OBSERVATIONS OF BRIGHTNESS BEHAVIOR OF ASTEROIDS AT LOW PHASE ANGLES.

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Introduction: Continuing of the program for study of brightness behavior at low phase angle we have carried out new CCD-observations of some different type asteroids, devoting more attention for asteroids whose albedos lie in the range of 0.036-0.060 (for eleven objects). As it was pointed out in [1], lowalbedo asteroids show the smallest amplitude of the opposition effect (OE) and the largest dispersion of amplitude OE as compared to other asteroid types. The observations including low phase angles (<1 deg) and linear part of phase dependence have been performed for sixteen asteroids, namely: 76 Freia , 122 Gerda, 176 Iduna, 190 Ismene, 214 Aschera, 218 Bianca, 250 Bettina, 303 Josephina, 309 Fraternitas, 313 Chaldaea, 444 Gyptis, 615 Roswitha, 635 Vundtia, 717 Wisibada, 954 Li and 1279 Uganda. For some asteroids the observations carried out in four BVRI standard bands. Some physical characteristics namely: taxonomic type, albedo, diameter, rotation period, lightcurve amplitude, minimal phase angle, amplitude of OE, determined values of the H and G parameters and color indices B-V, V-R, and R-I of the observed asteroids are presented in the Table.

Results and discussion: The observations of the selected asteroids were carried out in 1999-2007 at the Institute of Astronomy of the Kharkiv Karazin National University (70 cm reflector) jointly with the Simeiz Department of the Crimean Astrophysical Observatory (1 m reflector), using ST-6, IMG-1024 and IMG 47-10 CCD-cameras. The accuracy of magnitudes for the individual nights is not worse than 0.02 mag. The accuracy of the color indices for the individual night is equal to 0.02 – 0.03 mag. As a result of series of photometric observations we have obtained the magnitude- phase relations for ten asteroids and the observations of other objects are in preparation. The magnitudes we adduced to main maximum of lightcurve to decrease an influence of lightcurve amplitude increasing with phase angle.

We have determined new and improved available values of the rotation periods of the observed asteroids and obtained the lightcurve amplitudes for some of them. The new more accurately determined values of the absolute magnitudes can be used for more precise estimation of albedos and/or diameters of these asteroids. The figures show phase dependence of brightness for some asteroids in four BVRI bands: 190 Ismene, 214 Aschera, 303 Josephina, and 615 Roswitha.

Magnitude-phase relation of asteroid 190 Ismene shows the very small amplitude of OE among lowalbedo asteroids. Values of amplitude of OE in four BVRI bands are close between themselves. It is possible that only the shadowhiding mechanism forms opposition brightness for this asteroid. Our observations allowed also to icrease the set of magnitude-phase relations for lowalbedo asteroids. We calculated a mean value of amplitude OE in V band for six lowalbedo asteroids from our set (excluding 190 Ismene and 444 Gyptis) that is equal to 0.16 mag and compared with that obtained by [1] for C-type asteroids. These amplitudes of OE are equally and we can suppose that the mean amplitude of OE maybe close to 0.16 mag for dark asteroids. The differences in the OE amplitudes of some asteroids from the mean value can be due to their individual surface features.

The magnitude- phase relations of E-type asteroid 214 Aschera shows a linear behavior of brightness up to phase angle about 1 deg and the sharp nonlinear increasing begins only at phase angles less than 1 deg. That is different from other E-asteroids 44 Nysa and 64 Angelina for which the spike- effect begins at phase angles less than 2 deg [2]. Amplitude of OE is equal to 0.10 mag that is also different from amplitudes of OE of 44 Nysa (0.14 mag) and 64 Angelina (0.16 mag). The amplitudes of OE of this asteroid in other spectral bands are close to a value in V band with accuracy to observation errors. We did not search any anomalies in behavior of color index B-V with phase angle in range of opposition effect.

The asteroid 1279 Uganda shows brightness behavior in range of opposition effect as E-type asteroids. But the spectrum in range of 0.45 – 0.99 mkm [3] is close to S-type with maximum on 0.77 mkm and extinction band centered near 0.9 mkm. It is necessary to perform the new observations of this asteroid for detail study of its magnitude- phase relation.

Conclusion: As a result of our program in this stage we carried out observations sixteen asteroids of different types and obtained magnitude- phase relations including low phase angles for ten asteroids. We detected very small opposition effect amplitude for dark asteroid 190 Ismene and beginning of OE at 1 deg for E- type asteroid 214 Aschera. We will plan to continue the program for study of brightness behavior at low phase angles and will carry out the new observations for distant objects.

References: [1] Belskaya I. N., and Shevchenko V. G. (2000) *Icarus 146*, 490-499. [2] Harris A. W., et al. (1989) *Icarus 81*, 365-374. [3] Xu S., et al. (1995) *Icarus 115*, 1-35. [4] Tholen D. .J. (1989) *In Asteroids II (Eds. Binzel, Gehrels, Matthews).* 1139-1150. [5] Bus S. J., Binzel R. P. (2002) *Icarus 158*, 146-177. [6] Lazzaro D., et al. (2004) *Icarus 172*, 179-220. [7] Tedesco E. F., et al. (2002) *Astron. J. 123*, 1056-1085.

Table

Asteroid	Type	p_V[7]	D[7] km	P hours	Amp mag	Min. angle	Amp. OE mag	H mag	G	B-V mag	V-R mag	R-I mag
76 Freia	P[4],X[5]	0.036	183.7	9.973	0.15	0.06	0.16	7.90	0.17			
122 Gerda	PT[4]	0.19	81.7	10.688	0.12	0.32				0.91	0.49	-
176 Iduna	G[4],	0.083	121.0	11.287	0.30	0.15				0.68	0.33	0.34
190 Ismene	P[4],X[5]	0.047	119.1	6.519	0.10	0.30	0.03	7.73	0.29	0.66	0.40	0.40
214 Aschera	E[4]	0.52	23.2	6.834	0.23	0.13	0.10	9.41	0.44	0.71	0.41	0.37
218 Bianca	S[4]	0.18	60.6	6.337	0.18	0.31				0.84	0.44	0.38
250 Bettina	M[4]	0.26	79.8	5.054	0.35	0.30	0.31	7.03	0.17	-	-	-
303 Josephina	Ch[6]	0.059	99.3	12.497	0.15	0.17	0.17	8.94	0.19	0.70	0.42	0.41
309 Fraternitas	X [6]	0.060	49.3	11.205	0.10	0.25	0.13	10.59	0.29	0.73	0.37	0.41
313 Chaldaea	C[4]	0.052	96.3	8.392	0.18	0.14	0.18	8.80	0.15	0.72	0.34	0.35
444 Gyptis	C[4],C[5]	0.049	163.1	6.215	0.15	0.78	-	7.85	0.22	0.69	0.41	-
615 Roswitha	CX[4]	0.055	47.9	4.422	0.11	0.13	0.16	10.27	0.13	0.69	0.43	0.37
635 Vundtia	C[4]	0.046	98.2	5.894	0.15	0.16	-			0.74	0.30	0.41
717 Wisibada	DX[4]	0.067	31.0	-	0.05	0.20	-			0.68	0.44	0.44
954 Li	Cb [6]	0.056	58.0	7.207	0.11	0.03	0.13	10.17	0.22	-	-	-
1279 Uganda	S	-	9.0	long	0.04	0.51	0.13	12.44	0.64	-	-	-