POLARIMETRY AND PHOTOMETRY OF ASTEROID 44 NYSA: COMPARISION OF OPPOSITION EFFECTS IN E-TYPE ASTEROIDS. V. K. Rosenbush[1], V. G. Shevchenko[2], N. N. Kiselev[1], A. V. Sergeev[3], N. M. Shakhovskoy[4], F. P. Velichko[2], S. V. Kolesnikov[5] and N. V. Karpov[3], [1]Main Astronomical Observatory of National Academy of Sciences, Zabolotnoho str. 27, 03680 Kyiv, Ukraine, rosevera@mao.kiev.ua, [2]Institute of Astronomy of Kharkiv National University, Sums'ka str. 35, 61022 Kharkiv, Ukraine, [3]International Center for Astronomical, Medical and Ecological Research, Zabolotnoho str. 27, 03680 Kyiv, Ukraine, [4]Crimean Astrophysical Observatory, 98409 Nauchny, Ukraine, [5]Astronomical Observatory of Odesa National University, Shevchenko Park, 65014 Odesa, Ukraine

Introduction: Since 1989 we have carried out a systematic program of polarimetric and photometric study of opposition effects of selected Solar System bodies, among which are high-albedo E-type asteroids. Asteroid 44 Nysa was selected for polarimetric and photometric observations in 2005 because of a particularly favorable opposition that is a very rare event for this asteroid. The phase curve of brightness for 44 Nysa is rather well studied in the V spectral band [1, 2, 3]. However, similar investigation in other spectral bands has not yet been examined. Therefore we focused our efforts on providing the low-phase angle observations of this asteroid in different spectral bands. In this paper, we present the latest polarimetric and photometric observations of high-albedo asteroid 44 Nysa.

Observations and results: *Polarimetry.* The polarimetric observations of Nysa in the V band were carried out on August 10–14, 2005 when the minimal phase angle reached 0.4°. The one-channel photoele-ctric photometer-polarimeter mounted at the 2.6-m Shain telescope of the Crimean Astrophysical Observatory was used.

The phase-angle curve of polarization (Fig. 1) exhibits a narrow local minimum near backscattering direction with the amplitude ~0.3% centered at the phase angle $\alpha \approx 0.8°$, which is superimposed on a much broader regular negative polarization branch with the minimum at α_{min} = 5.8 ± 0.1° and intrinsic depth P_{min} = –0.30 ± 0.02%.

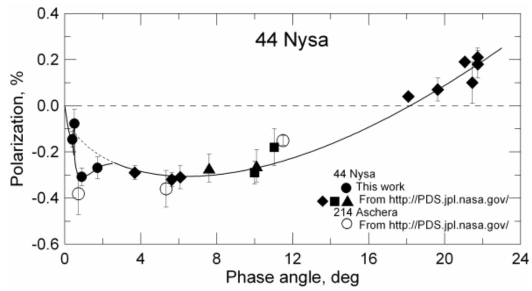

Fig. 1. The phase-angle dependence of polarization for asteroid 44 Nysa. The averaged in the BVRI filters values of polarization for asteroid 214 Ashera are also shown (data are taken from [6]).

Photometry. The photometric observations of asteroid 44 Nysa in the BVRI filters were carried out with two telescopes during 15 nights between August 4–31, 2005 that corresponded the range of phase angles 0.41–7.49°. The 2-m Zeiss telescope equipped with a focal reducer and CCD-detector Photometrics CH260 at the Peak Terskol Observatory (Northern Caucasus) and the 70-cm reflector with the CCD-camera ST-6UV at the Chuguiv Observation Station of the Kharkiv National University were used. Besides, during four nights on August 4–9 the observations were performed with a one-channel photoelectric photometer-polarimeter.

The composite lightcurve of 44 Nysa are constructed. The primary maximum is the brighter of the two one. The lightcurve amplitude is equal to 0.25^m. A comparison of the lightcurves before and after opposition reveals slight changes in their shape. We found that the lightcurve amplitude slight increases with increasing of phase angle, as already indicated earlier [2, 3, 4]. The differences in amplitudes in different apparitions is connected with the considerably inclined axis of rotation of asteroid Nysa to the ecliptic plane (the pole coordinates are λ_o=102°; β_o=50°).

Figure 2 presents the phase-angle dependence of brightness for asteroid 44 Nysa at phase angles 0.41–7.49°. There is a pronounced brightening of the asteroid with decreasing phase angle before opposition (filled symbols) as well as after opposition (open symbols) in all spectral bands. Using all available observational data for asteroid 44 Nysa in different apparitions we obtained the composite phase curves in the B and V filters (the plot in the upper right corner).

For colors the U–B, B–V, V–R, and R–I, a nonlinear systematical trend at low phase angles is observed although these deviations from linear fit are just a little greater than the observational errors. Figure 3 shows in detail the variations of the B–V color index of 44 Nysa with phase angle. In spite of the observed errors, it can be seen that at $\alpha < 2°$ the B–V color systematically increases as the opposition is approached. The amplitude of this rise is only 0.03^m. Nevertheless, this may be some evidence that the opposition brightening of the asteroid in the B and V bands is different, i.e. there is a real dependence of the parameters of the brightness opposition effect, specifically the angular width, on the wavelength.

Using our and all available photometric data for 44 Nysa we found the colors U–B, B–V, V–R, and R–I at zero phase angle and the phase coefficients of colors and compared with corresponding values for asteroid 64 Angelina taken from [5]. In general, the colors and phase coefficients for Nysa differ significantly from those for Angelina. The B–V, V–R, and R–I colors for Nysa are slightly bluish,

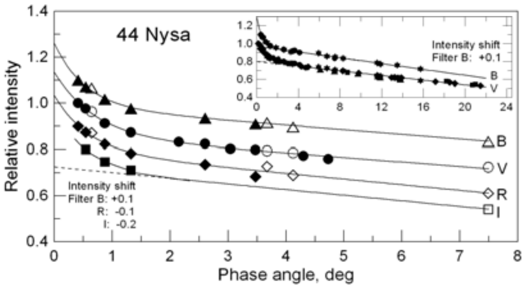

Fig. 2. The phase-angle curves of brightness for asteroid 44 Nysa in the BVRI bands. The composite phase curves of brightness for Nysa in the B and V bands at wide range of phase angles are shown in the upper right corner.

and U–B is distinctly reddish with respect to the corresponding colors of Angelina. Nysa has no reddening with phase angle: the phase coefficients are negative, while they are positive for Angelina, i.e. the phase reddening is clearly evident for Angelina. At the one- to two-sigma level, Nysa displays a small decrease (or becomes bluer) with increasing the phase angle.

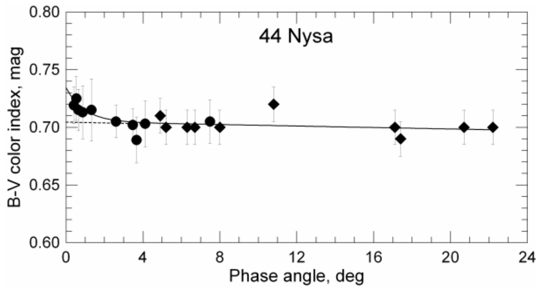

Fig. 3. The phase-angle dependence of the B-V color for asteroid 44 Nysa.

Main conclusions: On the basis of our and available polarimetric and photometric observations of high-albedo E-type asteroids we performed comparative analysis of the properties of their brightness opposition effect (BOE), polarization opposition effect (POE), and negative polarization branch. This led us to the following conclusions:

1. Our photometric data in the BVRI spectral bands show the presence of spike-like BOE for asteroid 44 Nysa that is very close to that discovered by Harris et al. [2] and other E-type asteroids. There are some indications that the angular semi-width of the BOE for 44 Nysa varies with the wavelength. There are no significant differences, within the accuracy of the analysis, between the parameters of the BOE for different E-type asteroids.

2. Our polarimetric observations of asteroid 44 Nysa as well as asteroid 64 Angelina [5] at small phase angles together with observations at larger phase angles (the APD http://pdssbn.astro.umd.edu) revealed that the negative polarization branch has a bimodal shape, namely, a narrow minimum of negative polarization located near opposition (POE), which is superimposed on a broad regular negative polarization branch. The phase angle of the minimum of POE for Nysa is about two times smaller than it is for Angelina. The substantial value of polarization for asteroid 214 Ashera at the same phase angle ~0.8° [6], which is characteristic for Nysa (Fig. 1), may testify to the presence of the POE for one more asteroid of the E-type.

3. Along with extremely pronounced the BOE and POE, Nysa shows another interesting feature. The asteroid gets bluer as its phase angle increases, a finding which was not expected for this object since another E-type asteroid 64 Angelina shows “phase reddening”. It is a direct result of the distinction between spectra of two asteroids having different mineralogy. According to [7], composition of "Nysa-like" E-type asteroids is consistent with silicate mineralogy higher in iron than the mineral enstatite, and composition of "Angelina-like" asteroids is consistent with silicate mineralogy, including a sulfide such as oldhamite. Diversity in the colors and the phase coefficients of colors for two E-type asteroids may suggest comparative difference of the surface compositions, physical states, and albedos.

4. Simultaneous existence of the POE and BOE, comparability of their angular widths, and wavelength dependence of the angular width are in agreement with the predictions of the coherent backscattering theory. Analysis of data allows us to assume that the albedo differences, some differences in OE, especially in the POE, and different phase-angle color trends for E-type asteroids 44 Nysa and 64 Angelina imply different composition and structure of their surfaces.

References: [1] Birch P. V. et al. (1983) *Icarus 54*, 1-12. [2] Harris A. W. et al. (1989) *Icarus 81*, 365-374. [3] Shevchenko V. G. et al. (1992) *Icarus 100*, 295-306. [4] Zappala V. et al. (1990) *Astron. Astrophys. 231*, 548-560. [5] Rosenbush V. K. et al. (2005) *Icarus 178*, 222-234. [6] Belskaya I. N. et al. (2003) *Icarus* 166, 276–284. [7] Clark et al. (2004) *J.Geophys.Res. 109*, E02001.