Bull. Spec. Astrophys. Obs., 1994, **38**, 171-184.

INSTRUMENTAL FACILITIES OF THE 6 M TELESCOPE

as of October 1994

1. ECHELLE-SPECTROMETER OF MODERATE RESOLUTION (ZEBRA)

(G. A. Galazutdinov, astronomer in charge)

This technique is devised for spectroscopy of faint objects in a wide wavelength range (3100-7800 ÅÅ). It is based on the spectrograph SP-161 modernized for using digital detectors. The diameter of the collimated beam is 130 mm, the aperture ratio of the mirror-lens camera is f/1.4, the focal length is 182 mm, the focal length ratio of the collimator and camera is 20. A 2-D photon counting system (IPCS) of 512×512 pixels is used as a detector. It includes the image intensifier tube of the type EMI9694 with S20 photocathode. In the blue and red spectrum ranges two changeable dispersion units are used, which are the combination of an echelle and a two-way prism. The central wavelengths corresponding to the maximum of concentration and the registered spectral range for different orders are as follows:

blue dispersion unit			:	red dispersion unit					
1	2	3	:	1	2	3	1	2	3
20	3300	3120-3480	:	39	4082	3897-4267	26	6043	5777-6309
19	3479	3290-3668	:	38	4164	3974-4354	25	6263	5987-6539
18	3670	3480-3870	:	37	4259	4065-4453	24	6571	6281-6861
17	3886	3676-4096	:	36	4370	4170-4570	23	6871	6571-7171
16	4131	3904-4358	:	35	4490	4286-4694	22	7206	6892-7520
15	4405	4162-4648	:	34	4628	4418-4838	21	7503	7174-7832
14	4721	4458-4984	:	33	4750	4535-4965	20	7891	7535-8247
13	5081	4797-5365	:	32	4889	4668-5110	19	8264	7888-8640
12	5506	5199-5813	:	31	5047	4819-5275	18	8844	8438-9250
11	6005	5675-6335	:	30	5227	4995-5460			
10	6604	6230-6978	:	29	5410	5169-5651			
9	7338	6923-7752	:	28	5606	5356-5856			
8	8255	7787-8723	:	27	5834	5576-6092			

(1) number of the order,

(2) central wavelength,

(3) spectral range.

The reciprocal linear dispersion for the blue dispersion unit is 0.7 and 1.8 Å/px for orders 20 and 8, and 0.7 and 1.6 Å/px for the red one (orders 39 and 18, respectively).

The entrance slit size matched to the detector and cross-dispersion prisms is 0.9×4 arcsec. The spectral resolution is determined by the line width ($\beta \approx 2.5$-3 px) and is ~2000. The spectrometer is equipped with a set of neutral attenuators, since the limiting count rate that produces a nonlinearity <20% is 0.6 events/px/s. With 3-4 hours exposure under 1″-1.5″ seeing the spectrometer can provide the spectrum of a star of V~17-17.5^m with a signal-to-noise ratio of about 60-80. The spectrometer is installed permanently in the Nasmyth-2 focus and is a part of the spectral complex which has a common means of control.

Reference

Gazhur Eh.B., Klochkova V.G., Panchuk V.E.: 1990, *Pisma v Astron.Zh.*, **16**, 473-480.

2. ECHELLE-SPECTROMETER FOR THE RED WAVELENGTH RANGE (LYNX)

(Dr. V.G.Klochkova, astronomer in charge)

The spectrometer is designed for stellar spectroscopy with high spectral resolution (R≈25000) in a wide wavelength range (5000-9000 ÅÅ). An echelle of 37.5 gr/mm with a blaze angle of 63.5° is used in the spectrometer. A cross-dispersion diffraction grating of 200 gr/mm is placed behind the echelle. The diameter of the collimated beam is 100 mm. The focal length of the camera is 200 mm (f/2).

K585 CCD is employed as the detector providing the following parameters:

pixel size	18x24 μ
number of pixels	520x580 pixels
working temperature	-120°C
pixel-to-pixel sensitivity variation	1-2 %
gain	16.2 e/ADU
readout noise	26 electrons
potential well capacity	240000 electrons
transfer inefficiency	<1E-5
number of cosmic ray events	≈7/min

The dispersion of the echelle is directed along the shorter side of the CCD. Spectrum orders No. 85-53 can be registered on the CCD without overlapping. The reciprocal linear dispersion is 0.125 Å/px and 0.2 Å/px in the 85th and 53rd orders, respectively. The shortest LB and longest LE wavelengths in the orders are listed in the Table.

The slit size matched to the detector and cross-dispersion unit is 0.5×3 arcsec. The source of the comparison spectrum is a Th-Ar lamp. At seeing $\beta \approx 1''$ over an exposure of 3-4 hours one can record the spectrum of stars of $V \approx 11\text{-}12^m$ with a S/N of 50-70. The spectrometer is installed at the Nasmyth-2 focus of the telescope. Control of the CCD and the image recording are executed with a PC AT386/387. Images of echelle-spectra are made available to the user in FITS format (size of one image is 0.7 Mbyte).

N	LB	LE	N	LB	LE	N	LB	LE
85	5622	5687	74	6457	6532	63	7584	7671
84	5689	5755	73	6545	6621	62	7710	7795
83	5758	5824	72	6636	6713	61	7832	7922
82	5828	5895	71	6730	6809	60	7963	8054
81	5900	5968	70	6825	6904	59	8098	8190
80	5973	6042	69	6924	7004	58	8236	8331
79	6045	6119	68	7026	7107	57	8380	8477
78	6126	6197	67	7131	7213	56	8532	8629
77	6206	6277	66	7236	7321	55	8687	8784
76	6287	6360	65	7351	7436	54	8846	8951
75	6371	6445	64	7465	7551	53	9012	9116

Reference

Panchuk V.E., Klochkova V.G., Galazutdinov G.A. et al.: 1993, *Pisma v Astron.Zh.*, 1993, **19**, 1069-1077.

3. HYDROGEN-LINE MAGNETOMETER-SPECTROPOLARIMETER

(V.G.Shtol, astronomer in charge)

It is designed for measurements of all Stokes parameters and stellar magnetic fields from polarization of spectral lines and in the continuum in the spectral range 4000 - 5000 ÅÅ. The hydrogen lines H_β and H_γ are usually used.

It is installed in the prime focus of the telescope at the fast spectrograph "UAGS". The minimum FWHI of measured lines is 6 Å. Spectral range or a spectral line is selected by fast rotation of the spectrograph grating. The position accuracy is 0.15 Å.

The first Table shows the accuracy (rms) of magnetic field measurements of a star via H_β and H_γ lines with FWHI = 20 Å, and residual intensity of 0.5 at 10 Å slit and 1.5″ seeing.

In the second Table are listed measurement errors of circular (v), linear (q, u) and elliptic (v, q, u) polarization in a 20 Å band for a one-hour exposure at the same seeing.

Data acquisition and reduction are performed with a PC AT/386. Preliminary data reduction is carried out in the real time in the course of observations.

rms (Gs)	50	100	300	1000	3000
Exposure(h)			magnitude (B)		
1	-	5.8	8.2	10.8	13.2
2	5.1	6.6	8.9	11.6	13.9
4	5.8	7.3	9.8	12.3	14.7
8	6.6	8.1	10.4	13.1	15.4

B magnitude.	5	7	10	12	15	17
Stokes parameters			Error of measurement (rms, %)			
v	0.0031	0.0079	0.031	0.079	0.31	0.79
q, u	0.0045	0.011	0.045	0.11	0.45	1.1
v, q, u	0.0055	0.014	0.055	0.14	0.55	1.4

References

V.G.Shtol: 1984, *Astrofiz. Issled. (Izv. SAO)*, **17**, 139.
V.G.Shtol: 1991, *Astrofiz. Issled. (Izv.SAO)*, **33**, 176.
V.G.Shtol: 1993, *Bull. Spec. Astrophys. Obs.*, **35**, 114.

4. MAGNETOMETER WITH A FABRY-PEROT INTERFEROMETER

(Dr. I.D. Najdenov, astronomer in charge)

The device is intended for high-precision measurements of magnetic fields of bright stars within the spectral range 4000-5000 ÅÅ. The method consists in scanning a portion of the spectrum using a Fabry-Perot standard with photoelectric registration. It is mounted at the first camera of the main stellar spectrogaph in the Nasmyth-2 focus.

The limiting B magnitude is determined by the sharpness of spectral lines measured. With 6 hours exposure, under 2″ seeing, and line profile slope equal to 1 it is close to 3.8^m at rms=10 Gs, and to 6.8^m at rms=40 Gs.

5. SPECTROPHOTOMETRIC SYSTEM IN THE NASMYTH-1 FOCUS

(Dr. S.I. Neizvestny, astronomer in charge)

It comprises a 1000-channel photon counting system (scanner), electrophotometer NEF-1, registration system MANIA, control and acquisition system. The scanner makes data acquisition with a high time resolution at 30 Hz frequency. All observations

are remote controlled. The control and acquisition system includes the host computer AT-386 in the control room and two satellite computers located on the Nasmyth-1 platform. An operation system UNIX is used. The data acquisition system facilitates automatic registration both with the scanner and the photometer in FITS format.

5.1. 1000-channel scanner (IPCS)

It is intended for moderate-resolution (2-15 ÅÅ) spectroscopy of faint objects (14-20 mag) within 3500-7500 ÅÅ, and also for absolute spectrophotometry and synchronous observation of the same target in spectral and photometric modes by using a beam splitter. To widen the dynamic range of the complex, a hole attenuator is used which allows one to weaken the input flux in the range from 0.0 to 8.5 mag with a step of 0.01 mag. The attenuator permits one to observe standards up to 5.5 mag.

The scanner is made according to the standard scheme of the Boksenberg photon counter and has two strobes (rules) for simultaneous registration of the object spectrum and sky background. The diameter of the collimated beam of the spectrograph is 80 mm. The collimator focal length is 2400 mm. A camera with a focal length of 150 mm is used.

The slit part of the spectrograph has a remote controlled dekker which contains the set of slits and diaphragms presented in the Table.

Table

position	name	width (diameter)	length (distance)	number
1	slit	2.2″	64″	1
2	diaphragm	4.5	22	3
5	diaphragm	3.4	22	3
6	diaphragm	2.8	22	3
7	diaphragm	2.2	22	3
8	diaphragm	1.7	22	3
9	diaphragm	1.1	22	3
10	diaphragm	0.8	22	3
11	diaphragm	4.6	22	3
13	slit	0.8	64	1
15	slit	1.1	64	1
16	slit	1.7		

The set of diffraction gratings gives the following dispersions:

(1)	(2)	(3)	(4)	(5)	(6)	(7)
R1	I	600	2.0	7000	86	4900-12600
R2	II	600	1.1	6000	77	4900-7700
R3	III	600	0.75	6500	60	5700-7300
B0	I	300	3.8	5000	68	3500-9000
B1	I	600	2.0	5500	84	3800-9900
B2	I	1200	1.1	5500	78	3850-9900
U3	I	1200	1.1	4000	75	2800-8200
U4	II	1200	0.5	4000	66	3300-5100

(1) grating

(2) working order

(3) grooves per mm

(4) reciprocal linear dispersion, Å/channel

(5) wavelength of maximum concentration

(6) reflection coefficient at concentration maximum in autocollimation

(7) working range

The spectrograph is equipped with two TV-guides for pointing on the target (field of view 3.5′) and setting and guiding on the slit (field of view 40″). On a moonless night under 2″ seeing the limiting magnitude of star-like objects clearly visible on the monitor is 19.5-20^m in the V-band.

An Ar-Ne-He lamp is used as the comparison spectrum source.

The spectral resolution of the scanner is determined by the linear resolution of the photon counter which is close to 2.5-3 channels (FWHM). The dynamic range of the scanner is limited by nonlinearity of the detector which is 20 % at the count rate 0.5 events/channel/s. The typical entrance slit width of the spectrograph is 1-1.5″ arcsec.

The device is automatic and controlled with the host computer located in the control room. At a seeing of 1-1.5″ (FWHM) and resolution of 10A for 60 minutes of exposure one can obtain the spectrum of an object of 19.5-20^m with a S/N=7-10. The accuracy of radial velocity measurements is 30-50 km/s (emission lines and dispersion 1.9 Å/channel). Spectra are processed using the MIDAS system. Data are supplied to observers on FITS tapes.

5.2. Photometer NEP-1

The photometer of the Nasmyth-1 focus is intended for synchronous spectral and photometric observations in different modes, and spectrophotometry of objects under investigation in absolute energetic units.

The instrument is installed in front of the slit part of the spectrograph SP-124. To take a part of the light beam a slicer is used that allows one to send to the photometer 6, 25, 50, 75 or 100% of light. At the photometer entrance a controlled wheel is placed which contains the following set of pairs of circular diaphragms located along the radii:

No.	diaphragm (″)	distance (″)	No.	diaphragm (″)	distance (″)
1	19	22.4	9	1.1	22.4
2	13.4	22.4	10	0.8	22.4
3	10	22.4	11	3.4	44.8
4	6.7	22.4	12	2.8	44.8
5	3.4	22.4	13	2.2	44.8
6	2.8	22.4	14	1.7	44.8
7	2.2	22.4	15	1.1	44.8
8	1.7	22.4	16	0.8	44.8

The photometer has two physical channels incorporating photomultipliers with photocathodes of type S-20, intended for synchronous observations in two different photometric bands. It is made by splitting of the beam using a dichroic mirror at the wavelengths 4000 and 5000 ÅÅ.

A set of filters provides the photometric Johnson system and narrow bands filters in different spectral intervals. The filters are located within the filter wheel assembly:

channel 1				channel 2	
No.	name	No.	name	No.	name
1	shutter	9	filter 4520A	1	shutter
2	filter U	10	filter 5020A	2	U
3	filter B	11	filter 6210A	3	B
4	filter V	12	filter 6500A	4	F(U+B)
5	filter R	13	-	5	-
6	filter F\(U+B)	14	-		
7	filter 6563A	15	-		
8	filter 4861A	16	-		

The interference filters at the positions 7-12 have FWHM~85 Å.

The photometer control system allows one to fulfil quasi-simultaneous sky subtraction and to record classical light curves synchronously in two channels (e.g. U and B, and others) with a time window from 1.0 to 0.002 s, and also the brightness curves "target" - "sky" with a window of 0.06 s.

For photometric calibration of spectra and UBVR photometry it is sufficient to send to the photometer 6 % or 25% of the total light flux, ensuring a reasonably accurate photometry. At synchronous observations of objects of B=18 with 6% of the light flux entering the photometer channel over an exposure of 10 min the measurement accuracy in U is 0.06^m, in BVR it is 0.02-0.04^m.

Results of observations are archived in FITS-format.

Reference

Vikul'ev N.A., Zin'kovskij V.V., Levitan B.I., Nazarenko A,F., Neizvestny S.I.: 1991, *Astrofiz. Issled. (Izv. SAO)*, **33**, 158-175.

6. MULTICHANNEL ANALYSER OF INTENSITY VARIATIONS - MANIA

(Dr. V.L. Plokhotnichenko, astronomer in charge)

The hard/software system MANIA (Multichannel Analysis of Nanosecond Intensity Alterations) is intended for the search and investigation of optical emission variations of astronomical objects on time scales from 0.1 μs to 100 s. The

principle of measurement is in defining the time of detection of each individual photon.

The system comprises computers AT-386 and AT-286 (MS-DOS, UNIX) and the time-code converter "QUANTOCHRON-3-16" compatible with the photometer located in the Nasmyth-1 focus.

Characteristics of the system:

the accuracy of determination of the moments of arrival of photons is 20 ns;

the apparatus dead-time is 100 ns;

the limiting intensity of the flux registered is 80000 counts/s.

Information on the moments of arrival of photons has a file structure and is stored on magnetic tape. The accumulated data are processed with the software elaborated in SAO which makes it possible to find and investigate both stochastic and periodical intensity variations. The intensity variation of $18\text{-}19^{m}$ object on time scales of 10-100 μs is registered during an hour exposure with an accuracy of 40%. The system can be used for storing photocounts in combination with any detectors at whose outputs standard pulses are formed. In particular, observations with the 4-channel UBVR photometer, photometer-polarimeter are posssible.

Reference

Zhuravkov A.V., Pimonov A.A., Plokhotnichenko V.L.: 1992, *Preprint,* No. 91,SAO RAS, 1994, *Bull.Spec.Astrophys.Obs.* **37,** 159.

7. CCD CAMERA FOR DIRECT IMAGING

(Dr. A.I. Kopylov, astronomer in charge)

A CCD camera for direct imaging is installed in the prime focus of the telescope (f/4) on a platform which is equipped with a remote controlled shutter and a wheel with four filters. The diameter of the filter is not larger than 60 mm and the thickness is smaller than 7 mm. Flashing of the CCD with green- or red-light diods or incandescent lamps is also provided. The CCD of type K983 with virtual phase is cooled by liquid nitrogen to a temperature of $-100^{\circ}C$, which is stabilized at this level. The size of the chip is 520×580 pixels. The pixel size is 18×24 μm. The angular sizes of the field and of the pixel are $1.3' \times 2'$ and $0.154'' \times 0.205'$. For different amplifications the ADU is equal to 28, 14 and 7 electrons. The readout noise is 13 electrons. The largest count of the ADU is 8191. The Kron-Cousins BVRI colour system is provided. The quantum efficiency at the maximum of filter bands is 24, 48, 48 and 40 % for B, V, R and I filters, respectively. The pixel-to-pixel sensitivity variations are about 2%. A typical rate of cosmic particles is about 3 events/frame/min. In the V-filter with an exposure of 10 minutes and

a seeing of 1″-1.5″ stars as faint as 24.5-25^{m} are registered with a S/N ratio greater than 5 in maximum (after a standard reduction procedure). The device is fully automated and controlled with a PC/AT386. Images are recorded in FITS format.

8. FAST LONG-SLIT SPECTROGRAPH (FS)

(Dr. A.I. Burenkov, astronomer in charge)

The device is designed for spectral study of extended objects: galaxies and HII regions. The remote controlled UAGS spectrograph is incorporated. The diameter of the collimated beam is 75 mm. A mirror-lens camera with an external focus f/1.5 and a focal length of 150 mm is used. The slit length of the spectrograph is 2.4′. The slit width may be fixed within 0-24″.

The following diffraction gratings are employed:

651 gr/mm, 2nd order, 6300-6900 ÅÅ,

1300 gr/mm, 1st order, 4700-5300 ÅÅ.

A 2-D photon counting scanner KN-12C (512×512 pixels) is used as the detector. The reciprocal linear dispersion is 1.5 Å/px, the entrance slit width is 1.3″, which corresponds to a spectral resolution of 3-4 Å. The scale perpendicular to the dispersion is 0.5 ″/px. The photon counter allows us to obtain spectra in the region 4500-7000 ÅÅ with a quantum efficiency of 4-6% under the dark noise of the order of 0.03-0.05 events/min/channel. After the observations the investigator receives a copy of the registered data on magnetic tape in the standard form of the SIMOIZ system (panoramic images of the object spectra, calibration spectra, direct object image on the spectrograph slit and flat field spectra KN-12C).

9. MULTI-OBJECT FIBRE SPECTROGRAPH (MOFS) - MEDUZA

(Dr. V.V. Vlasyuk, astronomer in charge)

The device is intended for simultaneous registration of a large number of spectra of faint objects with a low spectral resolution (R~300-1000) in the wavelength range 4500-8000 ÅÅ, that fall within the field of view of the 6 m telescope. Fibre light guides 200 μm in diameter, which correspond to 1.7″ in the focal plane, are used for light transmission from the focal plane of the telescope to the spectrograph slit. The fibres are as long as 0.5 m and their transmission is not less than 80% in the range 3700-8000 ÅÅ. The unit of the light guides in the spectrograph is dismountable and has 102 fibres. The light guides are fixed in the focal plane in a mask with holes whose positions correspond to those of the objects under investigation. The diameter of the field of view is 18′. At the request of the observer this mask can be manufactured at SAO. For this to be done, the applicant must communicate well in

advance the coordinates of the objects to be observed with an accuracy not worse than 0.1″. The minimum distance between the holes in the mask is 40″. 2 additional holes of 5 mm are made in the mask that are used to project stellar images, needed for adjustment and guiding, onto the TV guide.

The light guides at the input of the spectrograph are arranged in a slit 65 mm in length. The spectrograph is equipped with a lens collimator with a focal distance of 270 mm and a camera f/0.8 with a focal distance of 65 mm. The diameter of the collimated beam is 65 mm. The working range of the optics used is 4200-8500 ÅÅ.

The CCD of type K 983 with 520×580 pixels of the size 18×24 μm and photosensitive surface of 9×14 mm is used as the detector. The spectral sensitivity range is 3500-9500 ÅÅ. The readout noise of the detector used is 13-15 electrons. Depending on the brightness of objects the ADU (analog-to-digit-unit) is set within 4.5-16 electrons. The quantum efficiency of the CCD at maximum sensitivity is not less than 70%. The dispersion direction is along the shorter side of the CCD. The following diffraction gratings are used in the spectrograph.

grooves/mm	order	range, Å	recipr.dispers., Å/px
325	I	3800-6000	8.2
300	I	5500-9000	7.5
600	I	5000-9000	3.6
1200	I	4000-6000	1.5

The spectral resolution is determined by the monochromatic size of the light guide and is 2.5-3 px, the distance between the spectrum lines in the direction perpendicular to the dispersion is 6.7 px. An Ar-Ne-He spectral lamp is used as the source of comparison spectrum.

The number of spectra recorded simultaneously is 70-85. The spectrograph is provided with a remote controll. Personal computer AT386/387 is used for data acquisition. At 2-hour exposure under <2″ seeing the spectrograph can provide the spectrum of an object of $V\sim21^m$ with a S/N>10 and resolution of 15-20 Å.

10. MULTI-PUPIL FIELD SPECTROGRAPH (MPFS)

(Dr. V.L. Afanasiev, astronomer in charge)

The device is intended for 2-D spectrophotometry of extended objects with moderate spectral resolution. It is installed in the prime focus and consists of a multi-pupil unit and a fast wide-angle spectrograph. An object image is magnified in the multi-pupil unit with the microobjective and then is projected onto a 11×11 matrix of rectangular microlenses of 3×3 mm in size each.

Each lens forms an image of the pupil of the telescope which is illuminated by the portion of an object that corresponds to this lens. A set of objectives realizes magnification corresponding to angular sizes of the microlenses 1.6, 1.2, 0.6, and 0.4

arcsec, which provides the field of view of 18, 13.2, 6.6 and 4.4 arcsec. The matrix of micropupils whose linear size is determined by magnification is mounted at the spectrograph input with a collimator f/3.7 (f=270 mm) and camera f/15 (f=105 mm). The spectrograph has lens optics with the transmission within 4200-9000 ÅÅ. The collimated beam size is 65 mm. A 2-D photon counter KN-11 incorporated as the detector in the complex "QUANTUM" with a frame-by-frame recording of events is used. A set of diffraction gratings realizes the following dispersions and number of spectral elements (pixels) recorded simultaneously:

1	2	3	4	5
600	I	4000-6000	4.2	220
600	I	5500-9000	4.1	230
600	II	6000-9000	2.2	310
	III	4500-5500	2.1	320
1200	I	4000-7000	2.2	310

(1) lines/mm

(2) spectrum working order

(3) working spectral range, Å

(4) reciprocal linear dispersion, Å/px

(5) number of spectral elements (pixels) recorded simultaneously.

The spectral resolution is determined by the size of the monochromatic image of micropupils and is about 2.5-3 px (FWHM). The spectrograph is mounted on the universal prime focus platform that has a TV-guide (field of view 2′) for pointing and two movable fields of 50″ each for off-axis guiding by two stars. The limiting magnitude at a seeing of 2″ in the field of the TV-guide is $V\sim20^m$, and in the fields of guiding it is $V\sim18^m$. The limits of setting the centres of the field of guiding in radius and in tangential direction are 7-11′ and ±4′, respectively. The platform and the spectrograph are remote controlled from the control room. Data acquisition is executed with a PC/AT/386/387.

At 1 hour exposure in the range 4000-6500 ÅÅ one can obtain spectra of the portions of extended objects that have the surface brightness V~19-20 mag/sq.sec with a spectral resolution of about 4-5 Å, a S/N~5.

11. DIGITAL SPECKLE INTERFEROMETER

(A.F.Maximov - engineer in charge)

The digital speckle interferometer (SI) is designed to be located at the prime focus of the telescope to fully exploit the high angular resolution capabilities of the large mirror by achieving diffraction limited imaging in the 400-800 nm spectral range, up to 20 milliarcsec (mas), using speckle techniques. The SI provides two fun-

damental functions:

- short exposure speckle images recording to "freeze" the optical wavefront degradations caused by fast atmospheric turbulence;
- spectral band selection for interferometric imaging.

The general concept of a concave diffraction grating monochromator, first proposed by G.Courtes for solar imaging [1], is used in the SI optical layout. Bandpasses from 40 to 500 ÅÅ can be selected in the whole colour range 4000-8000 ÅÅ for speckle imaging. The instrument is divided into the following sub-systems:

- Field viewing and guiding unit with 1.5 arcminutes field coverage. The video-rate television camera can be used for the telescope focal plane visualisation.
- A mechanical shutter for providing required exposures in the range 1-20 ms.
- A cylindrical wheel enclosing 4 microscope objectives required for adjusting the detector's pixel size (30 microns) to the speckle size in the Prime Focus of the telescope (2 microns). The microscope objectives with the magnifications 3.7, 8, 20, and 40, provide the following scales in the detector's photocathode plane: 65, 30, 12, and 6 mas per pixel. The fields of view under investigation are 16.6, 7.7, 3.1, and 1.5 arcseconds, correspondingly.
- A holographic concave diffraction grating with the possibility of spectral bandpass selection by using a set of masks (2000 grooves/mm, 300 mm radius of the sphere, 20×20 mm ruled area, 55% efficiency).
- A set of prisms for atmospheric dispersion compensation in the range of zenith distances 0 - 60 degrees.
- A set of neutral density filters needed for bright star observations.
- The detector is a 24 mm single microchannel plate image intensifier fibre-optically coupled to a SIT television tube. A 256×256 pixel image format is used with the readout frame rate 50 Hz. The detector can be used both in analog and photon-counting image mode, depending on the image brightness.

We have estimated the overall efficiency of the instrumental chain, including the atmosphere, the telescope, the SI optics, and the television detector, at 0.4%. This is the mean value averaged over the blaze function of the grating. The low sensitivity due to short exposure time and narrow-bandpass limitation restricts the applicability of SI to bright sources: the typical limiting magnitude is 14-15 for binary star observations under 1.5″ seeing, 1 hour total exposure time, at SNR=10-15 for the central peak in the autocorrelation function of speckle images. It should be noted that the atmospheric seeing degradation is the dominant noise source in speckle interferometry.

At present, for bright pairs up to 7^m and those with a small magnitude difference, we attain an internal standard deviation on a single measurement of 2 mas. This grows to 5 mas for fainter pairs and those with larger magnitude differences. The maximum detectable magnitude difference for a resolved binary is 3.5^m When observing objects with a complex structure - stellar asymmetric shells, emission regions of active ga-

lactic nuclei, etc. - parallel observations of a reference point source are needed.

Currently, two different observation modes are provided for the SI. In one the instrument is operated using an on-line hard-wired digital vector correlator, providing in real time the two-dimensional autocorrelation functions of speckle images. Only objects with a central symmetry can be reconstructed from the autocorrelations. In the other mode the list of photon coordinates is stored on magnetic tape for the later optimum treatment of speckle data, including a variety of image reconstruction algorithms.

The instrument is fully software supported, including preliminary reduction routines, necessary corrections and calibrations.

Reference

G. Courtes: 1962 *Compt. Rendus de l'Acad. Sc.* (France), **254**, No. 10, 1738.

12. POLARIMETER "MINIPOL"

(Dr. V. D. Bychkov, astronomer in charge)

The MINIPOL polarimeter is the guest instrument at the telescope. It has been designed and manufactured at the University of Arizona and made available for use at SAO until 1996 for measurements of linear polarization in the spectral region 3000 - 9000 ÅÅ.

Design: In the collimated beam after the transforming optics and filters two achromatic half-wave plates (fixed and rotated) are placed to provide the modulation. The standard speed of rotation is 1250 rev per min. The beam then passes through a Wollaston prism and Fabry lens which split it on two orthogonal beams (U and Q Stokes parameters) which are recorded by two phototubes. The signal acquisition lasts for the time the polarization plane turns through 30 degrees. There are two changeable thermostats with different multipliers:

1. GaAs photocathode for the spectral band 3000-9000 ÅÅ with an average quantum efficiency of 10%.
2. Multialkali photocathode with a maximum sensitivity in the band 3000-5000 ÅÅ and a quantum efficiency up to 17%. The red limit is at about 7000 Å.

Location: The prime focus of the telescope. Remote control during observations is executed from the control room. A computer IBM PC/AT/386 is used for control and data acquisition.

Observations: In the typical observational mode the standard Johnson photometric system U, B, V, R, I is used. There is a set of filters that provide the Stromgrem system. Object-sky measurements are carried out consecutively. Diaphragm sizes (for the prime focus, in arcseconds) are 2.1, 4.3, 8.6, 12.9, 17.2, 21.5, and 25.8. The duration of one measurement in the standard mode is 60 s (10 integrations of 6 s

each), however it can be changed from one second to a few thousand seconds depending on the problem posed.

The instrument allows one to measure linear polarization of stars up to 19-20^m. For 10 minutes of observations of a 19^m star in the integral light a polarisation measurement accuracy of 0.07% can be reached.

Reference

Impey C.D., Malkan M.A., Tapia S.: 1989, *Astrophys. J.*, **347**, p. 96-111.