
Illumination conditions of the planet: Due to the inclination of the plane of the equator of Saturn to the plane of its orbit at an angle $B=26.75^\circ$, the planet is characterized by a significant difference in the supply of energy to its different latitudes during its revolution around the Sun (~29.45 years). Due to the eccentricity of the orbit (0.056), the southern hemisphere of Saturn receives on average 25% more energy from the Sun than the northern one [10]. This is because Saturn is in the aphelion of its orbit – in the summer for the northern hemisphere, and in perihelion – for the summer in the southern hemisphere. At the moments of equinox, the planet is approximately at an average distance to the Sun. Such changing in lighting conditions at different latitudes affect the optical and physical parameters of the atmosphere and on its vertical structure. We recorded changes in the visible atmosphere and pointed to variations in energy input from the Sun as a possible cause of the observed seasonal variations. They can lead to changes in the depth of the visible ammonian clouds and of methane absorption in the atmosphere. Therefore, seasonal changes should be studied in those parts of the spectrum in which clouds [1, 3, 6, 12, 14, 15, 18] and above-cloud fog are visible [5, 11, 20]. This includes the ultraviolet (UV) region and methane and ammonia absorption bands. At an average distance to the Sun, Saturn was in 1966, 1980, 1995 and 2010, when the rings for a ground observer were close to “disappearing” due to their edge-on visibility. At such moments of equinox, both hemispheres of Saturn were irradiated equally, and this were favorable for comparing the characteristics of latitudinal belts in opposite hemispheres. And the differences existing at these moments can be caused by the previous history of irradiation of different hemispheres by the Sun. From 1973 to 1980, and from 2002 to 2010 rings gradually opened up the northern hemisphere; in 1980, and around 2010 – they became invisible again. After these dates, the rings began to overlap the latitudinal belts closer and closer to the South Pole, closing almost the entire southern hemisphere in 1987 and 2017.

Changes on the disc of Saturn: According to studies of numerous images of Saturn, obtained since 1909, in the southern hemisphere in visible rays, up to 14 latitudinal belts were distinguished with a contrast of only a few percent [16, 21]. The images in the UV part of the spectrum – in the southern hemisphere, show 7 light and dark belts parallel to the equator, but with a contrast of tens of percent. The most conspicuous feature on Saturn’s disk all this time remained the equatorial region. To study, we used the brightness distributions over the planet’s disk at the equinoxes of 1966, 1980, 1995, and 2010 in the spectrum range 300-890 nm. We have selected about two hundred images of the planet obtained in visible light, in the UV and in absorption bands of methane. We digitized the images using the method described in [19], and obtained photometric scans in different latitudinal belts and along the central meridian. We normalized these scans to the brightness of the middle of the equatorial region and brought them to the same linear size. Then, we divided the northern part of the photometric profiles into their southern part, to obtain the waves of the brightness ratios at different wavelengths at the corresponding latitudes.

The results in absorption bands at wavelengths of 619, 725, and 790 nm [6, 7] indicate the presence of well-pronounced zonal changes. This indicates differences in the optical parameters and structure of clouds in different latitudinal belts, and a significant asymmetry between the southern and northern hemispheres. The lowest absorption in all the methane bands studied by us is characteristic of the equatorial regions. And the course of changes in absorption towards middle latitudes in opposite hemispheres differs significantly. With the visibility of the rings edge-on under the same conditions of the previous history of observations of Saturn in 1966 and 1995 – the absorption values in the northern hemisphere are significantly higher than in the southern; up to these moments it was the northern hemisphere that was open to the sun. After 1966 and after 1995 Saturn began to approach the Sun again. The results of spectral observations showed a rapid increase in the values of the equivalent widths in all methane bands. We observed the opposite effect in 1980, when the regions in the southern hemisphere already had large absorption [12]; up to this point, it was the southern hemisphere that was illuminated by the sun. That is, in 1966 in the ultraviolet and in the methane bands – the brightness of the studied belts was in the opposite phase [14] to similar data obtained in 1980 [5, 6, 9, 13], and in phase – with observational data in 1995. Thus, the greatest methane absorption at these moments of equinox was observed in that hemisphere of the planet, the middle
latitudes of which were illuminated by the Sun for almost 14 years. And in the hemisphere, in the middle latitudes of which there was winter for the same amount of time, and they were closed by the rings of Saturn, there was a minimum methane absorption. Also, there is a complete antiphase behavior of the spectral variation of the brightness ratios in the B_s/B_p hemispheres for the equatorial, temperate and polar regions. Antiphase is manifested in the fact that in UV in 1980 NEZ was brighter than SEZ; whereas at temperate latitudes and in polar regions, the southern hemisphere was brighter than the northern one.

In the methane absorption band with 3.619 nm, the brightness of the moderate and polar regions in 1966 were antiphase to the same data obtained in 1980 with an amplitude of up to 20%. An insignificant wave of brightness in antiphase, was also observed in the equatorial regions; but in 1966 and 1980 the SEZ was slightly brighter than the NEZ. Similar results were observed in 1995, when the greatest variations in reflectivity occurred between the equatorial (SEZ and NEZ) and temperate regions in the northern and southern hemispheres. That is, the layer of clouds at different successive equinoxes of 1966, 1980, 1995 alternately became lighter in one hemisphere, and darker in the opposite.

The last observed equinox on Saturn was in 2009-2010. In all previous equinoxes of 1966, 1980, 1995 – there was a significant asymmetry in absorption between the northern and southern hemispheres [15-17]. But in 2010, there are virtually no differences in absorption between both hemispheres at mid-latitudes. Until this moment, Saturn was tilting toward the Sun by the southern hemisphere, and an increase in methane absorption was observed in it. It was assumed that in the equinox of 2009-2010. the latitudinal distribution of methane absorption will turn out to be the opposite of that which took place in 1995, repeating the situation in 1980. But this did not happen. And when in 2007 it was possible to observe also part of the southern regions of Saturn's disk, and the northern cirmumpolar regions with latitudes 45-75° began to open from under the rings, then suddenly it was possible to see only insignificant differences in absorption between northern and southern latitudes. The same conclusion was confirmed by observations made from 2008 to 2012 [8]. That is, in contrast to the clear asymmetry in the changes in methane and UV absorption between the southern and northern hemispheres at all the previous moments of the equinoxes – at the equinox around 2010 differences in absorption between both hemispheres at temperate latitudes were practically absent. Moreover, absorption in the southern hemisphere, as expected, increased significantly, while in its northern part – the expected decrease in absorption – was absent. Such visible differences should cause variations in atmospheric parameters. They can be determined by comparing the calculations [2, 4] and analyzing the available polarimetric and photometric spectral data in 300-890 nm range under various conditions of Saturn's illumination by the Sun in different seasons of the planet's observations.