CAUSES OF OBSERVED LONG-PERIOD VARIATIONS OF THE POLARIZATION AT POLAR REGIONS OF JUPITER. O. S. Shalygina, V. V. Korokhin, L. A. Akimov, O. M. Starodubtseva, G. P. Marchenko, E. V. Shalygin, and Yu. I. Velikodsky. Astronomical Institute of Kharkov University, Sumskaya Ul., 35, Kharkov, 61022, Ukraine. E-mail: dslpp@astron.kharkov.ua

Abstract: Data of observations (1981-1998) have been reprocessed using new improved technique. The data from other observers have been added to the analysis. Anticorrelation between asymmetry of polarization and insolation has been found. The mechanism of influence of seasons' changing (through temperature variations) on north-south asymmetry of polarization formation has been proposed. Also a possibility of existence of influence of solar cosmic rays flux on polarization value is noted.

Seasonal variations of the north-south asymmetry of polarization: Earlier on the basis of of 23-year (1981-2004) observational period we have found the North-South asymmetry P_N-P_S of linear polarization degree P and its seasonal variations [1] (parameter of asymmetry P_N-P_S is 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 there is some relation between variations of polarization and insolation [1].

In this work we are continuing our studying the long-period variations of parameter P_N-P_S,: 1) our new observations are used; 2) our old data (1981-1998) have been reprocessed using new improved technique; 3) Hall and Riley data (1971-1974) (ultraviolet, visual spectrum range) [2] are involved for analysis.

New variant of P-asymmetry (on top) and intensity ratio (below) dependences on Jupiter's orbital location are presented in the fig.1.

Investigation of nature of periodicity: To investigate the nature of the dependence the approximations have been made using different functions. The best approximation was shown by one-periodic function (correlation coefficient is equal to 0.57. For comparison, correlation coefficients: for line approximation is 0.23; for two-periodic function, which had been used in previous publications [1], is 0.31). Hall and Riley data [2] have a good agreement with our data.

As one can see (fig.1) there is anticorrelation of long-term variations of polarization and insolation.

Causes of seasonal variations: Thus, assumption about existence of the *seasonal variations* of north-south asymmetry of polarization, proposed in our previous papers, is correct. Moreover it is possible to assume that variations of insolation are the principal cause of the seasonal variations of polarization.

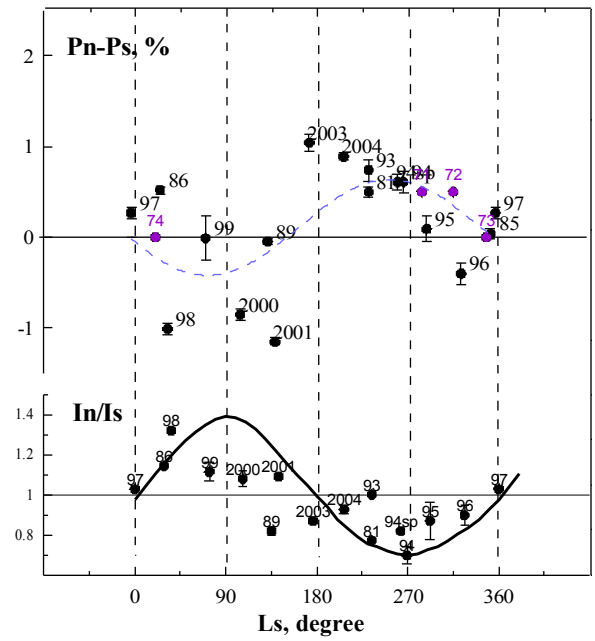

Fig.1. *Dependence of North-South asymmetry of polarization P_N-P_S (upper plot) and intensity ratio I_N/I_S (bottom plot) on planetocentrical orbital longitude of the Sun. Points are the data obtained from our observations (in blue light). Violet points – Hall and Riley's data 1971-74 [2] (ultraviolet, visual spectrum range). Dotted blue curve is approximating curve:*

$$Y = 0.53\sin\left(L_S - 165.7^\circ\right) + 0.11,$$

black curve is theoretically calculated asymmetry of insolation of polar regions

How seasonal variations of insolation may result in seasonal variations of polarization? We suppose that by way of variations of temperature.

Jupiter has a small axial tilt (about 3°). However, the orbital eccentricity of 0.05 results in 20 % variation in the dilution factor $1/r^2$ values due to the changing 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 are causing the great seasonal fluctuations of the incident solar radiation and causing the north-south asymmetry in insolation and temperature. As a result, seasonal variations of temperature are appear (mean temperature in Jupiter's atmosphere may vary in the range ±25 K, fig.2) [3, 4].

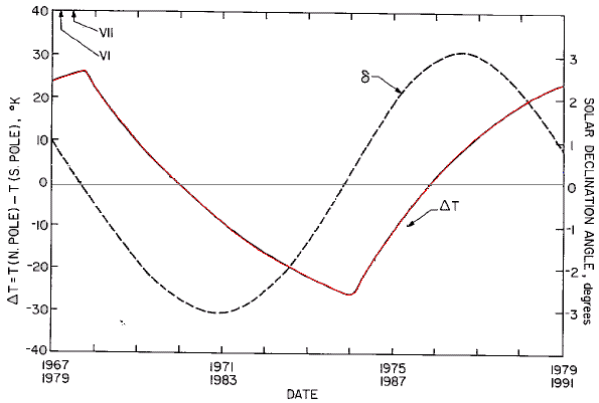

Fig. 2. *Model calculations of seasonal variations of stratospheric temperature difference at the polar regions of Jupiter (T_N-Ts) (10 mbar altitude) [4]*

Which agent in Jupiter's atmosphere may be sensitive to changes of temperature? Data of polarimetrical observations in visible, infrared and ultraviolet range are sensitive to presence of stratospheric aerosols' haze in Jovian atmosphere. This haze is located at the top pressure levels in the range from a few mbar to a few tenths of mbar, with much more abundance at high latitudes (latitudes greater than 40°-50°) [1, 5]. Aerosols of this haze may be in unstable state and temperature changing may influence on generation/dissociation of particles.

Anticorrelation of polarization asymmetry and insolation may be caused by following mechanism. Because of essential heating of thin stratospheric aerosol layer (in Jovian summer) the substance of haze may leave state of supersaturated vapor. Condensation become slower, concentration of particles decreases and polarization also decreases (as known, the rate of condensation decreases when temperature increases).

Thus, possible scenario of appearance of north-south asymmetry of polarization is: seasonal variations of insolation -> seasonal variations of temperature -> changes of activity of aerosol generation -> aerosol concentration changes -> polarization changes -> changes of north-south asymmetry of linear polarization.

Influence of solar activity on polarization changes: We investigated influence of solar wind, solar cosmic rays and X-rays on polarization values. We have found that some correlation between P_N-P_S and solar cosmic rays flux (protons, E>10 Mev) may exist (fig.3). Let's pay attention to group of points, which marked on fig.3 (1998, 2000, 2001). These points greatly deviate just as on fig 1. Maybe, extremely large flux of high-energy protons in this years (which has been registered) had influenced on increasing of polarization values.

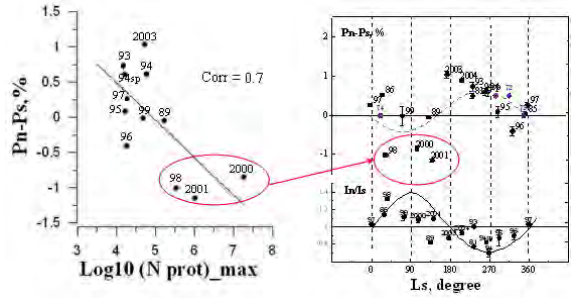

Fig.3. *Comparison of solar cosmic rays flux (amount of high energy protons, GOES-10 data) with polarization asymmetry(left) and fig.1 (right)*

Atmosphere temperature may be changed with increasing of amount of high-energy protons in Jupiter's atmosphere, as it happens at the Earth's stratosphere [6]. These changes may influence on aerosol generation processes and be a cause of polarization asymmetry. Protons of high energy may also be an additional centers of condensations and thus may influence on aerosol concentrations and consequently on polarization.

Conclusion:

1. There is a correlation between polarization asymmetry and insolation.
2. Seasonal variations of insolations (through variations of temperature) is the principal cause of variations of north-south asymmetry of polarization.
3. Probably, there is some influence of solar cosmic rays flux (protons, E>10 Mev) on polarization value.

On our site you can find more details of this work (http://www.univer.kharkov.ua/astron/dslpp/jup/).

References: [1] Starodubtseva O. M., Akimov L. A., Korokhin V. V. (2002) *Icarus*. 157, No2, 419-425. [2] Hall J.S. and Riley L.A. (1974) (T. Gehrels. Ed.), *University of Arizona Press*, Tucson, Arizona. 593-598. [3] Beebe R.F., Suggs R.M., Little T. (1986) *Icarus*. 66, 359-365. [4] Caldwell J, Cess R., Carlson B. (1979) *The Astrophysical Journal*. 234, 155-158 [5] West R. A. (1988) *Icarus*. 75, 381-398 [6] Xanthakis J. et al. (1980) *Πρακτικα τησ ακαδημιασ αθηνων*. 55, 362-371.