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Properties of polar aerosol haze in Jupiter's stratosphere

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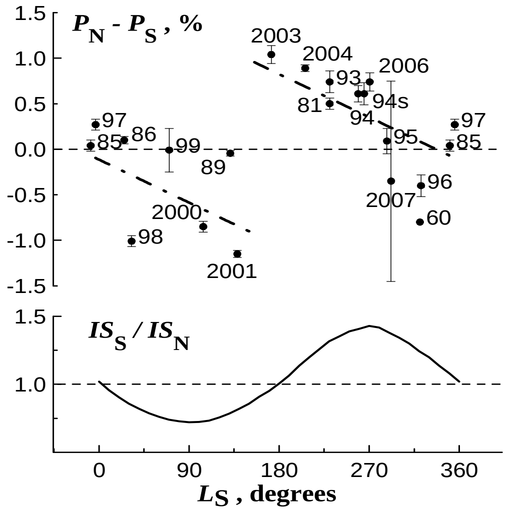
Polarimetric observations of Jupiter

As known, ground-based and cosmic polarimetric observations of Jupiter in visual spectrum range show the dependence of linear polarization degree P on phase angle and polarization increasing with latitude. Even at zero orbital phase angle polarization degree increases from zero (equatorial regions) to 7–8% (polar regions). Polarization plane has radial orientation. Also it is known, that there is a north-south asymmetry of linear polarization at Jupiter [1–3]. To explain these observational facts, we have started regular polarimetric observations of Jupiter in 1981. On the basis of these observations near oppositions in blue light during 1981–2007, seasonal variations of north-south asymmetry (P_N–P_S) of linear polarization P in polar regions and inverse relationship between P_N–P_S and insolation have been found [1]. 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.

North-south asymmetry of linear polarization

P_N–P_S data are well organized if plotted in accordance with Jupiter's orbital location, and there is some relation between P_N–P_S and insolation [1]. We are continuing our studying: our new ground-based observations were used; our previous data (1981–1998) have been reprocessed using new improved technique; Hall and Riley data (1960–1974) are involved for analysis [3]. Dependence of P-asymmetry on Jupiter's orbital location with new data is presented in the Fig.1. It is shown that periodic jump-like dependence of polarization parameter P_N–P_S on orbital location take place. One can conclude that there is a *seasonal* inverse dependence of polarization on insolation (polarization is higher in colder hemisphere) that has jump-like nature.



Orbital position of Jupiter

Figure 1: top – dependence of North-South asymmetry of polarization P_N–P_S on Jupiter's orbital location (L_S – planetocentric orbital longitude of the Sun). Points correspond to the data obtained by averaging over all Jovian longitudes in L_{III} system. Bars are errors of mean. Chain line is approximating curve. Bottom – asymmetry of insolation of polar regions

Origin of polarization in polar regions of Jupiter at zero phase angle

To generate the significant polarization it is needed non-zero and non 180° scattering angles availability. They may be realized for example at multiple scattering in Jovian clouds. However, polarization increase is observed only in polar regions, not in the direction of East or West limbs. We propose the following mechanism of polarization appearance at zero phase angle: the principal contribution in polarization is produced by the light reflected by underlying surface (opaque clouds) and then scattered on upper low-

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density atmosphere layers. Albedo of Jovian clouds is sufficiently high and they may be a source of light for above located atmosphere layers. This configuration makes possible to obtain the necessary scattering angles and may give significant polarization in scattering on atmospheric aerosol haze. As known, data of polarimetrical observations are sensitive to presence of stratospheric aerosol haze at top levels of Jovian atmosphere, observed at high latitudes (on pressure level p ~ 0.1–1 mbar) [2]. According to [4], the observed aerosol haze consists of benzene and polycyclic aromatic hydrocarbons (PAH) like naphthalene, phenanthrene, pyrene.

To check the proposed mechanism of polarization formation the computer experiment has been performed. The simple model was realized: the aerosol haze which consists (for simplification) of non-absorptive spherical particles is located at altitude *h* from underlying surface (opaque clouds). Phase angle of observations is zero. For describing the light scattering on particles the Mie theory was used. Only single scattering (on haze particles) are taken into account. Light from underlying surface (clouds) scattered by the layer of stratosphere aerosol haze is shown to give considerable contribution in the polarization. Results of experiment are in agreement in whole with observed facts: radial orientation of polarization plane; increase of polarization with latitude; polarization sign changing with wavelength increase. Though obvious simplicity proposed model demonstrates qualitative agreement with observations and permits to estimate mean radius of aerosol particles 0.5 μm which not contradict estimations of other researchers.

Causes of seasonal variations of polarization

As we consider stratospheric aerosol as probably cause of significant polarization appearence, it is reasonable to suppose that changes of aerosol characteristics (concentration, shape, size, refractive index) in the time may lead to changes in polarimetric properties of Jupiter's stratospheric layers. What could be possible cause of such changes? As known, Jupiter has a small axial tilt (about 3°). However, the orbital eccentricity of 0.05 results in 20% variation of 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 cause the great seasonal fluctuations of the incident solar radiation and cause the north-south asymmetry in insolation and temperature. As a result, seasonal variations of temperature appear (mean temperature in Jupiter's poles may vary in the range ±25 K) [5]. How seasonal variations of insolation may result in seasonal variations of polarization? We suppose that they can do it by variations of temperature. Aerosols may be unstable, and temperature changes may influence on generation and destruction of aerosol particles. In addition, although temperature in Jovian atmosphere is changed smoothly, but the seasonal changes of aerosol concentration should occur jumpwise (because of exponential character of dependence of condensation rate on temperature [6]) that is in a good agreement with jump-like dependence of polarization parameter on time of Jovian year.

Temperature effect on aerosol haze formation

Seasonal fluctuations of temperature in the stratosphere of Jupiter are shown to control formation the polar aerosol haze that consists most probably of PAH solid particles (naphthalene, phenanthrene). This can explain the seasonal changes of polarization in the Jovian polar regions.

The possibility of influence of solar cosmic rays (high-energy particles) on formation of polar haze on Jupiter is pointed out.

References

[1] Starodubtseva, O. et al. (2002) *Icarus,* 157, № 2, 419–425.

[2] West, R. (1988) *Icarus*, 75, 381-398.

[3] Hall, J. and Riley, L. (1974) (T. Gehrels. Ed.), 593–598.

[4] Friedson, A. et al. (2002) *Icarus*, 158, № 2, 389–400.

[5] Caldwell, J. et al. (1979) *Astrophys. J.*, 234, 155–158.

[6] Chernov, A. (1984) *Modern Crystallography III,* 3–120.