POLARIMETRIC OBSERVATIONS OF JUPITER'S POLAR REGIONS. O. S. Shalygina[1], S. V. Zaitsev[2], V. V. Korokhin[1], N. N. Kiselev[2], E. V. Shalygin[1], Yu. I. Velikodsky[1]. [1]Institute of Astronomy, Kharkiv National University, Sumskaya Ul., 35, Kharkiv, 61022, Ukraine. E-mail: dslpp@astron.kharkov.ua, [2]Main Astronomical Observatory National Academy of Sciences of Ukraine, Akademika Zabolotnoho St., 27, Kyiv, 03680, Ukraine. E-mail: kiselevnn@yandex.ru

Introduction: Remote sensing methods, first of all, photometry and polarimetry are effective for studying the planet atmospheres. The main mechanisms of polarization in planetary atmospheres are the light scattering on electrons, atoms, molecules and aerosols. Light reflected by Jovian atmosphere is polarized in various atmosphere layers. Studying the distribution of polarization parameters over the planet disk and analysis of their temporal changes can promote to obtain new information about physical conditions in Jupiter's atmosphere.

As known, ground-based and cosmic polarimetric observations of Jupiter in the visual wavelength domain show the linear polarization increasing with latitude. Even at very small orbital phase angle polarization degree increases from zero in equatorial regions up to 7-8% in polar regions (e.g. [1-5]). Strong spectral dependence of linear polarization degree *P* at polar regions (with turn of the polarization plane at λ=750 nm) [6] are observed. Also it is known, that there is a north-south asymmetry of linear polarization at Jupiter's polar region [1-5].

Polarization plane generally has radial orientation on Jupiter's disk [4, 5, 7] that is obvious to be caused by multiple scattering in atmosphere. It was considered that for the polar regions of planet the polarization is always positive. But there are the data showing that at very small phase angles (less then 1°) the sign of polarization changes [8].

This work deals with checking and explanation of these observational facts.

Polarimetric observations of Jupiter: Regular photopolarimetric observations of Jupiter are carried out at Institute of Astronomy of Kharkiv University since 1981. These observations were performed by different persons and using different technique [9]: from photoelectronic multiplier (1981-1986) to 1-dimension CCD (1989-1997) and CCD-matrix (1998-2004). Main task of this unique long-term series of observation is study of the seasonal variations of Jupiter's polarization.

New observations continuing this work are carried out by Velikodsky Yu. I. and Opanasenko N. V. at the 50-cm telescope at Maidanak Observatory (Uzbekistan) using CMOS photocamera Canon EOS 350D (2006, August), and by Korokhin V.V., Shalygina O.S., Shalygin E.V. and Velikodsky Yu.I. at the 70-cm telescope of the Grakovo Observatory (Ukraine) using CCD-matrix (2007, June). The peculiarity of processing the data obtained by CCD-matrix is discussed. Specially for studying the behavior of polarization plane, Kiselev N.N., Velichko F.P. and Zaitsev S.V. in 2007, June have performed observations of Jupiter in the V filter at the 70-cm telescope of the Grakovo Observatory using a photoelectric polarimeter.

Seasonal variations of the north-south asymmetry of polarization: On the basis of photopolarimetric observations of Jupiter during 1981-2004, seasonal variations of north-south asymmetry (P_N-P_S) of linear polarization in polar regions and correlation between P_N-P_S and insolation have been found (see our previous works [2, 10]). Parameter of asymmetry P_N-P_S is defined as a difference between values of linear polarization degree on north and south at the latitudes 60° at the central meridian. P_N-P_S data are well organized if plotted in accordance with Jupiter's orbital location and have good correlation with insolation [2]. We are continuing our studying and present new data of

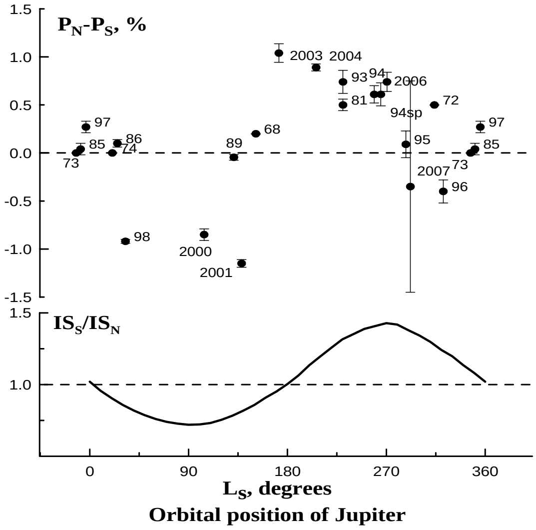

Fig. 1. Dependence of North-South asymmetry of polarization P_N-P_S on planetocentric orbital longitude of the Sun Ls (upper plot). Points correspond to the observations data. Bars are errors of mean. Solid line is theoretically calculated asymmetry of insolation of polar regions at latitudes 60°.

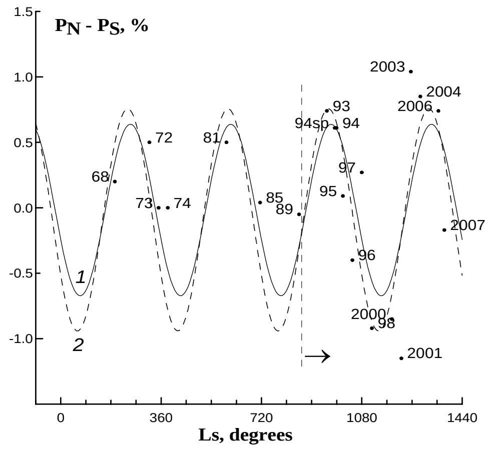

Fig. 2. Approximation of P_N-P_S dependence on Ls (for continuous Ls axis) by different functions: (1) sinusoid calculated over all observational data, (2) sinusoid calculated only using CCD observations.

observations (2006, 2007 in Fig. 1 and Fig. 2) which confirm our previously conclusions about nature of variations of Jupiter's polarization at polar regions

We assume that variations of insolation (through temperature change) are the principal cause of the seasonal variations of polarization [10]. Jupiter has a small axial tilt (about 3 degrees). However, the orbital eccentricity about 0.05 results in 20% variation in the dilution factor $1/r^2$ values due to the change of the distance r from the Sun. Besides, the perihelion and maximum of Jovian latitude of the Sun are almost coinciding in time. These factors produce significant seasonal fluctuations of the incident solar radiation and result in north-south asymmetry in insolation and temperature. Thus, seasonal variations of stratospheric temperature at the polar regions in Jupiter's atmosphere are ±25 K [11, 12].

Observational data and theoretical modeling indicate the presence of thin aerosol layer in stratosphere on p ~ 20 mbar pressure level with greatest abundance at polar regions (e.g. [13, 14]). This haze conceivably consists of benzene and polycyclic aromatic hydrocarbons (PAH) like naphthalene, phenanthrene, pyrene [14]. Particles of the least evaporating substances may be solid and formed by homogeneous nucleation and are the centers of condensation of lot evaporating substances [10]. Model calculations [6] estimate the mean radius of haze particles r=1-1.5 μm. Most likely, aerosols of this haze are in unstable state and temperature changing may influence on generation/dissociation of particles. Really, temperature variations in Jovian stratosphere have strong influence on PAH condensation [8]. We have show in [15] that main contribu-tion in registered polarization at zero phase angle in Jovian polar regions can be produced by the light reflected from underlying surface (clouds) and then scattered on aerosol haze particles. So, aerosol haze plays significant role in polarization of light at polar atmosphere of Jupiter.

Behavior of polarization plane for polar region of Jupiter at small phase angles: We conventionally call the linear polarization degree "positive" if polarization plane θ is oriented perpendicularly to the scattering plane, and "negative" if it coincides with the scattering plane. It means the positive polarization if an angle related to the scattering plane θ_r=θ-(Sca-90) close to 0° and the negative polarization if θ_r close to 90°.

Since Lyot's observations [4], many authors considered that polarization of Jupiter's north and south polar regions was positive [1, 3]. However, Chigladze has found that at very small phase angles (less then 1°) the angle θ_r changes from 0° to 90°, and polarization becomes negative [8]. During the observations in 2007, June we examined this effect. Polarimetric observations of areas close to Jupiter's poles were carried out at phase angles of -0.13° ÷ 0.62°. We present results of these observations which confirm the change sign of polarization near Jupiter's poles at very small phase angles (Fig. 3). Mechanism of the phenomena and probable influence of aerosol haze are discussed.

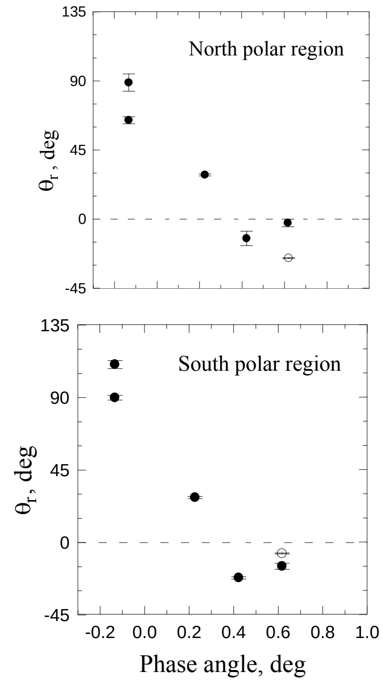

Fig. 3. Phase dependence of angle between polarization plane and perpendicular to scattering plane for north and south Jupiter polar regions. Filled circles – data obtained by 5 arcsec aperture, open circles - data obtained by 1 arcsec aperture. Negative and positive polarization are observed close to zero phase angle and near 0.5° respectively.

Conclusion: (1) New polarimetric data (2006, 2007) confirm an anticorrelation between polarization asymmetry and insolation of Jupiter's atmosphere. (2) Observations show change sign of polarization near Jupiter's poles at very small phase angles.

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