S. B. Novikov and A. A. Ovchinnikov. *The Development and Achievement of Methods of Optical Observations with High Angular Resolution at the Observatory on Mt. Maĭdanak.* The efficiency of practically all methods that are now used in astronomy to obtain information about celestial objects at optical wavelengths depends to a greater or lesser degree on the angular resolution which one succeeds in achieving in an observational experiment. The resulting resolution is determined by the atmospheric distortions of the wavefront arriving from the object, by the aberrations and errors of the mechanical motion of the telescope, and by the resolution of the analyzing and light-gathering equipment. Therefore, the work started at the end of the 1960's on building a new astronomical observatory for Moscow State University's P. K. Shternberg State Astronomical Institute touched on a broad range of problems connected with the selection of a site and optimizing all parts of the atmosphere-telescope-light-detector path. The first successful materials that have been obtained are the result of the efforts of many coworkers at the P. K. Shternberg State Astronomical Institute.

The generally recognized concept of an isolated mountaintop[1], in accordance with which the sites for all the new promising observatories of the world have been selected, forms the basis of the site selection for a new observatory. Mt. Maĭdanak, with a height of 2,600 m above sea level in the Uzbek SSR, was selected for the construction of the new observatory from the results of a comparative investigation of a whole series of sites.

The results of astronomical and climatic investigations showed that the amount of observing time is 2,000 hours per year, and the average atmospheric quality of the images is FWHM = 0″.7. The correlation of image quality with the intensity of turbulence and with the wind regime discovered in a comparatively thin (<20m) atmospheric layer next to the ground allowed one to conclude that this layer makes a significant contribution to the formation of optical distortions and to select an optimum height for the telescope tower.[2]

The atmospheric part of the optical path connected with the tower and telescope, in which the inhomogeneities are determined by man-made factors, became a subject of interest to us at the start of the 1970's. Model and full scale aerodynamic and thermal experiments showed that the release of energy in the space under the dome, the accumulation of heat by structures from solar heating, and the radiative cooling of surfaces are the main effects which determine the optical inhomogeneity of this part of the path. A quantitative investigation of the space under the dome of the AZT-11 telescope of the Abastumani Observatory showed[3] that the indicated effects can make the image quality worse by more than a factor of three. Taking these circumstances into account, a number of design decisions aimed at optimizing the temperature regime of the space under the dome and of the dome surface were stipulated in the design of the tower for the AZT-22 telescope.[4] Western astronomers were studying the astroclimate problem at the end of the 1970's and, on the whole, they arrived at similar results.[5]

In the 1980's, after the appearance of the first telescopes on Mt. Maĭdanak, work was started on a more detailed investigation of atmospheric distortions of a wavefront. Investigations of the correlation of the tilts of wavefronts from pairs of stars that are located at different angular distances showed that the size of the zone of isoplanaticity for the wavefront tilts is no less that 40″ on Mt. Maĭdanak. Investigations of the dynamics of wavefront phase distortions showed that the main part of these distortions for a one-meter aperture is determined by low spatial frequencies (up through the third radial mode, inclusive) and by correlation times of no less than 0.1 sec. These results show that, for observations on Mt. Maĭdanak, one can obtain a significant advantage in angular resolution by using adaptive optical systems.[6]

A first-order adaptive system, which compensates in real time for wavefront tilts, has operated since 1981 on telescopes on Mt. Maĭdanak.[7] The system allows one to compensate for wavefront tilts in a band from 0 to 30 Hz with an accuracy $\sigma < 0''.2$ on a telescope of 0.6 m aperture for stars of $8^{\rm m}$ or brighter. The profile of the image of the double star ζ Bootis obtained by using this system is shown in Fig. 1.

The good astroclimate of Mt. Maĭdanak, the optimization of the thermal regime of the space under the dome, and the careful alignment of the optical and mechanical part of the "Zeiss-100" telescope allowed one to achieve a FWHM $\sim 0''.6$ to $0''.7$ image quality in a number of observing programs.

1. Speckle Interferometry of the Asteroid IV Vesta at the 1988 Opposition. Speckle interferometric series of images of Vesta and reference stars were obtained in January 1988 on the 1-meter telescope by means of a speckle camera, in which a UM-92 electro-optical converter serves as the light detector; this is joined to a motion picture camera. Measurement of the power spectra of the speckle images has been done on the coherent-optical processor of the astronomical observatory of Khar'kov State University.

Along with measurements of the effective dimensions of an object from the power spectra that are traditional for speckle interferometry, an attempt has been undertaken in this paper to obtain an image of Vesta at the diffraction limit of the resolution of the telescope by using minimal *a priori* information. The images were synthesized from the speckle interferograms by the "displacement-sum" method. Approximately every fourth frame in the series contains a dif-

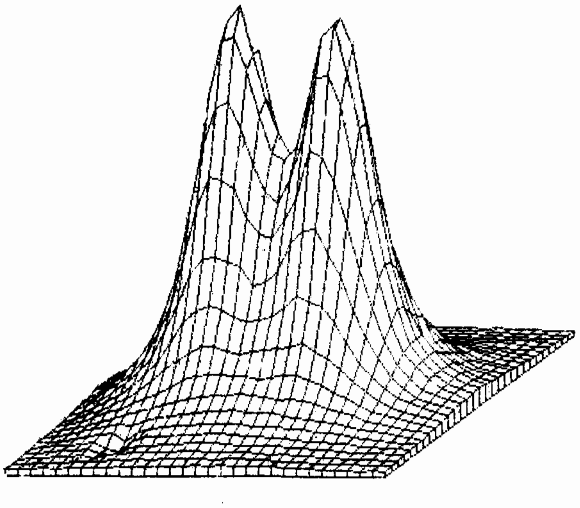

FIG. 1. The photometric profile of the image of the double star ζ Bootis ($m_A = 4.83, m_B = 4.83, \rho = 1''.1$, Sp. A2III). The image has been obtained on a CCD-matrix by using a first order adaptive system.

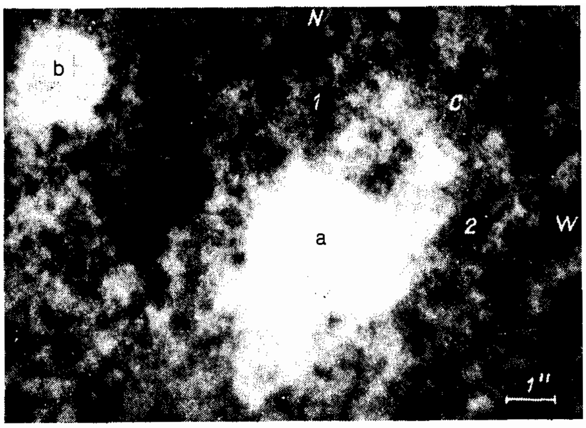

FIG. 2. A photograph of a) nucleus of NGC 1275 and of the object b) in the B spectral range obtained by the superposition of five individual negatives with an initial resolution of FWHM = 0″.7 and with subsequent linear amplitude filtering. The nucleus "*a*" has a finite size of the order of 0″.5 and is elongated in a NW to SE direction. Two systems of jets leave the nucleus in the direction of its elongation; the position angle of one (1) of which (340°) coincides with the position angle of a radio jet, and that of the other (2) jet coincides with the position angle (320°) of a system of high velocity gas satellites.

fraction image of the disk of Vesta which can be distinguished comparatively easily on a random background. The synthesized images of the disk of the asteroid have an effective resolution of FWHM = 0″.13.

An analysis of the images obtained shows that the generally accepted model for Vesta of a regular triaxial ellipsoid is unsatisfactory, and that the actual shape of the asteroid and the albedo formations on it require the use of a more complicated model for interpreting the data.[8]

2. Positional Observations of the Satellites of Mars at the 1988 Opposition. 856 photographic images of Phobos and 937 images of Deimos were obtained on the one-meter telescope at the 1988 opposition of Mars. The mean square error of a single coordinate measurement that has been derived from an analysis of 1,252 measurements was 0″.120. Such accuracy has been attained due to the good astronomical and climatic characteristics of Mt. Maĭdanak and to the original procedure for the positional observations.

During the first observing session made by the "Phobos-2" spacecraft on February 21, 1989, the image of Phobos turned out to be in the center of a narrow field of view. 15 images of the satellite were obtained during the following observing session on February 28, 1989. The mean square closing error calculated from these data was 2 km. This value amounts to 0″.005 in scaling to the average for the 1988 opposition. The difference of a factor of 24 between the accuracy of a single Maĭdanak measurement and the resulting accuracy tells us there are not even any small significant systematic errors.[9]

3. Observations of The Near-Nuclear Region of NGC 1275. A series of photographs of the galaxy NGC 1275 with an average image quality of FWHM = 0″.7 were obtained on the one-meter telescope in January 1989. The imaging was carried out on ORWO ZU-21 emulsion which, in combination with a WK-38 filter, corresponds to the B spectral band.

The NGC 1275 system consists of a central gE galaxy, which has a velocity of 5,200 km/sec, and of a galaxy of irregular shape (a z galaxy with a radial velocity of 8,200 km/sec that is situated in the northwest part of the first galaxy. For a detailed explanation of the questions about the origin and interaction of the galaxies of this system, it is very important to obtain the details of the structure of the nucleus and of the near-nuclear region with high angular resolution.

The results of processing the observations are shown in Fig. 2. A discrepancy of the positions of the optical and radio nuclei has been discovered for the galaxy NGC 1275: the radio nucleus is displaced by 0″.3 to the southeast of the optical one. Here the position angle of the displaced radio source equals ~145°, which almost coincides with the position angle of the radio jet closest to the nucleus, which is observed to the southeast of the nucleus of the galaxy.[10]

4. The Optical Image of MG 1131 (The Einstein Ring). This object, the first example of an almost axially symmetric gravitational lens, was discovered in the radio region on the VLA at $\lambda = 2$ cm and 6 cm. An optical image of this object was obtained on the one-meter telescope on April 5/6, 1989 by means of the "Kvant" panoramic digital detector with a FWHM = 0″.6 image quality. The image structure in the optical region is reminiscent of the radio structure with some difference. Evidently the optical radiation emerges from a region of smaller linear size, which leads to the formation of an image of smaller angular size after the rays pass by the gravitational lens.[11]

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Translated by Frederick R. West