TO THE 30th ANNIVERSARY OF THE SPECIAL ASTROPHYSICAL OBSERVATORY

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Below we present some reports delivered at this Conference.

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Selected programmes for stellar spectroscopy at the BTA (1985–1995)

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In this communication we attempt to give a general characteristic of a number of spectroscopic programmes accomplished at the BTA in 1985–1995 and to assess results of work from engineering and scientific organizational points of view. Then we dwell upon the programmes that have not yet been carried to completion. First of all we characterize the technical aspect of the period under review. Concerning the schedule of the BTA performance, in particular, Panchuk (1998) presents statistics of using various techniques in spectroscopic study of stars. It follows from Table 1 of the paper just cited that over the last decade spectroscopic studies of stars have been accompanied by changes in technology of BTA observations, which has unconditionally had an effect on the character and duration of programmes carried out. It should be emphasized that there was lack of synchronism in the mastering of new technologies by different research groups, which would lead to extra fractioning of telescope time and other resources. In 1986 a Stellar Spectroscopy Group (SSG) was formed in the optical department of SAO, which served a basis for the creation of a Laboratory (SSL) in 1991. The change–over to digital methods of spectrum registration and the creation of adequate systems of high and moderate spectral resolution were the principal objectives to be achieved by this Laboratory. Since the main body of the Laboratory was formed from spectroscopists with well professionaly established interests, the scientific themes were preserved and developed. In the period under review new techniques of spectroscopic observations were developed in the SSL in collaboration with the Advanced Designs Laboratory and other subdivisions of the Observatory (Gazhur et al., 1990; Klochkova & Panchuk, 1991; Klochkova et al., 1991b; Panchuk et al., 1993; Najdenov & Panchuk, 1996). Table 1 from the paper of Panchuk (1998) shows that the contribution made by the SSG (SSL) to the technology of spectroscopic observations of stars grew from 16 in 1988 to 66 % in 1996, i.e. in 1996 66 % of all spectroscopic investigations of stars were performed using the techniques developed in the SSL.

To meet their own requirements, in 1985–1995 the Laboratory co-workers were allotted 266 nights on BTA, which makes 16 % of the total time allocated for star spectroscopy. The distribution of time between the applicants and the types of light detectors are given in Table 1.

Table 1: *Distribution of nights allocated at the BTA for the scientific programmes of SSL in 1985–1995*

Applicant	Device			Total
	Photo	Counter	CCD	
Panchuk	43	32	43	118
Klochkova	6	50	60	116
Chentsov	13		5	18
Galazutdinov			14	14
	62	82	122	266

In the period between 1986 and 1996 Klochkova, Panchuk and Chentsov published 77 papers from the results of BTA observations. The papers were distributed over the editions in the following way: AZh — 3, Pisma v AZh — 20, Bull. SAO — 40, Astrofizika — 1, A&A Transactions — 2, A&A, A&AS — 6, MNRAS — 3, PASP — 1, MSAIT — 1. 14 % of the papers were written in co–authorship with researchers of other institutions. The overwhelming majority of spectrograms we obtained with BTA were interpreted by the model atmosphere methods, therefore let us first examine the analytical aspect of work. The period 1985–1987 is characteristic of development of a group method. The essence of the method we proposed is as follows. A set of isolines, along which equality of observed and theoretical characteristics is obeyed, corresponds to a set of measured spectral details in the coordinates "effective temperature, T_e — the atmosphere surface gravity g". The region of intersection of these isolines indicates the most probable values of T_e and g. If a single star is investigated by the model atmosphere method, we can say nearly nothing about the systematic errors of the method except for the estimate of the errors caused by inaccuracy in measuring spectral details. If, however, a collection of stars of close spectral class is studied, or (which is better) stars as members of a star cluster are observed, it becomes possible to reveal some systematic errors due, as a rule, to the imperfection of theoretical calibration of specific parameters and the growth of model systematic effects when passing to the adjacent spectral classes or luminosity classes. Certainly, the group method of stellar spectroscopy using the atmosphere models turned out by over an order of magnitude more labour–consuming, but it enabled qualitatively new results to be obtained.

The investigation of stars, members of open clusters, allowed us to reveal systematic errors in chemical composition determination, which are caused by temperature and luminosity variations. Apart from the independent astrophysical interest shown in the investigations of disk stars of different types (B, A, F on the MS, K giants, cepheids, peculiar stars), such extensive spectroscopic programmes served a basis in further studies of halo stars. For instance, if one compares the mean chemical composition of a representative group of disk A stars with a sample of halo A stars (members of the blue part of the horizontal branch), one can minimize the influence of temperature systematic effects (the mean T_e values for the two groups of stars are practically the same). Or, if one compares the chemical composition of F supergiants at high galactic latitudes and F supergiants, members of open clusters, one can rid the results of differential determination of chemical composition of the influence of luminosity effects. The observational data obtained permit an empirical approach to the problem of studying departures from LTE with the use of apriori information on the dispersion of chemical composition of unevolved disk stars to be stated (Klochkova, 1991a). The information about the accomplished observational programmes can be found in the review by Klochkova (1991b).

We dwell now upon the programmes that are currently of particular interest to us.

I. Stars of the blue horizontal branch in globular clusters

A star evolves to the horizontal branch as a result of helium flash in the core (at the top of the giant branch) and loss of the considerable part (up to 90 %) of mass of the envelope. The evolution of the star within the horizontal branch is determined by the mass loss after the helium flash and by operation of two mechanisms: helium burning in the core and shell burning of hydrogen. When doing detailed echelle spectroscopy of BHB and EHB stars in the clusters M13 and M15 (Klochkova et al., 1991a), in three of the objects in M15 we detected anomalous ratios of hydrogen and helium line intensities, which may be interpreted as direct evidence of complete loss of the hydrogen envelope due to the helium flash. It should be emphasized that this conclusion has been drawn for stars – members of a globular cluster, i.e. for the first time it is possible to check differentially the chemical composition peculiarities by the group method. We recall that for the clusters M13 and M15 programmes are being carried out at BTA for investigation of chemical composition of brighter stars being at the evolutionary stages "pre–horizontal branch", which belong to the giant branch (Klochkova et al., 1994; Klochkova & Mishenina, 1998). This will make it possible to trace the history of synthesis of heavy elements inside selected globular clusters.

II. Lithium abundance in the atmospheres of halo subdwarfs

It is well known that the lithium abundance in the atmospheres of low–mass halo subdwarfs is not a function of metallicity beginning with the values [Fe/H] < −1.5 (Spite & Spite, 1982). The abundances of the rest of the elements decrease in proportion with metallicity. This phenomenon is interpreted as an indication of primordial, cosmological nature of the observed lithium. However, there is another point of view which is worthy of notice too – the primordial lithium abundance is an order higher than the abundance observed in the halo (i.e. the same as observed in disk stars), while in halo stars as a result of gentle but long–term mixing of the outer layers where the temperature is high enough for lithium to burn out, the abundance of lithium has decreased by an order, the hypothetical mechanism of mixing being insensitive to differences in metallicity. In halo subdwarfs with an effective temperature below 5500 K the lithium abundance is observed to diminish with decreasing temperature, which is interpreted as a result of more effective operation of the mixing mechanism. Thus, the efficiency of mixing mechanism may be tested both in hotter subdwarfs by checking the reality of the slight inclination of "Spite plateau" detected by Thorburn (1994) and in cold subdwarfs by comparing the shape of the low–temperature drop obtained for a group of stars of different metallicity. Our contribution to the solution of the problem is as follows. Firstly, we determine the atmospheric parameters by a purely spectroscopic technique (Klochkova and Panchuk, 1995), whereas in the west a less labour–consuming method was used until recently. Photometric evaluations of effective temperature are now thought to introduce extra noise to the dispersion of lithium over the plateau and may be the cause of the slight slope of the plateau (Bonifacio and Molaro, 1997). Secondly, our echelle spectra provide information about a great number of other elements, which allows the history of nuclear transformations of matter containing protostellar lithium to be traced. The hardest point for the hypothesis of cosmological origin of lithium is how the mixture observed in the atmospheres of subdwarfs is obtained (heavy nuclei are present, i.e. part of matter has passed through the high–temperature mechanisms, and lithium is present, i.e. part of matter has never had a temperature higher than 2 mln K). Thirdly, we have shown that a considerable part of stars treated previously as subdwarfs on the MS for halo stars are actually supergiants with convective envelopes, and the cosmological lithium abundance in the atmospheres of these stars is not preserved (Klochkova et al., 1996). Fourthly, we have doubled the sample of investigated stars with effective temperatures below 5500 K (measurement of weak lithium lines in the spectra of these stars is extremely difficult). So far there has been no evidence that the Yale models of mixing disagree with the observations of Klochkova & Panchuk (1996a).

III. Stars of the "post–asymptotic giant branch" stage

The stay of stars on the asymptotic giant branch is consistent with the operation of two shell sources: hydrogen burning and helium burning. Whereas on the AGB may be found stars as massive as 8–9 solar masses, but among white dwarfs no objects with masses larger than 1.4 solar masses are found. Hence it follows that the short–duration stage of transition from AGB to WD is accompanied by a rapid mass loss, the layers enriched in matter altered both in the main reactions of shell burning and in the neutronization reactions being necessarily uncovered at a certain moment in the course of mass loss. Large–amplitude pulsations in the atmosphere of a post–AGB star raise the matter above the photosphere just where dust is formed and then the radiation pressure blows this dust away from the star. The low mass loss rate is typical of objects which are, on the average, more bright in the optical range. With high rate of the mass loss the BVR radiation from the objects is supressed by the influence of the circumstellar envelopes. In the course of intensive mass loss (the superwind stage) the star may become invisible in the optics. When T_e reaches 30000 K, the preliminary ejected matter (if not far away from the star) is ionized, and we observe PN. Remnants of AGB can also be found from CO and OH molecule lines — the envelopes expand at velocities 15–20 km/s. We had taken interest in the objects having spectra of F and G supergiants, strong IR excesses and specific character of variability in the optical range before the IRAS survey was published. The first spectroscopic investigation of such objects was performed by photographic technique (Klochkova & Panchuk, 1988a,b; 1989). As a result of the IRAS flight, tens of IR sources have been discovered which are presently identified with cold and hot dust envelopes around "post–AGB stars". This was followed by a "boom" in ground–based spectroscopy, but up to now for half of the cases of detection of abundance variations of both light and heavy elements synthesized in neutron addition reactions followed by beta–decay using the high resolution spectroscopy technique with the application of the model atmosphere methods has still been due to the 6 m telescope (Klochkova, 1995; Klochkova & Panchuk, 1996b; Zacs et al., 1995; 1996; Klochkova et al., 1997a). The success has a simple explanation: using BTA we can observe fainter objects, i.e. those losing material on the average at a higher rate, and the probability of detection of objects with the changed chemical composition is higher than in the investigation of similar objects with a low mass–loss rate, which are bright in the optical range and observable with medium–size telescopes.

IV. Spectroscopy of stars with pseudophotospheres

Thanks to the new spectroscopic devices of the 6 m telescope, the S/N ratio and the spectral resolution adequate to the task studying pseudophotospheres have been realized. As a result, for the first time for 6 Cas (Chentsov, 1995) and HD 168607 (Chentsov & Musaev, 1996) on the trough–like wind profiles discrete absorption details have been detected, their regular motion along the profile, which suggests a gusty character of mass loss, has been managed to be traced. This throws new light on the proportion of the wide class of early supergiants and LBV (luminous blue variables). The famous object

IRC+10420 has been found to increase the surface temperature (from F8 to F5) over the past years and with a high degree of probability may be referred to LBV (Klochkova et al., 1997b). The programme of investigation involves the symbiotic star MWC 560 (Chentsov et al., 1997), since over the last few years we have had rare opportunity of observation of formation and stable presence in it of a powerful pseudophotosphere, which brings it closer to supergiants in the optical range.

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For additional information on the work accomplished at BTA in the directions indicated apply to: http://www.sao.ru/~valenta/

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