A NEW METHOD FOR REGISTRATION OF OSCILLATIONS IN ATMOSPHERES OF JOVIAN PLANETS

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Our analysis shows that a change of gas and aerosol vertical speed in the range of $w = (10-50)$ cm/s determines the volume of top layers of visible clouds of giant planets, and therefore, may allow to find the reflectance characteristics of an observable cloud layer. In the presence of the certain factors, causing a change of a value of an air vertical moving speed as well as direction of such moving, it will modulate processes of cloudy formation and/or their destruction. In this connection we assume that the fluctuation processes of cloudy creation and their disintegration can serve as a preferable method for registration of possible giant planetary atmosphere oscillations.

INTRODUCTION

Vorontsov, Zharkov and Lubimov [16] were the first who predicted theoretically that the atmospheres of Jupiter and other giant planets can oscillate just like the solar photosphere. In [7, 8, 11] a significant work was performed to recalculate oscillation periods, using two different approaches to the technique of calculations and the newest models of the internal structure of the giant planets [4].

Detection and continuous observation of the oscillations in planetary atmospheres would be a very powerful tool for study of internal structures of these planets. Theoretical (analytic) researches showed that the analysis of the pressure modes of low orders allows to determine the radius of planetary nucleus. Really, the periods of free oscillations of the giant planets are sensitive to their internal structure. To be "zond" for testing the internal planetary structures these waves should exist during a time as long as several oscillation periods. In this case these waves must overcome the attenuation and have a sufficiently large amplitude to be registered as atmospheric line shift by using:

1) the Doppler displacement of spectral lines [12];
2) temperature oscillation during a geterodin observation of infrared hydrocarbon's bands [11];
3) planetary brightness oscillations in spectral range 390–420 nm offered below.

The P-modes of Jupiter's atmosphere have been most intensively studied during the last ten years. Some of them may have significant amplitudes near the upper edge of the visible cloud layer. Each oscillation mode produces perturbations of the equilibrium density, pressure and other atmospheric parameters. It was found [9] that in the upper troposphere some of propagating $P - modes$ produce a vertical air mass shift with a velocity about $w = (10\text{–}30\,\mathrm{cm/s})$.

FUNDAMENTALS OF THE METHOD

Several cloud layers are known to be present in the Jovian atmosphere. The Jupiter's tropospheric clouds consist of an upper layer of ammonia clouds at a 200–300 mbar level, and of a deeper water layer located at a 2–5 bar level and others. It is known that elementary processes are extremely important in formation of cloudiness. Microphysical properties of the Jovian clouds were studied by Carlson *et al.* [1]. It was found that the value of atmospheric vertical velocity, temperature profile and some other parameters of the clouds determine their dynamical properties, and determine the height of the top of a cloud and the maximal updrafts. They are the reason of cloud's creations also. Therefore, studying dynamic and thermal atmospheric structure we can study the law of occurrence and evolution of cloudy structures. On the other hand, studying cloud fields and distribution of their microphysical parameters we can obtain certain information about the degree of turbulization of a layer, intensity of vertical and horizontal movements of gas and aerosol, radiation mode, *etc.*

Ibragimov [5], Solodovnic [13], Yair *et al.* [17] and some other authors have shown that in atmospheres of giant planets all the macrostructurian parameters of water and ammonia condensation clouds are rather sensitive to dynamic factors of the atmospheric layer studied. The computations show that increase of the vertical speed of the atmospheric gas transfer results in the growth of volume both of water and ammonia cloudiness [6]. But the influence of these atmospheric factors on deeper water and upper ammonia clouds are essential distinguished [5]. So, inside a water cloud both the concentration of the arising cloudy particles and their average sizes are more sensitive to the turbulent atmospheric fluctuations. But in an ammonia cloud the change of the value and direction of the vertical velocity gives considerable variations of the number density of arising cloudy particles and their average sizes. Our computation has shown that increase of w results in growth of size and amount of condensed cloud particles at all altitudinal levels (hence, to increasing the integral characteristics of the observable cloudiness).

Thus, any change of the gas and aerosol vertical velocity determines significantly the volume of the top layer of visible cloud of the giant planets. So, it determines visible reflection characteristics of an observable cloudy layer. Therefore, existence of the certain factors changing the value and direction of vertical motions in atmosphere, will modulate processes of formation and/or destruction of clouds.

From the general equations of meteorology and approximate dynamic and kinematic evaluations of physical parameters of atmosphere [10] it follows that clouds in atmospheres of the giant planets are to be formed in the presence of ordered movements of gaseous masses with a vertical speed from units up to some hundreds of cm/s [5, 17].

In the general case, for Jupiter and Saturn the geometrical thickness of a cloud changes with value and direction of the vertical velocity of atmospheric masses:

1) the geometrical thickness of a cloud increases with increasing w;

2) in the most of modeling cases the specific content of condensed phase in clouds decreases when the sign of the vertical speed is changing, *i.e.*, their disintegration takes place;

3) if there are atmospheric movements with a $w = -(10\text{–}15)$ cm/s (falling air masses), a gradual slowing down of cloud growth is observed initially, and only later a cloud development is replaced by its disintegration;

4) if $w = 20$ cm/s the cloud formation or its disintegration begins practically at once when the sign of vertical speed changes; the time of cloud occurrence and/or beginning of its disappearance decreases with increase of the air mass vertical speed.

Since the Jupiter and Saturn tropospheres have a rich chemical composition [5, 17], a change of some component (especially water, methane, and ammonia), which are condensed at certain levels in atmosphere, results in variation of brightness of the cloud layer. Therefore, if a periodic variation of the vertical speed produced by oscillations of planetary atmospheres is present, we should observe periodical variations both of reflection and absorption of visible cloud layer too.

We have evaluated the changes of gas and aerosol optical parameters for Saturn's atmosphere. For our calculations we used the multilayer multiple scattering program developed by Dlugach [2]. We adopted the following assumption about the upper layers of Saturn's atmosphere: (1) aerosol scattering plays the dominant role in the process of radiative transfer; (2) cloud particles are nonabsorbing homogeneous spheres and the observed absorption is due to gas; (3) in spectral range of 300–600 nm the reflected radiation originates in the part of atmosphere, which may be represented by two homogeneous layers: the upper one is an optically thin gas layer and the lower one is a gas-aerosol semi-infinite medium.

For Saturn's Equatorial Zone at a wavelength of 316 nm the calculations have shown that an air mass lifting with a vertical speed $w = 30$ cm/s results in absolute reflectivity increasing equal to 0.0035 (for its average value of 0.200) in a time around two hours. At a wavelength of 600 nm for EZ this change is equal only to 0.00007 for its average value of 0.550. At the same time, our estimations of the spectral transmission coefficients for the Earth's atmosphere [3] as well as our observations concerning changes of spectral absolute reflectivity of different Saturn's disk features permit us to conclude that the observations in spectral interval 390–420 nm are the most preferable for registration of possible Saturn's atmosphere oscillations. Just for these wavelengths the spectral transmission coefficients of the Earth's atmosphere do not already deform a useful signal from planets so strongly (as it occurs in ultraviolet at 316 nm), so the light flux from the planet becomes high enough for its reliable registration by the photometrical method with photon counting.

As it has been shown by our calculations, for Saturn's EZ at 400 nm an air mass lifting with a vertical speed $w = 30$ cm/s can give absolute reflectivity increasing of 0.001 for its average value of 0.200 (the amplitude of these variations is about 5 mma) approximately in two hours. Analogously, for Jupiter's EZ this increment is equal to 0.0012 for an average value of 0.390 (the amplitude is about 3.3 mma). In this connection we assume that the fluctuation processes of cloud creation and disintegration can serve as a preferable method for registration of the optical characteristic of the oscillations in a planetary atmosphere, especially for the registration of possible free oscillations of a giant planet atmosphere. In the considered spectral range obtained values of changes of planetary atmosphere brightness [15] are quite accessible for their registration using the photon counter at Mount Maidanak Observatory [14].

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