

LABORATORY STUDY OF SOME OPPOSITION EFFECT FEATURES. V. A. Psaryov, I. N. Belskaya, Yu. G. Shkuratov, A. A. Ovcharenko (Institute of Astronomy, Kharkiv National University, Sum'ska 35, Kharkiv, 61022 Ukraine, irina@astron.kharkov.ua)

**Introduction:** One of the important parameters usually used to characterize small Solar system bodies is the geometric albedo of their surfaces. It is calculated using body's brightness at zero phase angle, which cannot be reachable in the ground-based observation. An extrapolation of the measured brightness to zero phase angle introduce additional errors in albedo determination. To investigate the brightness behaviors at very small phase angles we carried out laboratory measurements of samples of diverse composition and grain size. Moreover analysis of correlation between opposition spike slope and reflectance of lightscattering surfaces has been carried out. It has been shown that relative brightness phase slope  $G$  grows from 6%/degrees to 110%/degrees and higher, when albedo changes from 3% до 100%. The width of opposition spike depends mainly on the characteristic size of sample grains. For small-grain samples of ultra-disperse quartz (several tens nm) the width of opposition zone decreases to  $0.1^\circ$  or less.

**Measurements:** Measurements were made with the laboratory photometer permitting reach a minimal phase angle as small as  $0.005^\circ$ . The equipment and techniques of laboratory samples preparing and measuring were traditional [1,2]. Measurements in the narrow red spectral band ( $\lambda = 0.67 \mu\text{m}$ ) were made in two phase angle ranges ( $0.005^\circ\text{--}1.5^\circ$  and  $0.2^\circ\text{--}17^\circ$ ). Structure and average grain sizes were estimated with samples microphotographs. Reflectance (albedo) of samples was determined as a ratio of backscattered light intensity from a sample to the intensity from Halon standard [3]. The estimates were provided for five phase angles:  $0.008^\circ$ ;  $0.04^\circ$ ;  $0.53^\circ$ ;  $1.06^\circ$ ;  $1.56^\circ$ .

**Analysis:** Photometric phase curves of laboratory samples were constructed after some indispensable data reductions. The width of opposition effect was estimated for each sample as well as brightness phase slope  $G$ . Brightness phase slope  $G$  was used as a quantitative parameter:

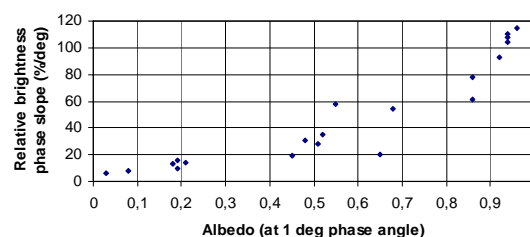
$$G = (I(\alpha_{\min}) - I(\alpha_{\max})) / I(\alpha_{\max}) \Delta\alpha,$$

where  $\Delta\alpha = \alpha_{\max} - \alpha_{\min}$  is a width of the opposition effect range,  $\alpha_{\max}$  is the phase angle of the beginning of nonlinear in log scale growth of backscattered light flux. The angle  $\alpha_{\min} = 0.005^\circ$  is the least phase angle which is limited by our device construction.

Results of the analysis have been presented in table and figure. For the diagram "albedo-phase slope" we use data of albedo at  $1^\circ$  phase angle.

0.19	< 20	10	iron grains
0.19	< 10	16	iron grains
0.21	< 1	14	dry blue water-color crust
0.45	$\leq 1$	19	mixture of soot (3%) + chalk
0.48	<90	31	meteorite "Saratov"
0.51	<3	28	Fly ash
0.52	1-50	35	Crushed baked brick
0.55	5-20	58	Mortar (lime building mixture)
0.65	< 1	20	Dry red water-color crust
0.68	<65	54	Olivine
0.86	<25	61	Orange dye
0.86	<3	78	Sulfur crystals
0.92	0.01	93	Ultra-disperse SiO2
0.94	<1	108	MgO screen
0.94	?	110	Milky glass
0.94	30	104	Al2O3 crystals
0.96	30	115	Iron scales

diagram "albedo - opposition spike slope"



**Results and discussion:** There are some main consequences of the obtained laboratory data analysis:

1) The brightness phase slope varies significantly at very small phase angles (up to 120 %/deg). It can considerably effect estimations of a surface brightness at zero phase angle for small Solar system bodies by extrapolation of large phase angle observations.

2) Our results show the following features: the phase slopes  $G$  in the vicinity of the smallest phase angles increase from 6 %/deg (for darkest samples) up to 115 %/deg (for brightest samples). A correlation between relative brightness phase slope and albedo was found. For majority of samples we can affirm: the higher the surface albedo, the more prominent the opposition spike. This spike is related to the coherent backscatter enhancement effect that is adequately described and studied [4].

The width of the opposition effect region decreases from  $12^\circ\text{--}16^\circ$  down to  $0.2^\circ\text{--}0.1^\circ$  as a function of size and albedo of lightscattering surface grains. As a rule the smallest and the brightest grains demonstrate the narrowest opposition spike (under  $0.1^\circ$  or less).

**References:** [1]V. Psarev et al. (2007) JQSRT, 106, 455-463. [2]A. Ovcharenko et al. (2006) JQSRT, 101, 462-470. [3]V. Weidner, J. Hsia, (1981), J. Opt. Soc., 71. 856-861. [4] Shkuratov Yu. et al. (2004) Photopolarimetry in Remote Sensing., NATO Sci. Ser., London;191-208.

Albedo ( $1^\circ$ )	sample grains size, ( $\mu\text{m}$ )	brightness phase slope (%/deg)	Lightscattering surface
0.03	$\leq 1$	6	Soot
0.08	$\leq 1$	8	mixture of soot (25%) + chalk
0.18	$\leq 1$	13	mixture of soot (10%) + chalk