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EXPLORING THE INFLUENCE OF ATMOSPHERIC CIRCULATION AND ROTATION ON JUPITER'S GREAT RED SPOT

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Abstract:
The atmosphere of Jupiter, with its unique chemical composition and complex dynamics, stands in stark contrast to Earth's atmosphere. Jupiter's atmosphere is characterized by the presence of trace impurities such as CH4, NH3, H2S, PH3, and C2H6 in minuscule quantities. Moreover, the visible disk of Jupiter exhibits intricate and dynamic features, including zonal circulation patterns and uneven latitudinal distribution of horizontal wind velocities within its atmosphere. Notably, Jupiter's atmosphere harbors a robust equatorial acceleration, encompassing latitudes ranging from -15 to +15, with distinct features at latitudes of -7 and +7, coexisting with a more sluggish flow at the equator. Another intriguing aspect is the presence of a formidable jet stream at a latitude of 25, symmetrically positioned relative to the Great Red Spot (GRS) at a latitude of -20, a celestial phenomenon that has captivated observers for over 350 years. This study delves into various atmospheric phenomena on Jupiter, including cyclones, anticyclones, turbulence, and the enigmatic Great Red Spot, which has piqued the interest of numerous researchers. Discussions regarding the nature of the Great Red Spot persisted until 1979 when the Voyager 1 spacecraft transmitted its first detailed images to Earth, conclusively confirming that the Great Red Spot is a long-lived atmospheric storm on Jupiter. However, a significant revelation from prior research is that the size and proportions of the Great Red Spot have experienced substantial reductions over the past century, spanning from 1880 to 2000, with ongoing shrinkage at a rate of 0.190. The primary drivers behind these changes involve the drift of the Great Red Spot, variations in its rotational period with respect to Jupiter's disk, as well as fluctuations in its axial rotation period. Furthermore, longitudinal oscillations and the complex dynamics of the Great Red Spot continue to present intriguing puzzles for researchers. This study also investigates the internal dynamics and structure of the Great Red Spot, shedding light on the nature of its peripheral ring, its distinctive coloration, and its interactions with other oval formations within the Jovian atmosphere. These intricate details provide valuable insights into the ever-evolving nature of this remarkable celestial feature.

Keywords: Jupiter, atmosphere, Great Red Spot, equatorial acceleration, zonal circulation, atmospheric dynamics.

I. Introduction

Chemical composition and structure of the atmosphere of Jupiter significantly differ from the atmosphere of the Earth group. Content of other impurities CH_4, NH_3, H_2S, PH_3, C_2H_6 in the composition of the atmosphere of Jupiter, is very small. Besides, the visible disk of Jupiter is a complex dynamic system with characteristic zonal circulation and non-uniform latitudinal distribution of horizontal velocities of individual atmospheric flows. The characteristic peculiarity of Jupiter is the existence of powerful equatorial acceleration, which covering belt of latitudes from -15 to +15, also inside this at latitudes of -7 and +7, and a slower flow on the equator. Another peculiarity is the existence of a no less powerful jet flow at the latitude of 25, which located symmetrically relative to the latitude of the Great Red Spot (GRS) (? = -20) (observed more than 350 years), which three Earth located in the southern hemisphere, would freely fit into it and this is particularly interesting. Phenomena of cyclones and anticyclones, turbulence, and the Great Red Spot, as well as some problems of the Jupiter, have been considered by many authors [1–9]. Discussions on the nature of Great Red Spot continued until 1979, till spacecraft "Voyager 1" transmitted first detailed images to Earth. These data proved the hypothesis on the Great Red Spot that it is a big long-lived storm in the atmosphere of Jupiter. However, in work [6], authors indicate that the size and proportions of the Great Red Spot significantly decreased over the past 100 years, from 1880 to 2000, and decreasing at present with the velocity of 0.19^0. Basic reasons of change of such size are drift of the Great Red Spot, and other factors are variations of its rotation period with the Jovian disk, as well as the variation of rotation period around its axis also longitudinal fluctuations, and the complex dynamics of Great Red Spot, still open for researchers. Moreover, an internal dynamic of structure, the nature of the peripheral ring, the color of the GRS, and its collision with other oval formations, which give some factors of modifications to this phenomenal formation.

Maybe, it is one of the central focuses for understanding the essence of phenomena occurring in the Great Red Spot. Dynamics of other oval formations, the vortex energy source, and the relation with the Great Red Spot, and many others, are problems awaiting solution. In parallel, GRS drift velocity not fixed, but according to the materials obtained by Hubble Space Telescope (HST), scientists confirmed previously planned 90-day longtime oscillations of the GRS of Jupiter. Furthermore, previous observations show that the rotation period was 6 days, and from 2006 to 2012 (just during this period, when the size of the Spot decreased quickly) and also its rotation period decreased to 4 days. This fact includes that one of the main issues is that the rotation period is between 4 and 6 days. Considering the above-mentioned factors, we may declare our researches plan now, which is on the problems of the Great Red Spot of the Jupiter. Therefore, firstly we need to analyze the following main questions:

- How the process of cyclones and anticyclones influence on the instability of the GRS? - How cyclones and anticyclones effect on rotation velocity of the system of Jupiter? - How cyclones and anticyclones, dispersion law of gravitational-gyroscopic, strong radio waves, and magneto-spherical field impact on the stability of the Great Red Spot? - How cyclones and anticyclones impact on the solid pole (cool process) and gas-liquid pole (hot process), on the hydrostatical equilibrium and gas motion on the atmosphere and liquid on the GRS? - How cyclones and anticyclones influence on temperature gradient vector and its direction, on the search of the heating procedure and energy balances?

For that reason, let us clarify the first question since this is the main factor of the existence of the Great Red Spot.

II. How the cyclones and anticyclones influence on rotation stability of the Great Red Spot.

In this situation, for processing the cyclones and anticyclones, more suitable for applying is the Rossby models [following as in [6]). Since, within shallow water theory, the equation describing the dispersion of waves on the planet rotating with the planet around the Z-axis is clockwise.

Here, the equation describing this process expressed in the local Cartesian coordinate system and has the form:

(□ □

□ $^2 4□^2_z$ □$k_□^2 c_z^2$)□ $2k^z$□ $^y c_z^2$ □0 where □$_z$ is the projection of the rotation velocity of the system on $^R jupiter$

the local vertical; □$_y$ is the projection of the rotation velocity of the system on the meridian; c_z - the adiabatic velocity of sound, $R_{jupiter}$ -radius of the planet Jupiter; k_z is the wavenumber along latitude; the k_y -the taken along of the meridian. Here, as a high-frequency solution - is the dispersion law of gravitational-gyroscopic waves, and the low-frequency solution - is the dispersion law of Rossby waves (Suitable solution): $2kz□ y$

□R □□ $R_{jupiter}(k2$ □ $4□2z\ /cz2)$.

Moreover, if the so-called Rossby model is performed, then the rotation of the system, significant effects on the dynamics and peculiarities of wave structures. Consequently, with consideration of the scale of the structure in a plane, that is perpendicular to the local vertical. Therefore, the motions in the wave are subsonic in any case; this is sufficient condition for the existence of the Rossby regime, to keep rotation direction. Considering the Coriolis force and its inhomogeneity along the meridian, the long-wave perturbations at the lower latitudes are Rossby waves (planetary waves), supporting or creating zonal (along the latitude) flows on the nonlinear stage. It is regularly alternating cyclonic and anti-cyclonic Rossby vortices in the mid-latitudes. However, the speed rotor is parallel or anti-parallel to the vector of the local angular velocity of the system, respectively. Hence, there is a strict analogy, to other characteristic examples of Rossby cyclonic, and anticyclone vortices are so-called ―barges‖ in the Jupiter atmosphere. Therefore, there is the Rossby auto solution of the Great Red Spot of Jupiter, which has the Cariole's force in cyclones is directed from the center of the vortex. Moreover, decreasing occurs in it, and in anti-cyclones, conversely, the increase of gas density; anti-cyclones are more longlived than cyclones, which related to dispersion characteristics (note) due to increased density. The total angular momentum of the anticyclone is higher than of the cyclone, under all other equal conditions. Therefore, it should be noted that the Rossby vortices drift slowly; along with velocity on the parallel to the west, in this case, the conditions of the Rossby regime are performed in level better and under larger size scale of the system.

III. The mathematical statement of a problem

According to the complete system of equations describing the motion of gas in the atmosphere, without consideration of dissipative effects, the equation of motion could be written in the form (by the type of Euler):

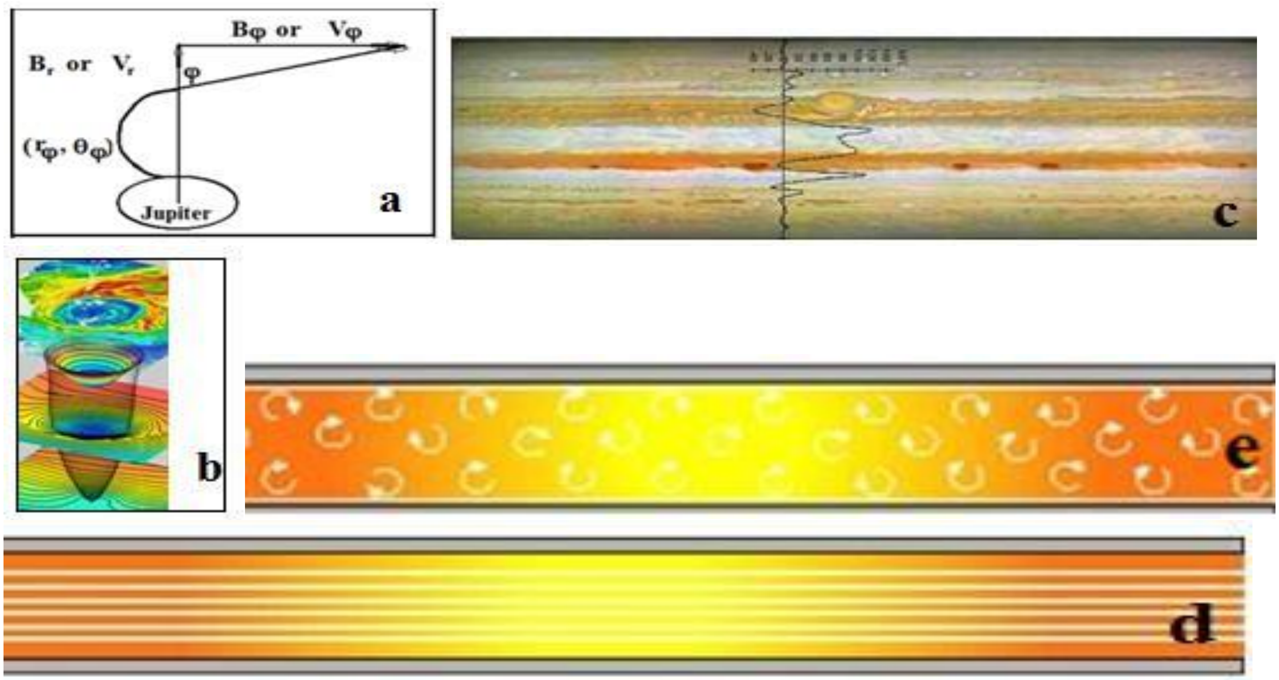
□$\overline{V}_g$ □ □ □ □ □ □ □ □□ □

□t □$[Vg□V_g]$□□g□Z □k □ fV □ F , where, V is horizontal velocity, V_g □ __$f\ k$ □□Z .Geostrophic component of velocity- g, Z –isobaric surface, f=2sinand - the rotation velocity of Jupiter, along latitude, F is horizontal gravity force, -horizontal operator surface, t –time. In case if the cell is symmetrical,

 *d*g   *g dz*

then the zonal component equation might be expressed by: ____ *f* *Fz*,g ___ . It should be *dt*

f dx noted that, if we present magnetospheres field from the upper pole, which pressure is higher than the down pole, then hot temperature gradient vector directed up will impacts on the solar wind with turbulence, so that the rotation drags the magnetic field into Archimedean spiral form, as is shown in fig (a) below. It means that formula of law Archimedean spiral could be written as *r**a*i.e. the type of spiral after formulation might relate to the so -called Parker's spiral: *r**r*0 (*v*/)(0),



where the winding angle is $\tan\square \; \square \; \frac{B_\square}{B_r} \; \square \; \frac{v_\square}{v_r} \; \square \; \frac{\square(r \; \square \; r_0)}{v_r}$ ..Upward pole of Jupiter by Parker's spiral is formulating from the turbulence rotation (figure (b)), directed to converse rotation of vertical axis Z of the planet, which gradient vector of temperature directed up to down vertical. In order of pressure differences between upward in higher to downward lower transition temperature from hot pole to cool pole, consequently, the part of downward contain solid molecules without fluid and gas. Consequently, the Great Red Spot (figure (c)) contain the center circumference circulation of the cyclone with liquid and gas, which by quasi-laminar (figure (d)) liquid (gas) transiting to turbulence (figure (e)), dependences of Reynolds number are very large and tends to infinity

Re ____________(*inertia* *forces*) Re 1,Re In this case as usually the continuity equation is *u**v* 0,At (*viscoce* *foces*) x x

the same time x-momentum u u v u U dU 1 .Where U is the free stream velocity,

x y dx y

u

uv

y

Note that in turbulent flows mechanical energy is transformed into internal energy in two different ways:

(a) in direct dissipation: transfer is due to the viscosity in laminar (for small viscosity term)

(b) in turbulent dissipation: transfer is due to the turbulent fluctuations

It seems to us the 68 per sent energy of Jupiter may be transferred from the turbulence kinetic energy and others thermal searches.

Since the size of the Earth is two diameters, a large red spot is an anticyclone in the atmosphere of Jupiter, the long-term stability of which is due to the very fast rotation of Jupiter around its axis (a day on Jupiter is 10 Earth hours). If there is a pressure drop, then it acting in opposite direction to theCoriolis force and growing with the meridian displacement of the flow, then the medium shows elasticity, and waves called the Rossby waves, arise in it. Their frequencies are very small - less than one hundred thousandth of a hertz. Because the Coriolis force that excites them is proportional to the angular velocity of rotation, the view of Jupiter exists without collapsing and would be preserved all time by its natural equilibrium. Frankly speaking, for the Jupiter issue the energy and magnetic field accepted the hypothesis in the following: the mechanical coupling between different parts of the planet the comparison is an advanced character only to friction. The electrical conductivity of most interior and lower atmosphere of Jupiter is higher enough for the internal magnetic field of the planet contribution significantly on mechanically coupling, frictional coupling for transforms rotational energy irreversibly into heat, magnetic coupling transforms rotational energy reversibly into magnetic energy. In this case, the magnetic field will have a toroid type, which we describe in the Parker spiral form for the initial impact on the atmosphere of Jupiter.

If we take into account that the ―wake‖ of the GRS was at rest before the start of the clarification process, then this suggests a dynamic relationship between atmospheric flows around the GRS and the ―life cycle‖ of SEB, the behavior a long period of time.Although the Small Red Spot may appear small compared to the large scale of Jupiter, however, this spot is actually the size of the Earth, and the three times the diameter of the Earth. Both of these sunspots are giant hurricanes in Jupiter's southern hemisphere, powered by warm air rising from their centers.

The appearance of new red spots on Jupiter in recent years and their dynamics suggest that global climate change is taking place on the planet. The structure, speed of rotation of its various parts, size and color largely depend on its interaction with a huge number of smaller vortices.

The most striking feature of the thermal wind field of the GRS core is related to the fact that evidence has been revealed for the existence of a weak counterclockwise rotation. Atmospheric vortices on Jupiter apparently exist for a more limited time, longer than cyclones and anticyclones on Earth.

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Iv. Conclusion

The result of our investigations consists of how the cyclones and anticyclones, and turbulence's stability effects on Great Red Spot and to the rotation of Jupiter. In this case, considered some factors noted by issues for the stability of rotation of Jupiter with GRS. For this reason, the necessary conditions of the long-time existence of the stability of GRS on Jupiter have been considered. By mathematical model describing the equation of motion for fluid–gas and stability conditions of GRS, also radio-waves with magneto -spherical field, under spiral form turbulence with the wind, have been investigated. According to the work [2-9], as well as the above results, we can conclude as follows:

- in cyclones, the Coriolis force is directed from the center of the vortex, therefore, a decrease is formed in it, and in anticyclones, on the contrary, an increase in the gas density;
- anticyclones are much longer-lived than cyclones, what is associated with the increased density inside them and, therefore, other things being equal, the total angular momentum of the anticyclone turns out to be higher than that of the cyclone, so it is more difficult for it to disintegrate;
- Rossby vortices slowly drift along the parallel to the west with a speed not exceeding V_{dr} ⍰ V_R where V_R is the phase velocity of Rossby waves; 20 Journal of Natural Sciences, Vol. 8(2), December 2020
- the conditions for the Rossby regime are met the better, the larger the size system and its speed of rotation. Therefore, its manifestations on the giant planets are much brighter than in terrestrial conditions.

The authors declare no competing financial interests

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