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6 m telescope spectroscopy: statistics of techniques and programmes

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Abstract. Based on the official 6 m telescope observational schedule, the degree of use of different spectroscopic techniques is assessed. The minimum acceptable length of the observing programme is evaluated. In the author's opinion even at this stage of time allocation one third of time allotted for spectroscopy is lost because of fractioning into numerous minor programmes. As a consequence, half of the applicants that acquire 6 m telescope time have no publications from the results of observations. A number of measures are suggested for improvement of the 6 m telescope efficiency.

Key words: Instrumentation: telescopes – spectroscopy: programmes

1. Introduction

Since 1977 the 6 m telescope time allocation has been accompanied by an official document (half–year schedule) in which are specified the terms of fulfilment of the programme, the applicant (author), the technique of observations, and the person responsible for the fulfilment of a given programme. Since 1985, the schedule has also contained a brief name of the programme. In order to perform homogeneous processing of this information, let us make two simplifying assumptions. Firstly, when evaluating the length of use of a particular piece of spectral apparature, we will account for the time the apparature has to be officially prepared for application on the telescope (i.e. we disregard the minor percentage of changes in the techniques and programmes caused by weather conditions or for technical reasons). Secondly, since for a part of the BTA operation period there is no information on the programmes, we restricted ourselves to the account of the time allotted to a particular applicant (in the case there are several authors of the same programme, the time is shared in equal parts).

2. Techniques

Consider first the application of the techniques of spectroscopic observations. Because of the difference in "pressure" of the requests for light and dark nights, it is convenient (with some degree of conditionality, since some of the devices are applicable to investigation of both stars and galaxies) to treat separately the methods of spectroscopic investigation of stars and the techniques for spectroscopy of extragalactic objects.

Statistics of "extragalactic" and "stellar" techniques is presented in Tables 1 and 2, respectively.

Designations used in Tables 1 and 2 are as follows.

- N is the number of nights, P is the number of applicants ("programmes"), t=N/P, ** means the incomplete utilization of time in 1979 caused by the substitution of the main mirror of the 6 m telescope.
- UAGSIT is the spectrograph UAGS ("Karl Zeiss", catalogue No.16–190/23–9) at the prime focus (PF), photographic recording with the image tube (IT) (Afanasiev and Pimonov, 1981), + – with the panoramic photon counter KN12, * – with the CCD (Afanasiev et al., 1995a).
- 160IT is the spectrograph SP160 at the PF, photographic recording with the IT (Zandin et al., 1977a).
- ScanTV is the 1024 channel TV scanner based on the UAGS (PF); since 1984 based on the SP124 (N2) (Drabek et al., 1986), * – the SP124+CCD (Neizvestny et al., 1996).
- 161IT is the medium resolution SP161 at the focus Nasmyth–1 with the IT and photographic recording (Zandin et al., 1977b).
- MOFS is the multiobject fiber spectrograph with KN12(+) and CCD(*) (Afanasiev et al., 1995b).
- F/P is the spectrometer with a Fabry–Perot etalon and the two–dimensional photon counter (Dodonov et al., 1995).
- ZEBRA is the spectrometer at the N2 focus based on the SP161 with the two–dimensional photon counter KN11(+) and CCD(*) (Klochkova and Panchuk, 1991).

Table 1: *Distribution of the number of nights (N_1) allotted for spectroscopic investigations of extragalactic objects at the BTA according to the observational techniques.*

	N_1	P	t	UAGS IT	160 IT	Scan TV	161 IT	MOFS	F/P	ZEBRA	MPFS	MSS CCD
1977	153	16	9.6	116	14	16	7					
1978	132	20	6.6	92	23	15						
1979**	71	11	6.5	59	12							
1980	70	7	10.0	59	11							
1981	89	10	8.9	70	7	12						
1982	97	12	8.1	40	14	13		30				
1983	96	10	9.6	43	12	19		22				
1984	116	17	6.8	60	15	37		4				
1985	116	14	8.3	73		20		8	12			
1986	119	14	8.5	22		76		21				
1987	87	16	5.4	31+		56						
1988	119	17	7.0	18+		93		13+				
1989	137	20	6.8	25+		62		27+	11	20+		
1990	95	19	5.0	8+		38		22+	6	12+	8+	
1991	106	16	6.6	17+		44		6+	12	21+	6+	
1992	96	15	6.4			35		7+	10	15+	29+	
1993	87	17	5.1			27		14*	5	8+	27*	6
1994	109	19	5.7	3*		21		18*	12	4+	34*	17
1995	119	19	6.2	30*		24*		8*	21		38*	17
1996	124	23	5.4	27*		20*		9*	18		33*	17
Σ	2138			793	108	628	7	124	95	80	175	57

Table 2: *Distribution of the number of nights (N_2) allotted for spectroscopic investigations of stars at the BTA according to the observational techniques.*

	N_2	P	t	MSS Photo	PF	161 IT	124 Dis	Scan TV	Magn FM	ZEBRA	ESPAC KN-11	LYNX CCD	MSS CCD	M/H
1977	85	21	4.0	54	22	9								0.57
1978	100	24	4.2	65	29			6						0.54
1979**	73	14	5.2	39	26		4	4						0.87
1980	136	16	8.5	85	32	6			13					0.60
1981	152	20	7.6	114	21			17						0.33
1982	167	23	7.3	98			17	41	11					0.70
1983	136	27	5.0	94	5		5	23	9					0.44
1984	156	24	6.5	107	17			20	12					0.45
1985	100	16	6.2	57	7			24	12					0.75
1986	152	26	5.8	70				51	31					0.73
1987	162	27	6.2	69	3+			56	34					0.85
1988	169	25	6.4	48	9+			37	48	27+				1.52
1989	163	33	4.6	50	8+			31	45	29+				1.36
1990	143	29	4.2	13	3+			42	39	29+	8		9	2.47
1991	173	27	6.3	45	4+			53	47	19+	5			1.52
1992	175	26	6.4	5	7+			48	42	8+	52	13		0.90
1993	165	31	4.9		4*			41	48	16*	5	40	11	1.20
1994	114	20	5.4		16*			26	10	2*		43	17	0.73
1995	108	30	5.1		18*			24*	5	3*		38	20	0.77
1996	97	21	4.8		11*			19*	3			33	31	0.47
Σ	2726			1013	242	15	26	563	409	133	70	167	88	

• MPFS is the multipupil field spectrograph with the KN12(+) and CCD(*) (Afanasiev et al., 1990, 1995c).

• MSS CCD is the Main Stellar Spectrograph with the CCD (Panchuk, 1995).

• MSS Photo is the Main Stellar Spectrograph with photographic recording (Vasil'ev et al., 1977).

• PF is the spectrographs UAGS and SP160 at the prime focus, photographic recording with the IT, PF+ is the spectrograph UAGS with the KN12, PF* is the UAGS and MPFS spectrographs with the CCD.

• 124Dis is the planetary spectrograph SP124 (Gusev et al., 1976) with the dissector (Alekseev et al., 1983).

• MagnFM is the two-channel photoelectric magnetometers based on the UAGS (PF) (Shtol' et al., 1985), and based on the MSS (N2) (Glagolevskij et al., 1979).

• ESPAC is the autocollimation high resolution echelle spectrometer with the KN11 (Klochkova et al., 1991).

• LYNX is the high resolution echelle spectrometer with the CCD (Panchuk et al., 1993; Klochkova, 1995).

• M/H is the time ratio of using the systems of medium (PF, 161IT, 124Dis, Scan TV, MagnFM, ZEBRA) and high (MSS, ESPAC, LYNX) spectral resolution.

Analysis of Tables 1 and 2 allows the following conclusions to be drawn.

1. For 20 years of operation of the 6 m telescope about 2/3 of calendar time has been allotted for spectroscopic investigations.

2. 32 % of observational time assigned for spectroscopy was used for work with 3 standard spectrographs of the BTA manufactured in the 1970s (MSS - 24 %, SP161 - 5 %, SP160 - 3 %). 30 % of observational time was ensured by the modified spectrographs UAGS (UAGS+IT, TV-scanner at the PF, hydrogen-line magnetometer, UAGS+KN12, UAGS+CCD). Another 27 % was spent using the systems including the cameras from the UAGS (for instance, planetary spectrograph SP124 was employed as a TV-scanner with the camera F:2 from the spectrograph UAGS). Thus, 2/3 of the spectroscopic work was done at systems with a collimated beam diameter less than 100 mm.

3. The foreign light detectors were used at the 6 m telescope in no more than 8 % of the cases (3D spectroscopy, four-stage IT with the two-dimensional counter at the spectrometer ZEBRA, 1024 × 1024 CCD chip on the scanner).

4. The annual average number of spectroscopic techniques used grows, the mean share of time for each of the methods is reduced, the average number of stellar methods being always higher.

5. Since 1980 in both stellar and extragalactic investigations the annual average length of one programme has steadily decreased (on the average from 9 to 5.5 nights, i.e. 1.5 times in 15 years), the mean length of stellar programmes being always lower.

6. In the period 1979–1994 (except for 1985) the N_1/N_2 ratio remained lower than unity, reaching minimum values (about 0.5) in 1980, 1987 and 1993. In 1996 the N_1/N_2 grew to 1.3 basically because the share of time allotted for all stellar spectroscopy tends to diminish over the last few years, being presently 71 % of the share average for 20 years.

7. In the middle 1980s the use of photographic techniques of spectrum registration of extragalactic objects was terminated, whereas the period of photographic observations with the MSS was excessively prolonged. We recall that even in 1989 the Programme Committee recommended that "the MSS should not be stopped for adapting it to new light detectors...". Cessation of manufacturing Kodak photographic emulsions was attempted to be made up for by home-made ones (see Birulya et al., 1993).

8. As a consequence the means of moderate resolution were used to a maximum as compared to the methods of high spectral resolution. A reverse tendency was observed with other large telescopes at that time: "the renessance of high resolution spectroscopy" predicted by Wolff (1983).

9. Since the moment the MSS was equipped with CCD the high resolution techniques have been started to be used in extragalactic investigations at the BTA.

Thus, the artificial extension of the term of using the outdated techniques for spectroscopic and spectropolarimetric studies of stars at the BTA has led to delay of using the new methods, chronical lag in the level of investigations and lowering the proportion of using the 6 m telescope for stellar spectroscopy. From the point of view of provision of observations, the reduction of the average length of stellar and extragalactic programmes means more frequent change of the mounted equipment and rise in the operational costs. That is why the systems mounted at the 6 m telescope for permanent use, the MSS and the echelle spectrometer LYNX at the N2 focus and the TV-scanner at the N1 focus, turned out to be in advantage. The information capacity of such systems should be increased (by means of increasing the number of simultaneously transmitted spectrum elements, and preservation of the required spectral resolution and throughput, see, for instance, Klochkova and Panchuk, (1991).

3. Programmes

Now refer to the statistics of observational programmes. In the period 1977–1996, for spectroscopy of stars and extragalactic objects a total of 120 and 75 time requests, respectively, were granted. A comparison of the observing time and the number of applicants is given in Table 3.

Let us try to estimate the losses of the telescope time due to the excessive fractioning. Make the convention that the time of obsolencence of a programme (or the method it is provided by) is 10 years. On the other hand, with the account of the forecast of efficient operation of the telescope derived from meteorological data (Erokhin and Plyaskin, 1983) and the results of analysis of the archives of the echelle spectrometers (Kononov et al., 1996), assume that accomplishment of a programme of 2 nights per year is unlikely. Under such assumptions, we must cut off the distribution from Table 3 at a value of 40 nights for 20 years. It is seen that the "losses due to fractioning" amount to 32 % and 41 % of the time allotted for spectroscopy of extragalactic objects and stars, respectively and embrace 162 requests out of 195. If 35 nights for 20 years are adopted as the "level of fractioning", the estimate of lossses is then more optimistic: 27 % and 36 %, 155 requests. Therefore we think that to assess the efficiency of BTA operation in 1977-1996, it is suffice to analyze the work of only 40 applicants since each of the remaining 155 applicants received the amount of time insufficient (under specific seeing and with a particular technology of observations) for the fulfilment of the majority of the programmes. Table 4 gives the number of the nights allotted and the year in which the applicant has been allocated time at the 6 m telescope only for 40 leading applicants who received 35 nights and more. We call the sum of the nights listed in Table 4 "potentially effective" time (68 % of the total time allotted for spectroscopy).

As follows from Tables 1 and 2 and the references, the part played by SAO in the formation and development of spectroscopic techniques is decisive. This is certainly favoured by the fact that the astronomers live permanently in the Observatory site. The community of astronomers who permanently reside at SAO to carry out various observational programmes was formed and grew quickly enough. Then part of the observers evolved into designers of new generation devices. Consequently the designers took active part in observations. The existence of such a "feed-back" saved us from erroneous directions in the development of spectral apparature. Over the period of 20 years the astronomers of SAO have acquired 51 % of the total time allotted for stellar spectroscopy and 40 % of the time for spectroscopy of extragalactic objects. With reference to the "potentially effective" time (Table 4) the corresponding proportions amount to 74 % and 46 %. Note that these numbers should not be compared with the 30 % of SAO time quota for research programmes that existed until 1993, since in the present paper we do not consider non–spectroscopic methods (direct photography, photometry, speckle interferometry) which are largely used by external applicants.

4. Publications

When counting the number of publications, we abided by the following rules. Firstly, the number of publications of a given applicant was started to be counted a year after the applicant's name first appeared in the schedule (one year is a minimum time for data reduction and publication). Secondly, publications prepared jointly by several co–authors were put on account of the authors who had already appeared in the schedule as an applicant by the moment of publication of results.

Thirdly, the applicant was also assigned the publications in which he forgot to mention that the data had been obtained with the 6 m telescope. Publications were counted using the Astronomy Abstract Journal (Russian), Astronomy and Astrophysics Abstracts, and SIMBAD data base. For 20 astronomers of SAO we made a comparison of the counting results with the official list of publications and were convinced that none of the sources mentioned contains all publications of a particular author, for instance, in the Astronomy Abstract Journal about one fourth of the papers indicated in the list of the authors' publications are not abstracted and in SIMBAD one cannot find all papers of the applicants which are published in the major home–issued journals (A.Zh. and Pis'ma v A.Zh.). Nevertheless, for the applicants listed in Table 4 we have made a comparison of the data obtained from different sources and come to the conclusion that for the assessment of the BTA time allocation efficiency one can use the results of such bibliographic counts. In the present paper we refrain from formal comparison of the number of publications and the amount of the BTA observing time for each of the applicants. However, the point "publications from the data of the previous observations at the BTA" is present in the time request form, i.e. the link "observations — publications — time allocation for subsequent observations" is supposed to exist. Here we restrict ourselves only to the statement that for a certain part of the applicants the first and the second sections of this link are not traced. Really, out of 120 applicants who acquired time for stellar spectroscopy (and accordingly 75 applicants for spectroscopy of extragalactic objects) 65 (35, respectively) have not a single publication from the results of BTA observations. The SAO applicants acquired 46 % of the time allotted for spectroscopy, and each of the applicants has publications from the BTA results. On the whole the counts of the number of publications justify our suggestion when evaluating the "potentially effective"

Table 3: *Distribution of the number of applicants (T) and the number of nights (N), allotted for spectroscopy of extragalactic objects (1) and stars (2) in the period 1977–1996.*

N	>90	89-80	79-70	69-60	59-50	49-40	39-30	29-20	19-10	<10
T_1	6	-	3	2	3	3	6	5	16	31
ΣN_1	809	-	227	133	153	132	205	122	210	163
T_2	4	-	2	4	1	5	7	11	18	68
ΣN_2	780	-	156	258	52	215	210	246	264	315

Table 4: *Main applicants of the observing time, allotted for spectroscopy of extragalactic objects (left) and stars (right).*

N_1			N_2		
Afanasiev	163	1977	Glagolevskij	329	1977
Lipovetsky	162	1977	Kopylov I.	197	1979
Karachentsev	146	1977	Panchuk	132	1979
Markaryan	140	1977	Klochkova	122	1984
Khachikyan	106	1977	Romanyuk	79	1989
Varshalovich	92	1982	Vojkhanskaya	77	1977
Zel'dovich	77	1981	Magakyan	69	1978
Stepanyan	76	1986	Fabrika	64	1988
Zasov	74	1985	Bychkov	63	1989
Kopylov A.	68	1981	Gnedin	62	1978
Dodonov	65	1990	Chentsov	52	1977
Boulestex	51	1985	Strayžis	47	1981
Izotov	51	1986	Pugach	44	1988
Lorenz	51	1983	Karetnikov	43	1977
Sil'chenko	49	1987	Kipper	41	1978
Petrosyan	43	1980	Gershberg	40	1981
Oleak	40	1977	Snezhko	37	1981
Vorontsov	38	1977	Andronov	36	1990
Kazaryan	35	1978	Iliev	36	1980
Shapovalova	35	1988	Somov	36	1989

time.

5. Discussion and conclusions

The analysis of the measures of development and application of spectroscopic techniques at the 6 m telescope allows the following conclusions to be drawn.

- The 6 m telescope is a spectroscopic instrument and in the variety of the equipment with spectral devices it compares favourably with other large telescopes.
- The effective application of most of the techniques depends on the organizational approaches and measures (for instance, simultaneous change–over of all the researchers to a new type of detector or acquisition system). In this respect the possibilities of the observatory have not been used to full advantage.
- The certain part in the development of spectroscopic methods and in their subsequent application has been played by the condition that the developers of these techniques have permanently and hardly worked at the BTA.

There is also another point of view, "the astronomers must live in the capital and other research and cultural centres, develop light detectors there, formulate new ideas and come to the 6 m telescope for observations" (see Efremov, 1992). This view is not supported by the experience of SAO and the figures we have available. Spectroscopy at BTA is actually done with our own devices, more than a half of commercial designs turn out invalid as long–term used spectrographs (see Tables 1 and 2). It is not a secret that the spectral facilities are basically operated by the designers. On the other hand, our colleagues working at the major institutions of the capital are unable to maintain (in a remote mode of use) at the modern level their observatories that are located at the sites with far better seeing conditions than those at the BTA site. Suffice it to say that present–day spectroscopy at such observatories is at best at the initial stage. Eventually the scientific output of such observatories is limited only to photometry and is comparatively small. The huge research potential of the capital institutes could render us a considerable assistance in bringing to publications of all the results external users obtain at BTA. This would allow the scientific community and experts unbiased evaluation of validity of more than a half of spectroscopy requests, for which publications of results are lacking today. It is already 20 years that the BTA observing time has been allotted by the principle: "the telescope is accessible to any observer", but half the applicants who acquired time at BTA could not realize the second half of the principle: "the results of observations are available to everyone in the form of publications".

The future advance of spectroscopic investigations we associate with the following measures.

1. Increase in information capacity of stationary spectral systems (through increasing the collimated beam diameter of the Nasmyth foci spectrographs and using large–format CCDs).
2. Reduction of the number of the systems mounted at the prime focus accompanied by making them multipurpose.
3. Development of key projects that are regularly allotted time for their fulfilment.
4. Careful allocation of observing time, taking into account the extent and level of publishing the results of previous observations.

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