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Saturn CCD-spectrophotometry in 2009 and 2010 – a comparison of near- and post-equinox latitudinal distribution of molecular absorption

V..Tejfel, V.Vdovichenko , A.Karimov , G.Kharitonova, G.Kirienko

Fessenkov Astrophysical Institute, Alma-Ata, Kazakhstan (tejf@hotmail.com)

1. Introduction

The research of spatial and time variations of molecular absorption on disks of major planets represents one of the most effective ways of studying of planetary atmospheres instability. In many cases the narrow-band imaging of planets [1-4] is applied for this purpose, but nevertheless it is more preferable to measure profiles of the absorption bands in different sites of planetary disk. Thus it is possible to find out those features which do not come to light by usual photometry. During the last 16 years the Laboratory of lunar and planetary physics in Fessenkov Astrophysical Institute carried out annually CCD-spectrophotometric observations of Saturn. Primary goal of them is the study of the methane absorption bands variations at the wavelengths range 580-900 nm. The received data give the chance to track those changes which occurred in Saturn's atmosphere from the previous equinox ("edge-on" position of equator and rings in relation to the Earth and the Sun) to 2009 equinox.

2. The observation technique

The observations were carried out with 0.6-meter telescopes equipped by diffraction spectrograph SGS SBIG and CCD-camera ST-7XE. In addition to the spectrograms of the Saturn equator and central meridian the scanning of planetary disk was carried out by consecutive records of zonal spectrograms from S-Pole to N-Pole. at the spectrograph slit oriented in parallel to big axis of the ring As a result a number of atlases of profiles of the methane absorption bands and atlases of latitudinal variations of depths and equivalent widths of these bands have been prepared. Under these data it is possible to track a character of the changes occurring on Saturn during all period from an equinox 1995 to equinox 2009.

3. Behavior of the methane absorption on Saturn

In 1995 sharply expressed asymmetry of the methane absorption in southern and northern hemispheres has been noted [5]. For all bands the stronger absorption was observed at the temperate latitudes of northern hemisphere. Minimum absorption is characteristic for an equatorial belt and it remained during all period of Saturn's observations. At the temperate latitudes of southern hemisphere the absorption was much less, than in northern . It was possible to expect that the opposite picture must take a place at equinox 2009, that is to say the lowered absorption should be in northern hemisphere and raised in the southern one. However the observed results were very different from expected.. Actually in 2009 the equivalent widths of the CH_4 727 nm absorption band have near equal values at temperate latitudes of both hemispheres. The minimum absorption was observed in an equatorial belt. The absorption bands CH_4 619 nm, 702 nm, 675 nm and others are weaker in southern hemisphere and show as in 1995 increase in northern hemisphere (Fig.1).

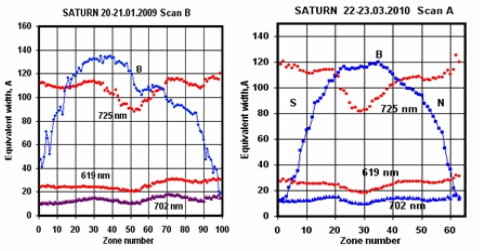

Fig 1 - Latitudinal variations of the methane absorption bands equivalent widths on Saturn in 2009 and 2010

Thus, though the overall picture of latitudinal variations of absorption differs from observed in 1995., but there was not opposite character of asymmetry.

Last period of the maximum ring opening was in 2001-2003. At this time and in 2004 the greatest methane absorption took place at southern latitudes about -20--30 degrees though the absorption minimum was observed in equatorial belt and at temperate southern latitudes with small recession towards high latitudes. Near S-Pole some increase of absorption was noticeable.. During the period between 1995 on 2009 the appreciable trend of the absorption in a southern temperate belt of Saturn was observed. as the growth of the CH_4 725 nm band depth.

It should be noted that the equivalent widths and central depths of the absorption bands show some different view of latitudinal changes (Fig.2).

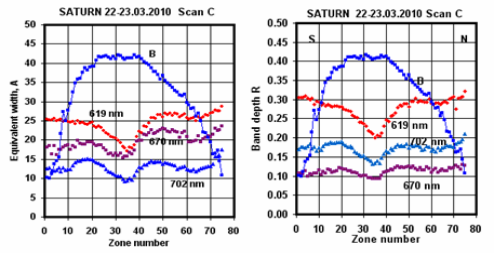

Fig. 2 - Latitudinal variations of equivalent widths and central depths of weak absorption bands

Some differences may be seen also in the latitudinal variations of the weak and temperate absorption bands, e.g. centered at 619 and 725 nm (Fig.3}

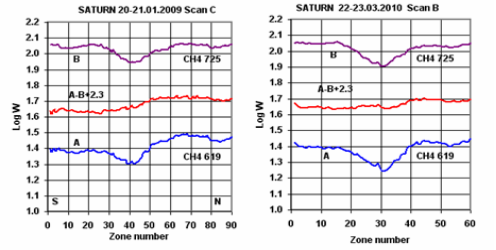

Fig. 3 -Logarithmic view of zonal variations of the CH4 absorption and the equivalent widths ratio for bands CH4 619 and 725 nm in 2009 and 2010

The ammonia absorption in 2008-2010 is also increased in northern hemisphere in comparison with southern as follows from the NH_3 645 nm band. measurements as noted earlier [6].

4. Discussion

An absence of mirror asymmetry for longitudinal absorption distribution at equinox 2009 in comparison with 1995 is caused most likely by distinctions in the insolation regime of hemispheres of Saturn during the periods of the maximum inclination of equator of a planet to a direction on the Sun and in the years previous to equinoxes.

Before 1995 equinox (Fig.4) Saturn was on greatest distances from the Sun and the inflow of solar radiation for northern hemisphere inclined to the Sun was the least. Before last equinox the distance from the Sun was the least and accordingly raised influx of radiation falled on southern hemisphere. Convective processes in southern hemisphere should be thus a little weakened and it was confirmed by Saturn's images from "Cassini" [7]. From other site there was observed during a number of last years clearly expressed and stable temperature difference between northern and southern hemispheres in the upper troposphere including upper cloud layer [8].

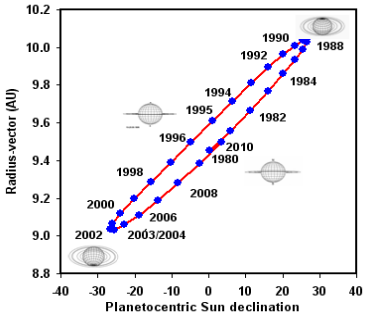

Fig. 4 - The changes of Saturn's radius-vector versus saturnocentric Sun declination

It should affect volume density of the cloud layer. Most likely it went down or an optical thickness of the haze above the cloud deck was increased. Accordingly it may cause strengthening of the absorption bands formed at the multiple scattering process within the clouds and haze.

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