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Astronomy

To the Question of the Atmosphere of Jupiter and the other Giant Planets

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ABSTRACT. The problem of the atmosphere of the planet Jupiter is discussed in the paper. A conclusion on inexistence of the atmosphere of Jupiter is made based on the analysis of observational facts and theoretical considerations. Proceeding from the similar views, it is deemed that the other giant planets Saturn, Uranus and Neptune do not have the atmosphere, either. The reason for the absence of the atmosphere of Jupiter is its low surface temperature and high gravitational acceleration. The average temperature on Jupiter's surface is 2.3-times lower and the gravitational acceleration 2.5-times higher than on the Earth's surface. In case of the other giant planets, the absence of the atmosphere is mainly conditioned by the low surface temperature because of the great distances from the Sun. The main surface temperatures of Saturn, Uranus and Neptune are at least 3.1, 4.4 and 5.5-times lower, respectively, than that of the Earth's surface. *© 2013 Bull. Georg. Natl. Acad. Sci.*

Key words: *Jupiter, giant planets, Stephen-Boltzmann law, Maxwell distribution, planets' atmosphere, gravitational acceleration.*

The "atmosphere" of the planet Jupiter is one of the problematic issues. This is confirmed by the fact that there are different versions about the nature of its atmosphere. Since the character of the planet's atmosphere is not clear enough, there are some vague concepts about the surface of Jupiter, and the established view about it is quite unclear. We are not going to discuss all the concepts regarding the atmosphere and the surface of Jupiter. We will just consider the aspects, which are principal, in our opinion, with regard to this problem.

If the atmosphere of Jupiter exists, then the superstability of the formations characteristic of Jupiter in its atmosphere is unclear. Existence of the atmosphere and the dynamically superstable formations therein, even in terms when the surface of the planet should suffer a strong disturbance from big satellites, such as Yo, Europe, Ganymede, and Callisto, sounds paradoxical. This fact too makes "stability" of the formations of Jupiter doubtful.

It is hard to imagine that such a stable formation as the red spot of Jupiter could exist in gas environment or even in a liquid one, while that red spot is considered to be a cyclone (cyclone or anticyclone) formed in its atmosphere. Cyclones are the areas of either low atmospheric pressure (cyclones) or high

atmospheric pressure (anticyclones) compared to their environment and, probably, the higher the pressure gradient between the cyclone and its environment, the higher the photometric contrast should be. The red spot of Jupiter is a contrast formation, and its cyclonic nature is unclear due to its super-stability. Jupiter's red spot could not have persisted for a long time either in any dense and expanded atmosphere, or in the atmosphere being in a liquid state.

Hence, Jupiter has no atmosphere. Its surface is formed by a smooth frozen mass of different substances and is a good reflector (has high albedo). The main reason for absence of the atmosphere of Jupiter, as well as in case of the other giant planets Saturn, Uranus and Neptune, which are farther from the Sun than Jupiter, is their large masses, i.e., high gravitational acceleration and low surface temperature. Solar energy Jupiter receives per unit area of its surface is 27-times less, on average, compared to the Earth's surface. According to the Stephen-Boltzmann law $E=\sigma T^4$, the temperature near the surface of Jupiter must be on average 2.3-times lower than that of the Earth.

Jupiter, like the other giant planets, is a body with a frozen solid surface and its red spot together with the other surface formations is a formation on the planet's surface. Those formations are formed from single or mixed solid masses of various substances, which differ from each other by light-reflecting capacities creating spectral and brightness contrast observed on the surface of Jupiter. The substances H_2, He, CH_4, NH_3 together with other chemical compounds create a solid surface of Jupiter and other giant planets.

Thus, we think that Jupiter has neither gas- nor liquid atmosphere. It is a planet with a frozen slippery surface primarily because of its low surface temperature and strong gravitational attraction. Similarly, the other giant planets Saturn, Uranus and Neptune have no atmosphere, either.

It is known that atmospheric formations of the Earth are unstable and the atmospheric flows are rapid. The fact of the currents of liquid environment (ocean currents) is also apparent. These currents are provoked mainly by the latitudinal temperature gradient added by the Earth's axial rotation. Neither Jupiter nor the other giant planets are free from such a latitudinal temperature gradient and the axial rotation.

Probably, as a result of sublimation of the substances of the frozen surface of Jupiter, a very thin gaseous layer can be formed near its surface, but so insignificant and transparent that it cannot prevent observation of the details on Jupiter's surface. The balance of sublimation of the substances and the further accretion on the surface should be such that only a thin, transparent, gaseous layer can persist on the planet's surface from time to time. Quantitatively, the balance of sublimation and accretion processes is determined by the planet's surface temperature T, gravitational acceleration g, and the masses of the atmosphere-forming particles, sublimating from the surface of the planet.

Undoubtedly, it would be problematic, if the atmosphere either gaseous or liquid were as stable (without currents) as allegedly the atmosphere of Jupiter.

Due to the problems of the Jupiter's atmosphere, we consider the visible formations of Jupiter to be the surface formations, in contrast to the statement that Jupiter has no surface. We believe that Jupiter has a solid surface and its visible formations such as the red spot and the equatorial belts, with their different chemical compositions are solid, contrast places on the surface.

Probably the red spot of Jupiter is magma leaked out as a result of the planet's volcanic activity on its surface rather than a cyclonic origin in its atmosphere. The albedo of the red spot differs from that of its surrounding solid area.

Gradual decrease of brightness of stars when they are covered by Jupiter, is proposed to be the proof of existence of the atmosphere of Jupiter. When the Jupiter's discus cover a star there is formed a diffraction image of that star on the edge of the planet. The process is illusory because of the light diffraction phenomenon. Therefore, Jupiter cannot cover a star

instantly. Thus, this process cannot serve as the proof of existence of its atmosphere.

So, the planet Jupiter is a body with a solid surface and without the atmosphere contrast to the statement as if it has a liquid surface and dense atmosphere, or an expanding atmosphere without the surface and with a low gradient of density. The formations on its surface, together with the different albedo, are the result of spectral selective reflection of light, hat, in its turn, is caused by different chemical compositions of the surface formations of Jupiter.

If Jupiter had the atmosphere, then we would be able qualitatively to describe the distribution of its particles (atoms, molecules) according to their velocity using the Maxwell distribution [1]. Number of particles Δn, whose absolute velocities could occur into $\upsilon+\Delta\upsilon$ interval, can be expressed as follows:

$$\Delta n = 4\pi N\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} e^{-\frac{m\upsilon^2}{2kT}} \cdot \upsilon^2 \cdot \Delta\upsilon ,$$

where k is the Boltzmann constant ($k=1.380648 \cdot 10^{-16}$ erg/K), T is the absolute temperature, m –the mass of particles, and N –a total number of particles in the system. In case of different masses of the particles, the average mass of atmosphere component particles can be taken into account.

If the Maxwell distribution method is applied, maximal number of particles comes on the velocity $\upsilon_p = \sqrt{2kT/m}$ where υ_p is the most probable velocity of the particles. It is essential to note that the temperature decrease causes reduction of the particles with higher velocity reduce compared to the υ_p particles, in proportion to the value $e^{-\upsilon^2/\upsilon_p^2}$, i.e., number of the particles with much higher velocities becomes very low compared to the number of particles of υ_p velocity.

A surface temperature of Jupiter is $T \approx 130$ K. The atomic weight of the hydrogen molecule is 2.02 unit. The mass $m=2.02 \cdot 1.6605655 \cdot 10^{-24}$ g. $1.6605655 \cdot 10^{-24}$ g is the mass of one atomic unit. Thus, even for the molecules of the smallest mass, the most probable velocity is $\upsilon_p=1.034$ km/sec. The second space velocity, i.e. the escape velocity on the Jupiter's surface is: $\upsilon_c = \sqrt{2GM/R}$, where $G = 6.672 \cdot 10^{-8}$ din $\cdot$ cm^2/g^2, is the gravitational constant, M and R are the mass and the radius of Jupiter, respectively. $M = 1.9 \cdot 10^{30}$ g, $R = 714 \cdot 10^7$ cm. It is accepted, that the most probable velocity of hydrogen molecules, corresponding to the superficial temperature of Jupiter, is $\upsilon_p=1.034$ km/sec, while for other particles or their mixtures, the υ_p velocity will be less.

As mentioned above, in case of low temperature, the share of the particles with high velocity is very small. Escape velocity at the surface of Jupiter is $\upsilon_c \approx 60$ km/sec. Ratio of υ_p and υ_c velocities excludes existence of vertical currents of particles, and their dissipation from the Jupiter's surface.

As to the other giant planets - Saturn, Uranus and Neptune, though their superficial temperature is considerably low because of their farness from the Sun, if they had the atmosphere, the ratios between the most probable velocities of their atmospheric particles and the 2nd space velocity, would be such that dissipation of particles (atoms, molecules) from their surfaces is excluded.

Conclusion. The giant planets – Jupiter, Saturn, Uranus and Neptune, are the bodies with solid surfaces and without atmosphere.

ასტრონომია

იუპიტერისა და სხვა გიგანტი პლანეტების ატმოსფეროს საკითხისათვის

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(წარმოდგენილია აკადემიკოს ჯ. ლომინაძის მიერ)

სტატიაში განხილულია პრობლემა პლანეტა იუპიტერის ატმოსფეროს შესახებ. დაკვირვებითი ფაქტების ანალიზისა და თეორიული მოსაზრებების საფუძველზე გაკეთებულია დასკვნა იუპიტერის ატმოსფეროს არარსებობის შესახებ. ანალოგიური შეხედულებებიდან გამომდინარე მიჩნეულია, რომ ატმოსფეროს მოკლებულნი არიან სხვა გიგანტი პლანეტებიც: სატურნი, ურანი და ნეპტუნი. იუპიტერზე ატმოსფეროს არარსებობის მიზეზი მისი დაბალი ზედაპირული ტემპერატურა და დიდი სიმძიმის ძალის აჩქარებაა. იუპიტერის ზედაპირზე ტემპერატურა საშუალოდ 2.3-ჯერ ნაკლები, ხოლო სიმძიმის ძალის აჩქარება 2.5-ჯერ მეტია, ვიდრე დედამიწის ზედაპირზე. სხვა გიგანტი პლანეტების შემთხვევაში ატმოსფეროთა არარსებობა ძირითადად, მზიდან დიდი დაშორების გამო, დაბალი ზედაპირული ტემპერატურითაა განპირობებული. სატურნის, ურანისა და ნეპტუნის საშუალო ზედაპირული ტემპერატურა შესაბამისად არანაკლებ 3.1, 4.4, 5.5-ჯერ მცირეა, ვიდრე დედამიწის ზედაპირზე.

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