ABOUT RADIATION CONSTANT OF THE ATMOSPHERE AT CLOUDINESS LEVEL ACCORDING TO JUPITER’S PHOTOMETRY IN 1960-2018. Ya. O. Shliakhetska¹, A. P. Vidmachenko¹,² ¹Main Astronomical Observatory of National Academy of Sciences of Ukraine, Str. Ak. Zabolotnogo, 27, Kyiv, 03143, ²National University of Life and Environmental Sciences of Ukraine, St. Heroyiv Oborony, 12, Kyiv, 03041, yanashl@i.ua.

Fig. 1. Top – the change in the activity factor of the hemispheres of Jupiter $A_J$ with time $T$. Below – change of solar activity index $R$ with time $T$ (http://sidc.oma.be/html/sidc_graphics.html).

Analysis of the data on the Jupiter integral value $M_J$ in the V filter for 1850–1991 and their comparison with the variations of the Wolf numbers $W$ – showed [11–13, 19], that at the maxima of Solar Activity (SA) $M_J$ values are the smallest for odd, and the greatest – for even cycles of SA. That is, the Hale magnetic cycle (~22.2 years) was more clearly manifested in the change in the integral brightness of Jupiter in visible light, than the 11.1-year SA cycle. Changes in the brightness of Jupiter with a double value of the orbital period (~23.8 years) and the orbital period (11.86 years) were also detected.

Our studies of the distribution of brightness across the disk of Jupiter showed the presence of asymmetry in the meridional distribution of the reflective properties of the clouds, when they became lighter at northern, then at southern temperate latitudes [21-23]. Such asymmetry is well described by the proposed factor of the photometric activity of processes in the planet’s atmosphere [7, 9, 10]. This factor is ratio of the brightness of northern and southern tropical and temperate regions $A_J = \frac{B_{NTZ}}{B_{STZ}}$.

Analysis of relations $A_J$, which we calculated by processing images obtained in 1960-2018 with using the technique presented in [14, 15, 18] allowed approximating changes in the $A_J$ values by a sinusoid with a period of 11.87±0.07 Earth years (Fig. 1). This value almost coincides with the length of the year on Jupiter ~11.86 years [16].

Solar activity affects the planet globally, which we observe by the nature of the change in integral brightness of Jupiter. Over the 11.1-year SA cycle, the influx of solar radiation varies from fractions of a percent in visible light to several tens of percent in the ultraviolet (UV). Due to significant eccentricity of the orbit (e=0.0485), and the fact that being in perihelion,
northern hemisphere of Jupiter is tilted to the Sun at a moment close to the summer solstice, it receives 21% more integral solar energy than southern [1, 2, 4]. Such variations insolation is displayed on changes in atmospheric characteristics [3, 5, 6, 20]. It should be noted that changes in the UV radiation of the Sun, which are associated with solar activity, have a stronger and faster effect on the energetics of the upper part of the atmosphere. And the response time to the heating of the atmosphere of Jupiter by insolation in the visible spectrum increases with the transition to ever deeper pressure levels. For example, studies have shown that after the summer season in the upper stratosphere at altitude with a pressure of 0.01 bar – in the northern hemisphere it was almost 10 K warmer than in the southern. The corresponding seasonal minimums and maximums of temperature in the atmosphere at levels with a pressure of 0.25 bar manifest themselves after 1.9 Earth years. This corresponds to the value of the radiation constant $\tau_R \approx 6 \times 10^{-17}$ s [17].

Presented in Fig. 1 data obtained in visible light. Visible clouds consisting of ammonia ice are located at pressure levels of 0.6-0.9 bar. We compared the obtained sine wave of variations $A_1$ with changes in the distance of the planet from the Sun and the solar activity index R (Fig. 1). An analysis of this comparison showed that the moments of Jupiter’s passage through the perihelion of the orbit practically coincide with the moments of the summer solstice for the northern hemisphere of the planet in 1963.8, 1975.6, 1987.5, 1999.3 and 2011.2. In 1969.7, 1981.6, 1993.4, 2005.2 and 2017.1 Jupiter passed through the aphelion of the orbit at moments close to the summer solstice in its southern hemisphere. The first (1967.4) and second (1979.3) maxima of the dependence $A_1(T)$ calculated by us took place at the moments of the beginning of extended (2.5-3.5 years) SA maxima: the third (1991.2) – immediately after the moment of maximum; the fourth (2003) – after 1.2 years, and the fifth (2014.9) – 2 years after the maximum Solar Activity.

From the obtained dependence $A_1(T)$, it follows that the values of $A_1$ do not always change symmetrically with respect to the value of $A_1=1$. Thus, the change in the activity factor of the hemispheres of Jupiter $A_1$ in 1960-1995 is in good agreement with the periodic curve with a period of about 11.86 years. In 1995-2012, this symmetry is broken due to a mismatch in the inflow of solar energy to the hemispheres of Jupiter due to a change in solar activity and movement in orbit. In 2012, the inflow of solar energy to the atmosphere of Jupiter by different methods began to synchronize again [20]. This was manifested in the restoration of periodicity of changing $A_1(T)$.

From 1960 to 2018 (for almost 5 Jupiter’s years), the sinusoid we constructed for relations $A_1=\text{B}_{\text{NTD}}/\text{B}_{\text{STD}}$ is reach the maximum value, on average, after 3.7 years (1.17-108 s) after Jupiter passes its perihelion. This delay value is a response to a 21% change in the irradiation of the hydrogen-helium atmosphere [2, 8] in different hemispheres when the planet moves in orbit. This corresponds to the value of the radiation constant $\tau_R = 1.17 \times 10^8$ s at the level of visible clouds of Jupiter.