	900518/V44/EF.12

The above compound names are ordinary strings of symbols and are formed in special *tar*-headers at the stage of information recording into the archives.

Application of the *tar*-format enabled free processing of archive data of the ODA system in the environment of the Unix-like OS by means of the utility *tar*. In this case, when reading, the data were shown in file systems in order of significance of simple names:

$$date/ \longrightarrow object/ \longrightarrow \ldots \longrightarrow filname.$$

6.10. Access to archive data

The ideology of the ODA system Version 1.0 did not make provision for the parallel maintenance of the operative reference database (RDB) to make access to the main archive base more effective. In particular, this was due to the comparatively small capacity of the used devices of direct access and low speed of exchange. However, the key parameters, *date of observation, object name, wavelength,* and *Stokes parameter*, were drawn to the level of the hierarchical names of *tar*-files. This made it possible to organize a simple enough (in the form of requests) and, at the same time, flexible retrieval fetch of archive information with the aid of an apparatus of *regular expressions* (patterns) by way of analysing only *tar*-headers of archive files (Kononov, 1995b,c).

In the process of retrieval of the desired archive data, analysis of full compound file names as strings of symbols was made. Since these names were of rigorous regular structure, the application of patterns in the retrieval was very effective. If the file was found, it was copied on the buffer disk and given a low-order name *filname*, that is, initial.

The procedure of access to archive data of the ODA system Version 1.0 made allowance for a wide range of modes which, using the patterns, provided automatic admission to a required place of the archive, complex retrieval and drawing of data, arbitrary positioning of the media, etc. Here the region of scanning could be both the whole archive volume and a particular *tar*-archive, that is, a specific date of observation. In addition, various forms of work could be utilized: dialogue, batch (with minimum intervention) or their combinations. The very access procedure was unified and applied uniformly to all local archives and the inquiries of the astronomers would normally be formulated as lists of patterns.

For example, to draw all files referring to observations of the object AM_HER from the local archive of the BTA scanner, it sufficed to indicate the pattern

AM_HER

For the archive of the continuum radiometers of RATAN–600 a list of patterns:

89*SS433*
9105*3C273*
901222/*/*/*[QU]/*

ensured access to observational data of the object SS433 throughout the year 1989, of the object 3C273 for May 1991 and of all the objects for the date 22.12.90 for the channels with the Stokes parameters Q or U.

6.11. New archive media

Experience of intensive long-term work with the archive has shown that in due course a considerable amount of information is lost. The most decisive factor here is the insatisfactory quality of the media in use. This concerns both the radio data archive and optical archive despite the doubling of information for the latter. Besides, the large number of archive volumes not only hindered effective access to the data but did not provide any means of global systematization of the available observational data.

It should also be noted that the early 1990s witnessed an active change-over of different types of systems to a new hardware with the environment Unix, which demanded a more effective computer medium from the point of view of its compactness, capacity, speed of exchange, and general reliability (Zin'kovsky et al., 1994; Chernenkov, 1995; 1996; Verkhodanov et al., 1993). With this taken into account a new project, ODA/DAT, was realized, which took account of the reorganization of all local archives on the basis of the improved computer technology: IBM PC 386/486, Unix-like OS, net facilities. As a result, all the archive data of the system ODA Version 1.0 were transferred, their format preserved, to a new type of medium — DAT cassettes DG90M 2 Gb in capacity (Kononov, 1995a,d-e; 1996b; Kononov, Mingaliev, 1996).

For conversion of archive information an extension ODA/DAT of the archiving system was developed, which is a package of C-programmes and command files functioning in the environment of the OS Xenix. ODA/DAT was realized as a separate subsystem on the computers IBM PC 386/486 connected to the local computer network of the LS (Fig. 6). For reading the initial archive data, the tape recorder IZOT-5003 was connected to one of the computers as a nonstandard device. The entire archive of the system ODA Version 1.0 was located on two DAT cassettes (disregarding copies) and contained about 800 Mb of information. The whole material was arranged in the order of observing dates. The optical data (types E, P, S) are collected in a separate volume.

Thus the project ODA/DAT made it possible to:

- preserve the existing archive data;
- represent them in an extremely compact form;
- make copies of archive volumes;
- provide effective access to the information;
- form reference databases and catalogues of archive media;
- on the basis of auxiliary RDBs to make a general statistical analysis of the archive data.

The archive established with the aid of the system ODA Version 1.0 included about 30000 observations: over 18000 in the radio range and 11000 optical observations.

6.12. The archiving system ODA Version 1.1

The next version of the integrated archiving system ODA Version 1.1 was placed in trial service stepwise in 1996. This system had been developed with provision made for the new computer technology in the Unix-like operation environment Linux. The system was tested with the data of the BTA high resolution echelle spectrometer LYNX (Panchuk et al., 1993; Klochkova, 1994) buffered on different media since 1991 and including about 1400 observations with a total size of 1.6 Gb (Fig. 5) (Kononov et al., 1996). At the same time the local archive of the BTA scanner was expanded through the data of the period 1993–1994, which were the latest for this instrument.

Concerning the architecture, this version was a two-level system functioning both in the ODA Version 1.0 mode and with automatic support of the local reference databases. As the archive media, DAT cassettes were already used. The common principles of developing enabled inclusion of the observational databases already created by the system ODA Version 1.0 into the main archive database of the new version.

Thus, the development and introduction of principles of informational integration of different types of archive systems on the basis of generalization of the notion "observational data" and the creation of the first integrated archive of the observatory can be considered to be the distinguishing characteristic of the **third** stage of advance of the archiving technology at SAO.

7. The unified archive of observational data

The idea of a unified archive originally formulated in 1987 laid emphasis on the general principles of establishing the archive as a database, on the methods of development and implementation of the software, and on the architecture of the archiving systems. Experience of development and operation of the first version of ODA has shown that to make advances in this area, one has to take account of a number of additional aspects that are elucidated below.

In the early 1990s the technology of processing of information at SAO underwent the following principal changes: the first IBM-compatible personal computers came to be used, which, from the present-day point of view, had modest parameters — processors i286/386 with a clock frequency of 16–33 MHz, a memory of 1–4 Mb and hard disks of 40–330 Mb. These computers found immediately application in making new data processing systems controlled by the operation system MS-DOS and Unix family.

A second distinction of using IBM-compatible computers was their gradual adoption in observing at the telescopes RATAN-600 and BTA. This was facilitated by the appearance of still more powerful computers with the processors i486/Pentium with a clock frequency of 33–90 MHz, a memory of 8–64 Mb, and hard disks of 660–1000 Mb. They formed the foundation for the creating of working places for the observing astronomers, which were supported by convenient and efficient data acquisition systems in the environment of the OS Linux.

All this required a certain revision of the technological chain of acquisition and conversion of experimental data:

1. Introduction of powerful computing facilities at the first stage — the stage of observing — permits the functions of the acquisition systems in forming their information outputs to be extended and thus alleviate the next links of the chain — the archiving and processing systems. First of all, this refers to the informational completeness of output data and their correctness.

2. The creation of a unified archive of observational data calls for particular rules of interaction of the acquisition and processing systems with the archiving system, which can be introduced through standardizing of the appropriate interfaces.

3. The advance in the net possibilities both at the observatory and outside of it places certain demands upon the form of representation of observational data. It is advisable here to hold to the international standards in representation and communication of astronomical information.

Taking account of these additional aspects, in 1992–1995 the conception of unified observational data archive was complemented essentially by the ideology of flexible archiving FLEX-system (FLexible EXchange) (Kononov, 1996a). Such a system must form the basis for the establishment of the observational data Bank at SAO, and its development characterizes a **fourth** stage of archiving technology advance of the observatory. It is contemplated that the principal results of this stage will appear in the next papers.

8. Conclusion

Completing the review of progress in the archiving technology at SAO and generalizing experience of the work done in this area, the following conclusions can be drawn:

1. Observational data archiving must be an indispensable and consistent link in the technological chain of experimental data conversion.

2. Decentralization of work over retaining unique information will ultimately result in its loss, that is, in its physical destruction or will make it practically inaccessible.

3. Over the past few years integration processes that reflect the need for multiaspect joint processing of different types of observational data, spectral and photometrical, optical and radio, etc., have become apparent. For this reason, the development of integrated archives systems is of prime importance.

4. It is only at the present time that the potentialities of computing facilities in storing and processing bulks of data become adequate to the amount of information actually existing at the observatory.

5. The disregard of experience gained by the designers of archive systems and often the sheer disorganization of the work being already carried out resulting from incompetent interference may finally lead to essential negative consequences in functioning of SAO as an observational centre.

The idea of a *unified* archive of SAO that was stated in 1987 and received further prosecution in the 1990s is getting increasingly significant. It has presently appeared to be the methodological foundation for the creation of the observational data Bank of the observatory as a whole and its individual parts, in particular, the observational data Bank of RATAN-600 (Kononov, Mingaliev, 1998).

In conclusion we should like to note some other points which are of importance in our opinion.

The main problem that has persisted throughout the years of SAO's activity, and which has been independent of the archiving technology, is moderated interest of the observers in the very process of archiving. Indeed, the observer who furnishes a great deal of information recalls but rarely the observations made a few years ago. This is accompanied by something like "technological snobbery". For instance, when the necessity for establishing digital archives of old photographic observations is stated, it is not unusual that one will hear "it's easier to repeat observations which are expected to be of higher quality". The amount of clear sky, as small as it is, needed for observing new objects is thus potentially cut down. A similar situation arises sometimes in scheduling observations at the radio telescope. This problem can be resolved at two levels:

- technological, when the archiving process becomes "invisible" to the observer;
- educational, when respect for the old data, i.e. for the work done by the predecessors is cultivated.

There is a demonstrative example. In the early century the Pulkovo astronomers obtained photographs of several globular clusters. Photographs of the same clusters taken half a century later and the earlier data in the aggregate enabled measuring of proper motions of stars at the greatly spaced epochs and isolating stars belonging to globular clusters. If the Hypparcos mission alone had been intrusted with the task of measuring proper motions, it should not have been performed for globular clusters.

Because of the indeterminate status of observational information, part of the data obtained, for instance, with BTA during the first years of its performance were left in the possession of the time applicants and appear to be lost now. The other part of photographic data were not digitized in due time and as a consequence of deterioration may also get lost. The resources needed for establishing a digital observational data archive will turn out to be smaller comparing with those required to maintain any of the present-day instruments in the process of a repeated observation. It should be emphasized that this is the matter of one third of the observational time that has been used at BTA by the present time. The above said holds also for RATAN-600, bearing in mind the thousands of unique observations made in the 1970s, the results of which are stored on paper tapes.

The populist talks about the total accessibility of observational data also may provoke negative attitude of some observers to the work concerned with archiving. It is known even from the time request form that one can be aware of long duration of some programmes, that is, the priority of the author of the observational programme for using the observational data is supposed to keep for a long time. On the other hand, it is known that at BTA there are practically no "depersonalized" methods, that is, the methods kept at the level of "night assistance". The technique of observation has become more sophisticated, meanwhile the work involved is rated lower. The result of a good deal of technological effort is the fact that a considerable fraction of the data available in the literature appear in papers authored jointly with the astronomers preparing instrumentation, performing observations and preliminary (or complete) processing of results. Thus the unresolved problems of copyright to observational results have become still more involved. It should be particularly emphasized that the affair will reach a legal deadlock if these aspects are left out of account.

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