Jupiter's Atmosphere

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As is known, ground-based and cosmic polarimetric observations of Jupiter in the visual spectrum range show increasing of linear polarization with latitude (even at zero orbital phase angle). Polarization degree increases from zero (equatorial regions) up to 7-8% (polar regions). Also it is known, that there is a north-south asymmetry of linear polarization at Jupiter [e.g. Gehrels et al., Astron. J. 1969. 74, 190].

To explain these observational facts, we started regular polarimetric observations of Jupiter with the 0.7 m telescope AZT-8 of our observatory. Figure 21 shows an image of Jupiter acquired in blue filter; Figures 22 and 23 present polarization degree and angle of polarization plane distributions, respectively. One can clearly see the polar effect.

On the basis of our earlier observations near oppositions during 1981-1999, seasonal variations of north-south asymmetry (P_N-P_S) of linear polarization P in polar regions and some relation between P_N-P_S and insolation have been found. The 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. Addition of new observational data (2000-2004) and joint analysis with previous data allowed us to find anticorrelation between asymmetry of Jupiter's polarization and insolation (see Fig. 24). Correlation coefficient between P_N-P_S and I_N/I_S is -0.7, i.e. there is significant anticorrelation. Thus, we can speak about seasonal variations of polarization.

We assume that variations of insolation (through temperature changing) are the principal cause of the seasonal variations of polarization. Jupiter has a small axial tilt (about 3 degrees). However, the orbital eccentricity about 0.05 results in 20% variations of Jupiter surface illumination 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 seasonal fluctuations of the incident solar radiation and result in north-south asymmetry in insolation and temperature. Seasonal variations of stratospheric temperature at the polar regions in Jupiter's atmosphere are ±25°K.

Observational data and theoretical modeling indicate the presence of thin aerosol layer in stratosphere on p ~ 20 mbar pressure level with greatest abundance at the polar regions; this haze conceivably consists of benzene and polycyclic aromatic hydrocarbons (PAH) like naphthalene, phenanthrene, pyrene [Friedson et al. Icarus 2002. 158, 389]. Most likely, aerosols of this haze are in unstable state and temperature changing may influence on generation/dissociation of particles.

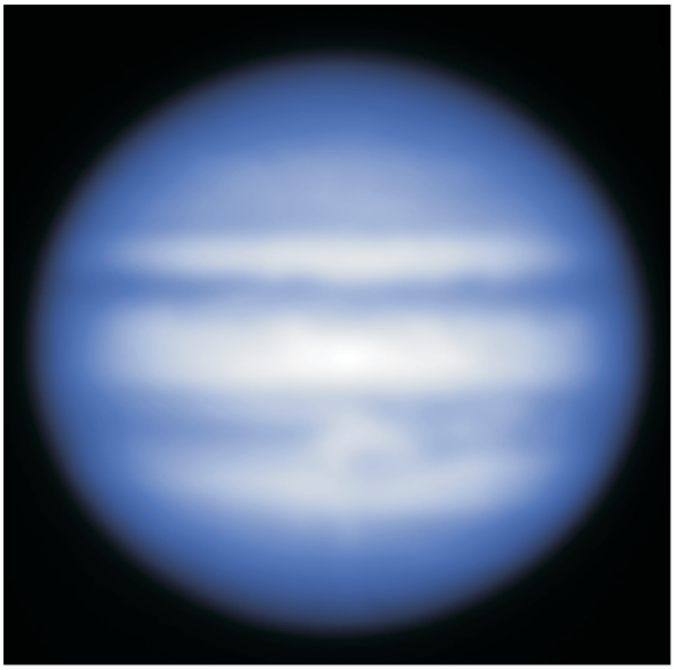

Figure 21. Image of Jupiter at λ = 456 nm obtained 1998.09.10 in opposition with telescope AZT-8 of Chuguev observational station of Institute of Astronomy, Kharkiv National University.

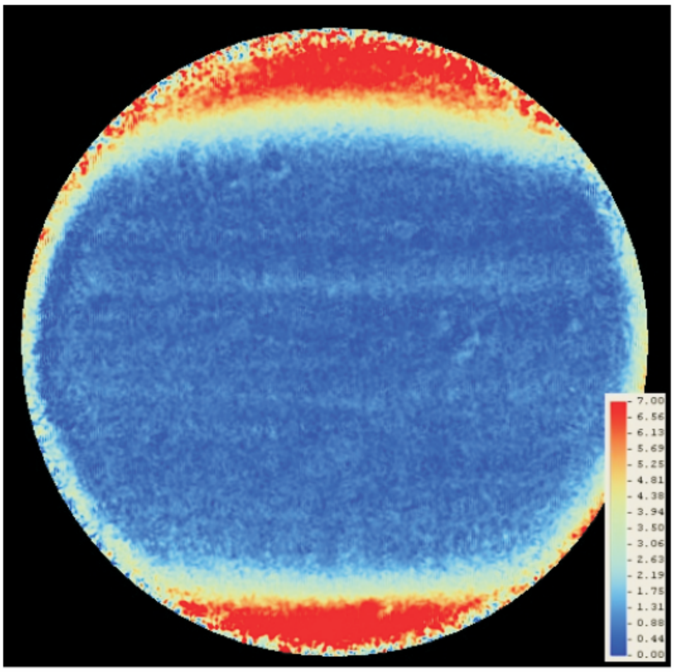

Figure 22. Distribution over Jupiter's disk of linear polarization degree in opposition at λ = 456 nm

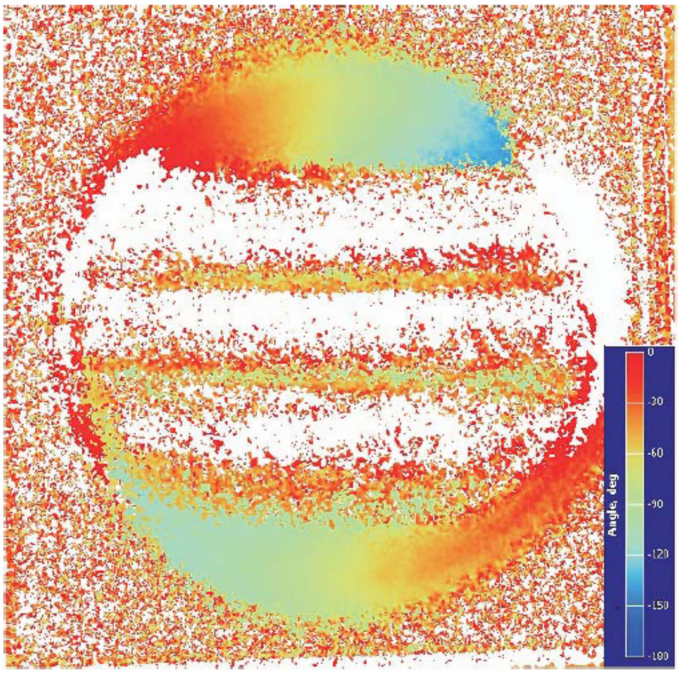

Figure 23. Distribution over Jupiter's disk of angle of polarization plane in opposition at λ = 456 nm

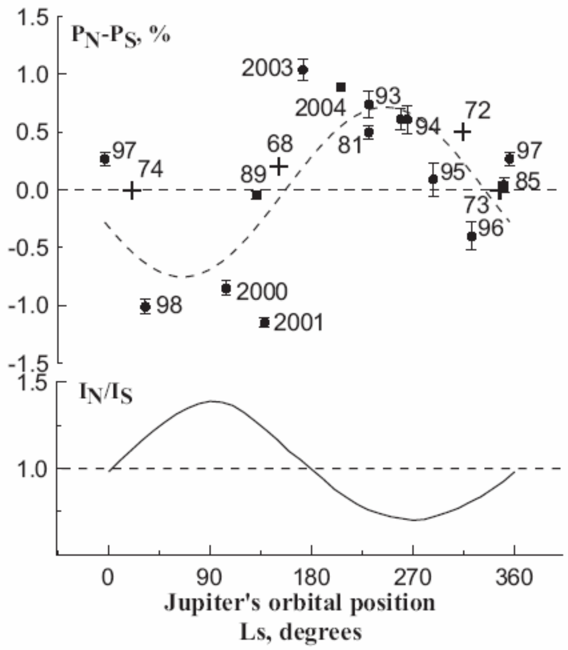

Figure 24. Dependence of North-South asymmetry of P_N-P_S on planetocentric orbital longitude of the Sun Ls (upper plot). Dashed line is approximating curve: P_N-P_S= -0.67sin(L_S+0.32)+0.05. Solid line is theoretically calculated asymmetry of insolation of polar regions (intensity ratio I_N/I_S at latitudes 60°)

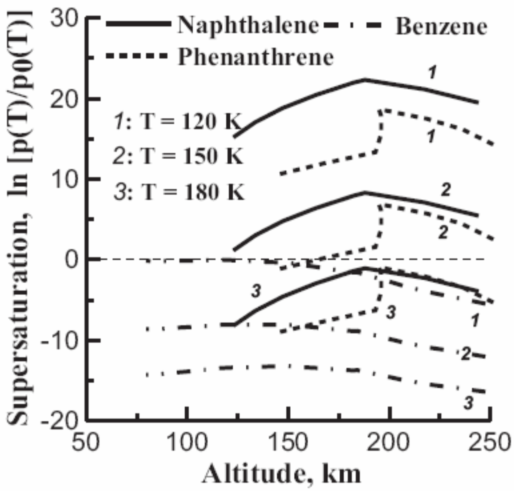

Figure 25. Altitude distributions of PAH supersaturation for different Jovian temperatures

The P_N-P_S values and its anticorrelation with insolation may be caused by seasonal variations of insolation and temperature. Our estimates show (Fig. 25) that temperature changes have strong effect on processes of homogeneous nucleation in Jupiter's stratosphere: benzene does not condensate at T>120°K (negative supersaturation means vapor undersaturation), whereas probability of naphthalene and phenanthrene nucleation at T=120°K and T=150°K is considerable. Average temperature in polar regions of Jovian stratosphere is about 150°K. This temperature is lower than triple points of naphthalene and benzene (359°K and 278°K, respectively), so they may produce crystal nucleus from gaseous phase. Particles of the evaporating naphthalene and phenanthrene substances may be formed by homogeneous nucleation and are the centers of condensation of different evaporating substances.

Also we note probable influence of solar cosmic rays (protons, E>10 Mev) flux on concentration of aerosol haze particles through series of chemical reactions that produce source material for aerosol formation.