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The Nature of the Celestial Elves, Sprites and Jets

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ABSTRACT

Due to the daily rotation of the Earth the lower layers of earth's atmosphere are continuously crossed by horizontal lines of the geomagnetic field. For this reason, near the earth's surface there is an upward-directed Lorentz force. Under the action of this force the positively charged objects move upward and the negative charges down. The existence of this force makes it possible to explain some poorly known phenomena that occur in the earth's atmosphere, namely, celestial elves, sprites and streams.

Keywords: Elves, Sprites, Jets, Celestial Discharges.

1. INTRODUCTION

Due to the daily rotation of the Earth the lower layers of earth's atmosphere are continuously crossed by horizontal lines of geomagnetic field. For this reason, near the earth's surface there is an upward-directed Lorentz force. Under the action of this force the positively charged objects move upward and the negative charges down. The existence of this force, which distributes charges in near-Earth space, allows us to explain some "mysterious" phenomena occurring both in the terrestrial atmosphere and on the earth's surface. So, there are a number of celestial phenomena, namely elves, sprites and jets, the nature of which is still considered

incomprehensible. Here we propose an acceptable explanation for these phenomena.

2. MAIN PART

2.1. The Nature of the Celestial Elves, Sprites and Jets

Recently, there has been convincing evidence of the existence of electrical discharges that occur on the upper surfaces of clouds and are directed upward toward the upper layers of the atmosphere. These outbreaks were called elves, sprites and jets (Figure 1).The cause of these electrical discharges is considered incomprehensible [1].

Trying to explain these phenomena, it is necessary to take into account that in the terrestrial atmosphere positive charges move upwards, and negative charges – downwards, in general [2,4-6]. Such a distribution of electric charges is realized in the clouds, – it is known that the lower part of a typical cloud has a negative charge and upper – positive charge (Figure 2) [5,6].Another confirmation of this trend is the fact that ascending water vapor is always positively charged [7].

But clouds form exceptional structures in which the described tendency of the distribution of free atmospheric charges is disturbed. For this reason, it is necessary to analyze here the processes taking place in the clouds, in more detail. First of all, it should be borne in mind that the charges of the clouds are in equilibrium, which is due to the action of two forces.

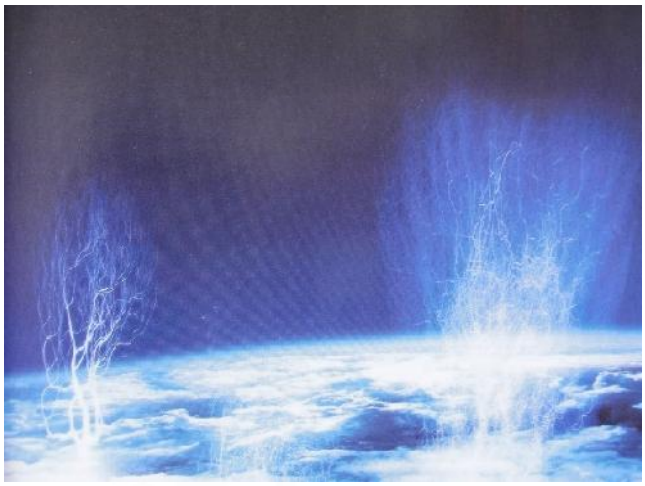

Figure 1 That's what blue jets look like [1]

The first force is electrostatic, it acts between the negatively and positively charged parts of the cloud (Figure 2), – this force sends negative charges up, and positive – down.

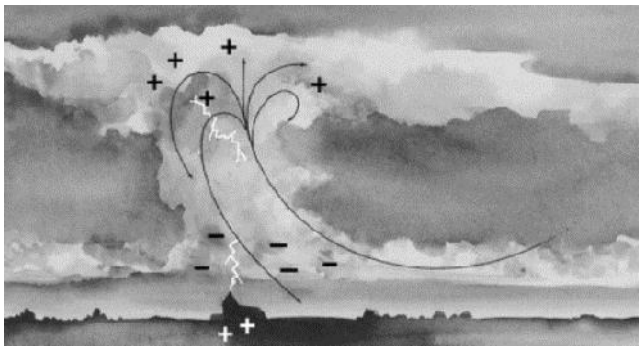

Figure 2 This is a typical cloud and its polarization: the lower part of a typical cloud has a negative charge and the upper part has a positive charge [2,6]

It should be noted again that this force only arises in the clouds; - outside the clouds it disappears: thanks to this force, the cloud becomes an electric capacitor (Figure 2).

The second force is the Lorentz force directed upwards $\mathbf{F_L}$ [8], – this force sends negative charges down, and positive charges – up [2-4].

It is necessary to dwell on the nature of the last force. During the daily rotation of Earth its atmosphere crosses the horizontal lines of geomagnetic field. Therefore, in the earth's atmosphere appears a force of electromagnetic nature, in fact, this is the known Lorentz force $\mathbf{F_L}$ [8], which distributes the atmospheric charges:

$$\mathbf{F_L} = q\cdot[\mathbf{v},\mathbf{B}] \quad (1),$$

where: q – electric charge,
v – the linear speed of earth's surface,
B – geomagnetic induction.

Since this force is directed upwards, under its action positive charges move upwards, to the upper layers of atmosphere, and negative charges – down, to the earth's surface [2, 8]. So, the existence of this force explains the positive charge of the upper atmosphere and negative charge to the earth's surface [2]. (In particular, it was shown that the existence of this force is manifested in the dependence of the lifting force of flying objects on the magnitude of their positive electrification [4].)

The calculations show that magnitude of Lorenz force $\mathbf{F_L}$, which acts on the elementary charge on equator line, is equal to:

$$\cdot\mathbf{F_L}\cdot = \pm e \cdot \cdot\mathbf{v_e}\cdot \cdot \mu_0 \cdot \mathbf{H}\cdot =$$
$$= \pm 1{,}602\cdot 10^{-19}\text{A}\cdot\text{s}\cdot 463\text{m}\cdot\text{s}^{-1}\cdot 1{,}257\cdot 10^{-6}\text{V}\cdot\text{s}\cdot\text{A}^{-1}\cdot\text{m}^{-1}\cdot 27{,}06\ \text{A}\cdot\text{m}^{-1} =$$
$$= \pm 2{,}5\cdot 10\text{–}20\ \text{Kg}\cdot\text{m}\cdot\text{s}^{-2} = \pm 2{,}5\cdot 10^{-20}\ \text{N} \quad (2),$$

where: $\pm e$ (= $\pm 1{,}602\cdot 10^{-19}$ A•s) – the elementary charge (of proton or electron),
$\cdot\mathbf{v_e}\cdot$ (= 463 $\text{m}\cdot\text{s}^{-1}$) – the linear speed of the earth's surface at the equator,
μ_0 (= $1{,}257\cdot 10^{-6}\text{V}\cdot\text{s}\cdot\text{A}^{-1}\cdot\text{m}^{-1}$) – the magnetic constant,
$\cdot\mathbf{H}\cdot$ (= 27,06 $\text{A}\cdot\text{m}^{-1}$) – intensity of the geomagnetic field at the equator [9].
Herein the acceleration of proton in up direction at the equator is equal to:

$$\cdot\mathbf{a_{H+}}\cdot = \cdot\mathbf{F_L}\cdot/m_{H+} =$$
$$= 2{,}5\cdot 10^{-20}\text{Kg}\cdot\text{m}\cdot\text{s}^{-2}/1{,}67\cdot 10^{-27}\ \text{Kg} =$$
$$= 4{,}175\cdot 107\ \text{m}\cdot\text{s}^{-2} \quad (3),$$

where: $\cdot\mathbf{F_L}\cdot$ (= $2{,}5\cdot 10^{-20}\text{Kg}\cdot\text{m}\cdot\text{s}^{-2}/1{,}67\cdot 10^{-27}$ Kg) – the Lorenz force acting on proton at the equator,
m_{H+} (= $1{,}67\cdot 10^{-27}$ Kg) – the mass of proton [9].
At the same time, the acceleration of electron in down direction on the line of equator is equal to:

$$\cdot\mathbf{a_e}\cdot = \cdot\mathbf{F_L}\cdot/m_e =$$
$$= 2{,}5\cdot 10^{-20}\text{Kg}\cdot\text{m}\cdot\text{s}^{-2}/9{,}1\cdot 10^{-31}\ \text{Kg} = 2{,}7\cdot 10^{12}\text{m}\cdot\text{s}^{-2} \quad (4),$$

where: $\cdot\mathbf{F_L}\cdot$ (= $2{,}5\cdot 10^{-20}\text{Kg}\cdot\text{m}\cdot\text{s}^{-2}$) – the Lorenz force acting on electron at the equator,
m_e (= $9{,}1\cdot 10^{-31}$ Kg) – the mass of electron.

Thus, it can be seen that this Lorentz force can cause a superfast distribution of atmospheric charges [2].

Thus, cloud charges are in equilibrium, because the described forces are equal and oppositely directed.

But such an equilibrium can be violated, because periodically there is an electrostatic force acting between the positively charged sharp objects of the earth's surface and the negatively charged lower sides of the clouds (Figure 2, down), – the occurrence of local positive charges on the earth's surface is due to electrostatic induction. Thus, if this additional force generates an electric discharge (lightning), the described equilibrium of cloud charges is violated. A consequence of such a lightning, i.e. leakage of negative charges from the bottom of the cloud, there will be a violation of the described equilibrium (because the electrostatic force disappears) and, as a consequence, the emergence of an upward directed flow of positive charges, that is, the appearance of elves, sprites and jets (Figure 1), – as it is established, these objects are appeared in ~1 $\cdot 10^{-4}$ s after traditional lightning [1].

However, the appearance of these ascending electric discharges can easily be explained by the described Lorentz force $\mathbf{F_L}$ (1): since this force is upward directed, it causes an upward movement of positive charges concentrated on the top of the cloud (Figures 2).

It is also not difficult to guess that this same Lorentz force is the real cause of downward-directed atmospheric discharges, i.e. lightning (Figure 3).

Figure 3 These are typical lightings, which are known to be downward directed fluxes of negative charges [5,6]

3. CONCLUSION

Near the surface of the Earth there is a constantly acting Lorentz force, which is directed upwards. Under the action of this force the positive charges are moved upward and the negative charges down. Thus, the described Lorentz force makes it possible to explain the appearance of both upward-directed and down-directed celestial electric discharges. In particular, the existence of this force explains such famous celestial phenomena as elves, sprites and jets.

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