Conference of the 6 m telescope users April 21, 1997, SAO RAS

SCHEDULE

1. *Yu. Yu. Balega (SAO RAS)*
BTA in 1996, II half year

2. **The present status and prospects of spectroscopy techniques at BTA**

V.E. Panchuk (SAO RAS)
The high spectral resolution techniques

V.L. Afanasiev (SAO RAS)
Problems and prospects in development of moderate resolution spectroscopy techniques at BTA

3. **Reports of applicants for observational time**

G. Weigelt (Bonn, Germany)
Optical and infrared speckle masking and spectroscopy

V.G. Klochkova (SAO RAS)
Spectroscopy of protoplanetary nebulae (the review of V.G. Klochkova is presented in this issue)

4. **Scientific reports**

Yu.N. Gnedin (MAO RAS)
News of astronomy: the Texas Symposium on Relativistic Astrophysics and Cosmology (December 1996, Chicago, USA) and the Symposium No.189 "Fundamental Stellar Properties: The Interaction between Observations and Theory" (January 1997, Sydney, Australia)

Yu.N. Parijskij (SAO RAS)
Search for first generation stellar systems – cooperative observations at BTA and RATAN-600

Below is presented the abstracts of most of the reports.

Yu. Yu. Balega

BTA in 1996, II half year

Observing conditions

The observational time record keeping at the 6 m telescope is done in two independent ways: by the Technical Department (TD) and by the observers. The BTA TD registers the total time the telescope is in operation with the slit opened. This includes the use-

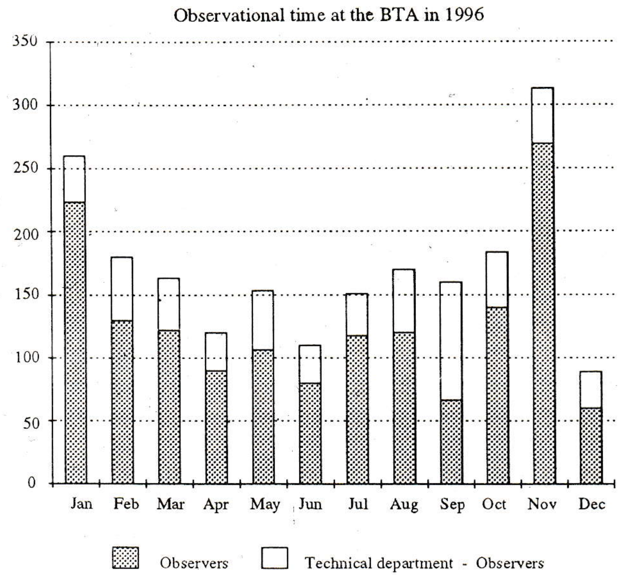

Figure 1:

Table 1: *Observational time at the BTA in 1996*

1996	BTA TD	Observers	Difference	%
Jan	260.5	229.0	31.5	88
Feb	181.0	131.0	50.0	72
Mar	165.0	122.5	42.5	74
Apr	121.5	88.5	33.0	73
May	153.5	107.0	46.5	70
Jun	108.0	78.5	29.5	73
Jul	151.0	119.5	31.5	79
Aug	172.0	120.5	51.5	70
Sep	162.0	67.5	94.5	42
Oct	183.0	140.0	43.0	77
Nov	313.0	268.5	44.5	86
Dec	88.5	61.0	27.5	69
Total	2059	1534		<75>

ful time the telescope is operated for an observational programme, the time of expectation of better weather conditions (the slit being opened), the time required to prepare the equipment etc., while the astronomer records the time needed for the programme to be carried out (Fig. 1, Table 1). The ratio of the two records has been constant for many years (about 70%). The ratio is higher under stable weather conditions. The low September ratio (42%) implies that the weather was unstable, the observers did not stop the telescope but no exposures were made. The observing time losses caused by troubles with the telescope in the latter half year were as low as 1.5%, which is an indication of high reliability of the telescope.

Telescope and equipment

To remove vibrations of the telescope body, the oil supply system was redesigned: the oil pumps of the vertical drive were taken from the telescope platform and positioned in the pumping compartment. In future, this will also enable cooling of oil in a common tank, reducing thereby heat liberation inside the dome.

A change-over to new computers in the control system was performed without stoping the telescope.

A local computer network connected with the common network of SAO, providing access to Internet, was created. This will offer a possibility of remote observations.

The CCD camera of the Company Photometrics was returned back to service with the aid of the Institute of Astrophysics in Potsdam, Germany. It was used in observations with the spectrograph SP-124 at the N1 focus.

For interferometric observations of long-period variables and protoplanetary nebulae at the BTA prime focus, the infrared range camera NICMOS-3 with an image size of 256 × 256 pixels was employed for the first time. The application of special reduction algorithms allowed infrared images of sources in a spectrum range from 1 to 2.2 μm with a spatial resolution of 0.1 arcsecond to be obtained. This work was performed in collaboration with the Institute of Radioastronomy, Bonn.

Fulfilment of observational programmes

For the second half year 82 time requests were submitted to the 6 m telescope Programme Committee 40 of which were granted. In 1996 the numbers were 72 and 42, respectively.

The top-ten list of applicants for the period of 1994–1996 is as follows:

D.A. Varshalovich, FTI (St.Petersburg)	51
Yu.N. Parijskij, SAO	41
V.E. Panchuk, SAO	34
I.D Karachentsev, SAO	32
Yu.V. Glagolevskij, SAO	28
G. Weigelt, MPI Radioastronomy (Bonn)	26
V.L. Afanasiev, SAO	25
A. Marten, Observatoire de Paris (Paris)	22
S.N. Fabrika, SAO	21
A. Guarnieri, Italy	21

From the view point of the weather conditions the following programmes turned out the most successful:

Wave gaseous structures (A.M. Fridman, IA RAS)

Compact groups of galaxies (G. Longo, Italy)

Circumnuclear envelopes in Seyfert galaxies

(G. Richter, Germany)

Decoupled galactic nuclei (O.K. Sil'chenko, SAI)

Identification of AGN from ROSAT list (H. Hasinger, Germany)

Dymamic spectroscopy of polars (N.N. Somov, SAO RAS)

Among the most striking results obtained in observations with the 6 m telescope in the second half year the following may be pointed out.

- The detection of a giant molecular hydrogen cloud where new blue dwarf galaxies SBS 0335–052 originate. These are the youngest among the observed nearby galaxies and have an extremely low abundance of heavy elements (V. Lipovetsky, S. Pustil'nik and others).
- With the programme "Optical identification of bright ROSAT sources", spectral identifications of 197 survey fields were accomplished, which resulted in detecting over 80 active galactic nuclei, 23 candidates for members of clusters of galaxies and other objects (S. Neizvestny, A. Ugryumov).

Director's reserve

The nights held in reserve were used in 1996 to carry out the following programmes:

Identification of AGN from the ROSAT list	G. Hasinger
Study of nearby galaxies	N.A. Tikhonov
Low-mass X-ray binaries	G.M. Beskin
Spectra of stars from the Byurakan surveys	A.N. Burenkov
Magnetic white dwarfs	S.N. Fabrika
Magnetic fields of peculiar stars	Yu.V. Glagolevskij
Star formation regions	Yu.N. Glushkov
Speckle interferometry of stars and galaxies	G. Weigelt
Occultation of young stars in Taurus by the Moon	A. Richichi
Differential speckle interferometry	R. Petrov
Spectroscopy of stars	V.E. Panchuk
Hale-Bopp comet	K.I. Churyumov

Technical nights

During the technical nights there were carried out the following operations:

- preventive maintenance of mechanical parts, seasonal change of oil;
- BTA ACS updating;
- testing of equipment (including foreign one);
- stabilization of tracking and pointing precision.

V.E. Panchuk

The high spectral resolution techniques

The first decade of BTA performance showed extensive use of the Main Stellar Spectrograph (MSS) with photographic recording. Besides, the Fabry–Perot magnetometer was used in the observations. In the second decade the introduction of panoramic detectors was initiated: TV photon counting systems and charge-coupled devices (CCD). For these detectors the first generation echelle spectrometers were developed.

The statistics of different high spectral resolution techniques used at BTA for the first 20 years are presented in the paper by Panchuk (1998, this issue).

The present–day state of the high spectral resolution techniques is determined by availability of the MSS redesigned to be operated with CCDs, of the echelle spectrometer LYNX and the prime focus echelle spectrometer PFES. The spectral resolution of these devices enables a wide scope of observational programmes (from study of absorption spectra to fast spectroscopy of bright stars) to be carried out .

In optimum recording of absorption details of a spectrum, the principal parameters are the signal read–out noise and the spectral resolution. For two types of the CCD used at BTA the spectral resolution limits are found and it is shown, that for spectral resolutions being lower than limiting one in the problem of increasing the accuracy of spectral line recording it is preferable to increase the spectral resolution rather than to raise the signal-to-noise ratio via larger exposures (Panchuk et al., 1998, this issue). So far CCDs with a read–out noise no lower than $6e^-$ have been employed at BTA, that is why one may derive benefit from changing over to devices of higher spectral resolution.

The development of high spectral resolution techniques at BTA is connected with the creation of an echelle spectrograph with a large collimated beam (NES). This device is placed on the Nasmyth focus platform and designed to be operated both alone and in conjunction (via the divider of spectral ranges) with one of the two spectral devices having been placed there (MSS and LYNX). The large size of the flat field of the NES camera allows for using large format CCDs (up to 4096 × 4096 pixels). The spectrometer is equipped with pre-slit units that enable measuring of the Stokes parameters and performing precision radial velocity measurement.

V.L. Afanasiev

Problems and prospects in development of moderate resolution spectroscopy techniques at BTA

The tasks of moderate resolution spectroscopy, R4 ≈ 1000 – 5000, of point and extended objects takes up over 40% of the BTA schedule.

At the present time four moderate resolution spectrographs are in use at the telescope. These are the fast prime focus spectrograph (UAGS), the multiobject (MOFS) and the multipupil (MPFS) prime focus spectrographs and the stationary Nasmyth focus spectrophotometric complex based on the standard BTA spectrograph SP–124. The four spectrographs are similar in collimated beam size (75–100 mm) and in focal ratio (F/1.5–F/2). All the spectrographs incorporate up-to-date detectors — CCD with a quantum efficiency of 55–80%. The methods of observations with the spectrographs is well developed and accessible.

However, a mere comparison of the total throughput of the BTA moderate resolution spectrographs with those of other large instruments is somewhat discouraging. The maximum quantum efficiency at a wavelength of 5000 Å is estimated to be 6–8% for the spectrograph UAGS, 3% for MPFS, 3–4% for MOFS, and the spectrophotometric complex SP–124 has a quantum efficiency less than 2%, even though it is equipped with an excellent CCD TK 1024. For comparison the efficiency of the RC spectrograph (similar to UAGS) of the KPNO 4 m telescope is more than 18%, EMMI placed at the Nasmyth focus of the 3.5 m telescope NTT of ESO, which is analogous with the complex SP–124, has an efficiency of about 30%. At last, the efficiency of the low resolution spectrograph LRIS of the KECK 10 m telescope is 34% at 5000 Å and 44% in the red (≫6500 Å) region. This implies that the efficiency of BTA even under good weather conditions is comparable with that of a 2–3 m telescope equipped with modern spectral devices.

What is the cause of these giant losses? Firstly, this is the low throughput of the optics of each of the spectrographs (fresnel losses at the surfaces) and the considerable geometrical losses — vignetting at the secondary mirrors of the cameras and their insufficient focal ratio, which causes vignetting at the entrance of the camera when working with diffraction gratings with large blaze angles. Assessment of such losses for each of the spectrographs show that they make a factor of 2–4 on the optics. Secondly, since with the typical focal ratio of the four spectrographs the normal slit size is 0.8–1.2 arcseconds, the quality of guiding during the observations is of importance. Experience of observing with other large telescopes has shown that the use of autoguiding systems under a seeing of 1.5–2 arcseconds in the case of BTA can improve the spectrograph efficiency by a factor of 1.5–2. It should be noted that with the presence of vibration of the BTA mounting at frequencies of 0.1–1 Hz with amplitudes that reach 0.5–2″ even at minor wind load, systems of fast local guiding of tip–tilt type employed at large telescopes are strongly recommended.

It is readily apparent that whether BTA will be competitive and promising in moderate resolution spectroscopy, even being equipped with CCD systems of marginal performance, will be determined by the efficiency of our spectrographs. A good deal of effort has to be undertaken on the part of astronomers and engineers of SAO in the updating of the spectral devices. Development of new spectrographs optimized for real light detectors and having high throughput is deemed to be the most radical. It is also important that the existing spectrographs do not allow large-size CCD to be used because of the small linear field of view of the cameras.

The development of a new generation moderate resolution spectrograph, MOUSER (Multi Object Universal Spectrograph for Extragalactic Research, see SAO Report of 1996) is currently being completed. The spectrograph is intended to be multifunctional and operated at the BTA prime focus. The device will be equipped with a system of fast guiding designed for using a CCD of 2048 x 2048 pixels. The expected total efficiency of the spectrograph in different modes of observations (direct images in filters, "long slit", multiobject and 2D spectroscopy) will be 20–35%. We believe that such a spectrograph, when put into operation, will essentially enhance our possibilities in the area of moderate resolution spectroscopy and improve the BTA performance efficiency.

G. Weigelt

Optical and infrared speckle masking and spectroscopy

The subject of the wonderful communication of Prof. Gerd Weigelt from the Max-Planck Institute of Radioastronomy in Bonn was application of speckle masking in modern astronomy. Speckle masking (bispectrum or triple correlation processing) yields diffraction-limited images in spite of image degradation caused by the atmosphere and by telescope aberrations. For example, with the SAO 6 m telescope a resolution of 0.02″ can be achieved at a wavelength of 500 nm. The limiting magnitude is about 17-18, depending mostly on atmospheric seeing conditions. Even at the site with a moderate seeing speckle masking can be effectively used in the infrared region of the spectrum. The theory of speckle data processing was briefly presented. In the second part of the presentation Prof. G.Weigelt discussed the application of speckle masking and the most interesting results obtained with the 6 m telescope in 1994–1996. Observations of the central object in the giant HII region of NGC 3603 made with the 2.2 m ESO/MPG telescope were first shown. The diffraction-limited image was reconstructed from 300 speckle interferograms, providing a resolution of 0.08″. This result was later confirmed by the Hubble Space Telescope observations. A high-dynamic range diffraction-limited image was obtained with the same telescope for Eta Carinae at 850 nm. Three faint star-like objects were first discovered in this image with separations from 0.1″ to 0.2″.

The 6 m telescope provides an angular resolution, which is nearly 3 times higher. Starting from 1994 it was regularly used for speckle masking observations of multiple stars, long-period variable stars, the proto-planetary nebula Red Rectangle, the nearest carbon star IRC +10216, and for the Seyfert galaxy NGC 1068. The observations were carried out both in the visible and the infrared wavelengths. For all the objects observed, diffraction-limited images were reconstructed. For example, the image of the Mira variable star R Cassiopeiae was made at a wavelength of 714 nm in the titanium-oxide absorption band, where Mira stars appear about twice as large as they do in white light. This pulsating red giant seems to elongate and squirm, changing shape and orientation as it goes through its months-long cycles. The Red Rectangle bipolar nebula was resolved into two lobes separated by about 0.14″. The dark lane between the lobes caused by the obscuring dust disk can be readily seen. The reconstructed images of IRC +10216 show a resolved central peak surrounded by patchy circumstellar matter. The structure implies a stochastic behaviour of the mass outflow of the pulsating carbon star, perhaps up to the dust condensation point. The K-band speckle masking reconstruction of the core of NGC 1068 with an angular resolution of 0.076″ shows the resolved nucleus of the 2.5 pc in diameter. The characteristic physical parameters of the source can be derived using these new data. All the results were illustrated by beautiful colour images of the objects.

Yu.N. Gnedin

News of astronomy

In the report the basic observational results presented at both meetings were discussed. For the Texas Symposium these results include:

(1) the HST Key Project to measure the Hubble constant;

(2) the problem of Large Scale Structure (LSS) of the Universe;

(3) the problem of galaxy formation;

(4) dark matter problem, etc.

The discovery by the HST of Cepheid variable stars in galaxies as distant as the Virgo cluster yields good agreement with the value of Hubble constant $H = 70 \pm 9$ km/s Mpc. A preliminary analysis of 40 distant supernovae and of the data concerning LSS and dark matter distributions offers strong evidence for energy density in empty space (physical vacuum) if the space is flat ($\Omega = 1$). This means existence of Einstein cosmological constant (Λ). The main result of investigation of the Hubble Deep Field is the discovery of normal galaxies at very large cosmological distances (red shift $z > 3$) and the discovery of strong starburst processes at $z > 3$.

The new space project, a 6–8 m orbiting telescope (New Generation Telescope) was also discussed at the Texas Symposium.

The subject of the Symposium No.189 was the confrontation between precise observational and theoretical determinations of fundamental stellar properties. Its goal was to better define the limits of our current understanding of the structure and evolution of stars. The areas of significant disagreement between the best observations and the best theories were disscussed at the Symposium. The fantastic amount of new and accurate data from the Hipparcos mission in the fields of absolute magnitude calibrations, stellar physics, distance scale determinations, etc. were also discussed.

Yu.N. Parijskij

Search for first generation stellar systems

In the frames of the "Big Trio" project, 6 m telescope observations are carried out of the areas around the objects having the features of extremely distant objects in the Universe, which have been detected with RATAN-600. For the purpose of economy of observational resources the project was broken up into the following stages: detection of radio sources in a selected area; selection of objects with ultrasteep spectra, mapping of the sample at the VLA, formation of a subgroup of apparently binary objects of FR II type, deep optical identifications at the 6 m telescope. Four stages of the "Big Trio" project have practically been accomplished.

The main result is the proof of existence of the cosmologically significant USS FR population with all indirect signs that it belongs to extremely distant the first generation objects. The surface density of such objects is close to one per square degree even at a flux density of 30 mJy and $R<25$. The R brightness for 8 objects is fainter than that of objects from the extremely distant population with $z>4$.

The second important result obtained in the course of partial realization of the 5th stage — multicolour photometry of host galaxies — is the separation of a group of star systems with a formally negative age. In the case this conclusion is confirmed, one should reject models without the cosmological term or consider other versions of cosmological solutions. We hope to finish the multicolour photometry and start spectral investigations, if only with a low resolution, in 1998.

The third result is the evaluation of maximum admissible redshifts on the basis of estimates of optical depth of the Universe from the Thomson scattering. From the present–day data, at redshifts larger than 10–12 the population of powerful radio galaxies almost disappear therefore new methods of study of the Universe are needed.

Conference of the 6 m telescope users October 14, 1997, SAO RAS

SCHEDULE

1. *Yu. Yu. Balega (SAO RAS)*
BTA in 1997, I half year

2. *E.R. Rudtskaya (RFBR)*
On the main principles of activity of the Russian Foundation of Basic Researches

3. **Reports of applicants for observing time**

O.K. Sil'chenko (SAI MSU)
Decoupled galactic nuclei

D.I. Makarov (SAO RAS)
Rotation amplitudes of flat edge–on galaxies

V. V. Sokolov (SAO RAS)
Optical observations of GRB970508 from May to October, 1997

4. **Scientific reports**

Yu.N. Gnedin (MAO RAS)
Astronomical Observatons of the Hale-Bopp comet: new, unexpected results

H. Zinnecker (Potsdam, Germany)
Young multiple systems in the regions of star formation

W. Dushl (Heidelberg, Germany)
The nucleus of the Seyfert galaxy NGC 1068 at 2.2 μm

M. Schoeller (ESO, Garching, Germany)
Current VLT project state

J. Krelowski (Torun, Poland)
Diffuse interstellar bands – the 75th anniversary of studies

V.E. Panchuk (SAO RAS)
Key programmes and spectroscopy of stars at large telescopes

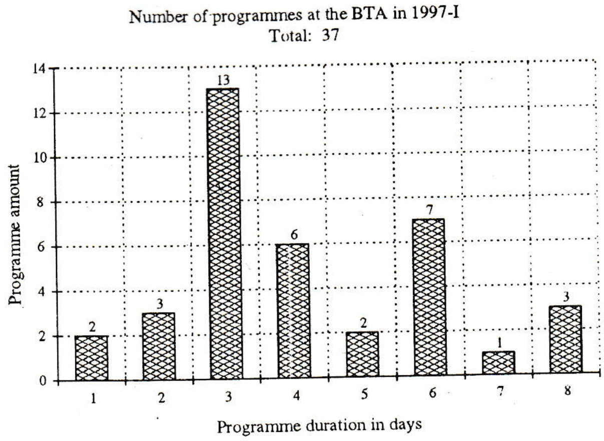

Figure 2:

Yu. Yu. Balega
BTA in 1997, I half year

In the first half year of 1997 68 time requests were accepted by the Programme Committee 37 of which were granted. The programmes "Interferometry of Mira variables and nebulae" (G. Weigelt, Germany), "Magnetic fields of Ae/Be Herbig stars" (Yu.V. Glagolevskij, SAO), "Magnetic fields of white dwarfs" (S.N. Fabrika, SAO) were allotted 8 nights each. Seven nights were assigned for the programme of G. Courtes (France) "Continuum of primeval galaxies". The programmes of G. Wade (Canada), V.G. Klochkova (SAO), N.A. Tikhonov (SAO), D.I. Makarov (SAO), A.M. Fridman (IA RAS), Yu.N. Parijskij (SAO), D.A. Varshalovich (FTI) were given 6 nights each. One night was allotted for each of the programmes of V.O. Chavushian "New gravilens" and A.G. Gorshkov "Unique radio sources". The amount of programmes with respect to the number of nights allotted is shown in Fig. 2.

The time allotted for the programmes of