PERIODIC CHANGES IN THE ACTIVITY OF JUPITER'S HEMISPHERES. A. P. Vidmachenko[1], [1]Main Astronomical Observatory of National Academy of Sciences of Ukraine, Str. Ak. Zabolotnogo, 27, Kyiv, 03680, vida@mao.kiev.ua.

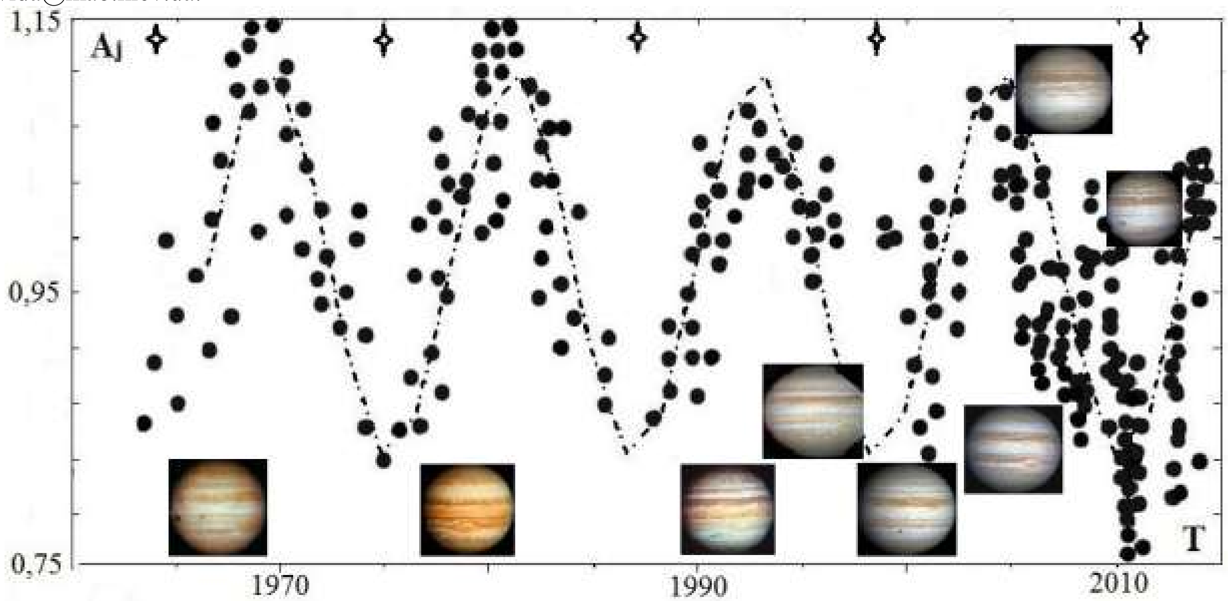

Fig. 1. Change of factor activity A_J of Jupiter's hemispheres with time T.

For planets with significant incline of equator to the orbital plane is characterized by a manifestation of seasonal changes in the optical characteristics of the atmosphere [6, 7, 10, 13, 15-23]. The inclination of Jupiter's rotation axis to the orbital plane is only 3.13°. In [8, 14, 23] we proposed to take into account the geometric modulation of solar irradiance due to the planet motion along the orbit and variations of Jovimagnetic latitude of the Earth φ_m, caused by the rotation of the planet's powerful magnetosphere; $\varphi_m = \varphi_E + \beta\cos(\lambda - \lambda_o)$,where $\beta \approx 10°$ is the angle between the magnetic axis and axis of Jupiter's rotation, λ – current longitude and λ_o – longitude of the planet's magnetic north pole. During the year on Jupiter φ_m varies from -13.13° до +13.13°. Therefore, a change in the reflectivity of Jovian atmosphere may occur extrema in a single planetary orbital period around the Sun. Because of the orbital eccentricity (e≈0.048) northern hemisphere receives almost on 21% greater flow of solar energy to the atmosphere of Jupiter [1], because at the closest to the summer solstice time – planet is situated at perihelion.

In [8, 9, 12, 14, 23] we showed that the ratio of the brightness of the northern and southern temperate zones is a good factor for the photometric activity of the atmospheric processes on Jupiter. From the spectral mathematical analysis we obtained the existence of cyclicity of long-period variations of this factor activity with a period of 11.86 years. This allowed us to talk about the existence of the seasonal reconstruction of the physical parameters of the Jupiter's atmosphere. Analysis of estimates magnitude of Jupiter's disk M_J in filter V, obtained from 1862 to 1991, and comparison these data with the Wolf numbers W, characterizing the variations of solar activity (SA), showed that a change in M_J has extrema in the peaks of SA: minimum for the odd and maximums for the even cycles. That is, a change in the Jupiter's brightness in visible light is much clearly manifested ~22-year magnetic cycle, and not the 11-year cycle. To combination of these data, we applied our described in detail in [11] and tested in [5], the program of spectral photometric analysis by the method of maximum entropy for observational data series. At the change of the visual Jupiter's brightness, we found the presence of periodic components with periods of such values: with reliability greater 95% T_1=23.9 (+1.4, –1.0), T_2=22.1 (+1.3, –0.9), greater 90% T_3=11.88 (+08, –0.6), T_4=11.1 (+0.7, –0.5) and T_5=3.4 (+0.3, –0.2) year [13]. That is, we found a manifestation of the double value of an orbital period (~23.9 years), of an orbital period (~11.88 years), and periods of solar activity, characterized by a change in the Wolf numbers W (T_2=22.1 and T_4=11.1 year). In addition, we have confirmed the existence of the periodic component T_5=3.4 years [2- 4] in change of photometric characteristics of the atmosphere of Jupiter; it can be explained by the superposition of one of the following two pairs of frequencies: $\nu_5=\nu_1+\nu_4$ and

$\nu_5=\nu_2+\nu_3$. Solar activity affects to the planet globally. That is what we observe by the character in changing of the Jupiter's integral brightness in visible light. But seasonal cycles should be manifested in an alternating change of the optical properties of the southern and northern hemispheres. The results of Jupiter's observations for the years 1977-1995 [14], we added the data obtained by many researchers for the years 1962-2015 (See, for example, on the websites http://kardasis. weebly.com/ – Manos Kardasis, http://obs. nineplanets.org/ obs/obslist.html – Amateur Astronomical Observatories, http://www.acquerra.com.au/astro/ gallery/jupiter/ index.live – Anthony Wesley an Australian amateur astronomer, etc.)

For analysis, we selected 270 planetary images with a good quality, obtained in visible spectral range. We digitized them and got the photometric scans along the central meridian from south to north pole. Then all scans are normalized to the brightness of the brightest parts, and have led to the same linear size. Analysis of the results showed that the cloud layer alternately became the lightest on the disc at latitudes where are the tropical and temperate zones and belts. For all 270 photometric scans of the Jupiter's central meridian, all digitalized normalized values of the relative intensity (I/I_{max}) in both hemispheres, have led to the same spatial area (in latitude and longitude) on the visible surface of planetary cloud layer; and then we calculated the ratio of brightness of northern to southern part of hemisphere. Selection of latitude edges of the tropical and temperate regions been varied within the range 0.20-0.65 of Jupiter's polar radius R_J in both hemispheres. The boundary edges of these regions we found by the least-squares method with using the best agreement of the result with a sine wave (dot-dashed line in Fig. 1). Calculations given period value of sine waves 11.91±0.07 earth years, values of edges of bright latitudinal zones in the southern $0.35\text{-}0.56\cdot R_J$ and in the northern $0.30\text{-}0.51\cdot R_J$ hemisphere. Such asymmetry is caused, most likely, by the presence in the southern hemisphere of Great Red Spot. It was his presence, apparently, a few moves the bright zone in the southern hemisphere to polar region. The calculated values of the ratio of brightness to southern part of northern hemisphere (factor A_j), we have shown in Fig. 1 by filled circles. The sign ✧ on top of the same figure are marked the moments of Jupiter's passage through the perihelion of its orbit at a distance of about 4.96 AU from the Sun. They practically coincide with the moment of the summer solstice for the northern planetary hemisphere in 1963.8, 1975.6, 1987.5, 1998.7, 2010.6. As can be seen, changes in factor activity of Jupiter's hemispheres A_J in 1960-1995 is in a good agreement with a sinusoid with period about 11.91 years. This value is almost identical with orbital period of Jupiter around the Sun; in 1998-2015 – the symmetry is somewhat disturbed. That is, there is alternately increase in the brightness or the northern, or the southern tropical and temperate zones for one period of Jupiter's rotation around the Sun. This periodic variation of brightness and the increased activity of planetary different hemispheres, may indicate the periodic global restructuring of the circulation system, the structure of cloud layers and haze above the clouds. This allows us to talk about the correlation of the observed variations of reflective properties of the investigated parts of Jovian disk, tilting the axis of rotation of the planet and/or magnetic field to the orbital plane; that is, about the existence of seasonal reconstruction in the atmosphere of Jupiter. At the same time, the response of the atmosphere to change of the visible planetocentric declination of the Sun does not occur instantaneously, but with a significant (some years) delay.

References: [1] Beebe R.F., et al. (1986) *Icarus, 66, 2, 359-365.* [2] Focas J.H. (1971) *Icarus, 15, 1, 56-57.* [3] Prinz R. (1971) *Icarus, 15, 1, 68-73.* [4] Prinz R. (1971) *Icarus, 15, 1, 73-79.* [5] Rozenbush V.K., et al. (1989) *Sov. Astron. Let., 15, 2, 155.* [6] Vidmachenko A.P. (1982) *Astrom. Astrofiz., 47, 70-75.* [7] Vidmachenko A.P. (1984) *Astrom. Astrofiz., 51, 56-62.* [8] Vidmachenko A.P. (1985) *KPCB, 1, 5, 91.* [9] Vidmachenko A.P. (1986) *KPCB, 2, 1, 48-51.* [10] Vidmachenko A.P. (1987) *KPCB, 3, 6, 10-12.* [11] Vidmachenko A.P. (1994) *KPCB, 10, 5, 62-68.* [12] Vidmachenko A.P. (1997) *KPCB, 13, 6, 21 - 25.* [13] Vidmachenko A.P. (1999) *KPCB, 15, 5, 320-331.* [14] Vidmachenko A.P. (1999) Sol. Syst. Res*., 33, 464-469.* [15] Vidmachenko A.P. (2015) *KPCB, 31, 3, 131-140.* [16] Vidmachenko A.P. (2015) *17 asys.conf., Ukraine, 14-16.* [17] Vidmachenko A.P. (2015) *17 asys.conf., Ukraine, 10-14.* [18] Vidmachenko A.P. (2015) *LPS XXXXVI Abstract #1051.* [19] Vidmachenko A.P. (2015) *AstSR., 11, 1, 37-45.* [20] Vidmachenko A.P. (2015) *AstSR., 11, 2, 133-142.* [21] Vidmachenko A.P. (2015) *LPS XXXXVI, Abstract #1052.* [22] Vidmachenko A.P., et al. (1984) *Sol. Syst. Res., 17, 164-171.* [23] Vidmachenko A.P., et al. (1984) *Sov. Astron. Let., 10*, *289-290.*