Daily Rotation of the Earth and a Hot Air Balloon Flight

Yuri Pivovarenko

Abstract
At the Earth's surface acts the electromagnetic force, which distributes charges. Under action this force the positive charges move upwards and negative charges – downwards. Here we have tried to demonstrate the significance of this force for terrestrial processes on the example of a hot air balloon.
Keywords: Hot-Air Balloon, Thermal Aerostat, Flame Charges, Flame Plasma, and Geomagnetic Field.

INTRODUCTION

There are many data showing that the positive charges are moving upwards and the negative charges move downwards near the Earth's, surface. In particular, the charge distribution is confirmed by the negative charge of the earth's surface and the positive charge of the upper atmosphere (Israel, 1961; Feinman, at al., 1965). Such as the distribution of charges confirmed by the flame structure: as is known, the lower part of the flame has a negative charge and its upper part has a positive charge (Stepanov, at al., 1968), – this proves the shape of flame, which is in the horizontal electric field (Fig. 1).

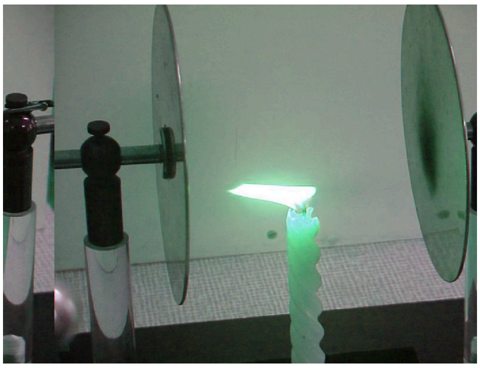

Fig. 1. Candle flame under the influence of a left directed electric field: the upper part of the flame is directed to the left, and the lower part is directed to the right.

Also described charge distribution is observed in the clouds: it is known that the lower part of the typical cloud has a negative charge, and its upper part has a positive charge (Feinman, at al., 1965).

As we have shown earlier (Pivovarenko, 2015; Pivovarenko, 2016), the described charge distribution may be due to the Lorenz force, which appears due to daily rotation of the Earth. As you can see (Fig. 2), during this movement the earth surface objects as well as objects of the near-Earth atmosphere, cross the horizontal lines of the geomagnetic field.

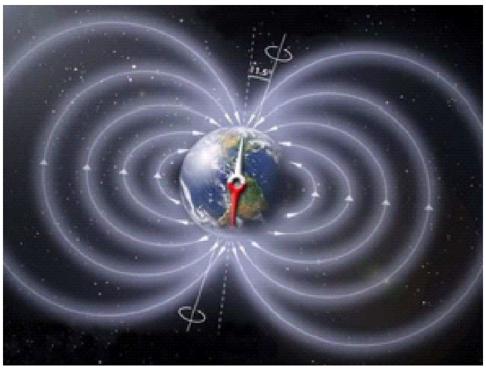

Fig. 2. As the Earth has daily rotation all objects on its surface cross the horizontal lines of force of the geomagnetic field. The appeared Lorenz force distributes the charges located on the earth's surface. Wherein the positively charged particles move up and negatively charged –

down.

For this reason, the Lorenz force $\mathbf{F_L}$ appears, pointing up:

$$\mathbf{F_L} = q.[\mathbf{v},\mathbf{B}],$$

where: q – electric charge,
v – the linear speed of earth's surface,
B – geomagnetic induction (Pivovarenko, 2015).

This force moves up the positive charges and negative charges down.

The existence of this force is confirmed by numerous facts proving that the evaporating water (steam) always has a positive charge (Krasnogorskaja, 1984). For this reason, it must be recognized that the rising steam, which you can often see (Fig. 3), forms a real electric current.

As is evident, the described Lorenz force can distribute both electric charges generated in the flame of a candle (Fig. 1) and the charges generated in the flame of a gas burner hot-air balloon (Fig. 4).

We will try here to demonstrate the possible effect of the forces described in the hot air-balloon flight.

Fig.3. Steam rising over a cup of hot coffee: it forms true electric current.

Fig. 4. Start a hot-air balloon.

RESULTS AND DISCUSSION

Charged particles may be created in the flame of a gas burner hot air balloon (Fig. 4). For simplicity, consider their education in the methane flame (Nekrasov, 1974):

$$CH_4 + 2O_2 \rightarrow 2H_2O + CO_2 \rightarrow H_2O + H_2CO_3 \Rightarrow HCO_3^- + H^+.$$

As we showed earlier, only positively charged particles are created in such a flame will move up (Pivovarenko, 2016). As is clear from the construction of a hot air balloon (Fig. 4), it will pick up only those particles. So his balloon will also acquire a positive charge.

We have tried to define what a positive charge q is needed to the hot air balloon is in equilibrium under the action described Lorenz force $\mathbf{F_L}$ and gravity. Assuming, that the whole mass of hot-air balloon (with a basket, but without air) M is ~$1{\cdot}10^3$ kg, we got the equations:

$$M|\mathbf{g}| = |\mathbf{F_L}| \Rightarrow$$

$$M|\mathbf{g}| = q|\mathbf{v_e}|.\mu\mu_0|\mathbf{H}| \Rightarrow$$

$$1{\cdot}10^3\,\mathrm{kg}{\cdot}9{,}8\,\mathrm{m{\cdot}s^{-2}} = q\,\mathrm{As}{\cdot}463\,\mathrm{m{\cdot}s^{-1}}{\cdot}1{\cdot}1{,}257{\cdot}10^{-6}\,\mathrm{kg.m.s^{-2}A^{-2}}{\cdot}27{,}06\,\mathrm{A{\cdot}m^{-1}},\ \text{and}$$

$$q\,\mathrm{A.s} = 9{,}8{\cdot}10^3\,\mathrm{kg{\cdot}m{\cdot}s^{-2}}/463\,\mathrm{m{\cdot}s^{-1}}{\cdot}1{\cdot}1{,}257{\cdot}10^{-6}\,\mathrm{kg.m.s^{-2}A^{-2}}{\cdot}27{,}06\,\mathrm{A{\cdot}m^{-1}} =$$
$$9{,}8{\cdot}10^3/14{,}1{\cdot}10^{-3}\,\mathrm{A^{-1}{\cdot}s^{-1}} =$$
$$\sim 9{,}7{\cdot}10^6\,\mathrm{A{\cdot}s} = \sim 0{,}7{\cdot}10^6\,\mathrm{C}.$$

where: M (= $1{\cdot}10^3$ kg) – the accepted mass of the balloon (without internal air);
$\mathbf{g}$ (= 9,8 $\mathrm{m{\cdot}s^{-2}}$) – the gravity acceleration,
$|\mathbf{v_e}|$ (= 463 $\mathrm{m{\cdot}s^{-1}}$) – linear speed of earth's surface at equator,
μ (= 1.0) – relative magnetic constant air;
μ_0 (= $1{,}257{\cdot}10^{-6}$ $\mathrm{kg{\cdot}m{\cdot}s^{-2}{\cdot}A^{-2}}$) – magnetic constant;
$|\mathbf{H}|$ (= 27,06 $\mathrm{A{\cdot}m^{-1}}$) – intensity of geomagnetic field at equator (Kuchling, 1980).

Taking into account the number of Faraday F = $9{,}648456{\cdot}10^4$ $\mathrm{C{\cdot}M^{-1}}$ (Kuchling, 1980) and equation (1), one can conclude that a positive charge may be theoretically produced from 7,3 moles of methane:

$$0{,}7{\cdot}10^6\,\mathrm{C}/9{,}648456{\cdot}10^4\,\mathrm{C{\cdot}M^{-1}} = \sim 7{,}3\,\mathrm{M}\ (\sim 116{,}1\,\mathrm{g})\ \text{of methane}.$$

Thus, if carbonic acid formed in the methane flame is fully dissociated (ionized), for equilibrium of hot-air balloon is needed ~116,1 g of methane. It is clear that obtained result don't take into account the possible discharge.

Here we do not take into account the further dissociation of carbonic acid (Nekrasov, 1974) and the extra chemical reactions that occur in the methane flame (Fialkov, 1997). To represent our hypothesis it is important that the methane flame contains a lot of cations, as well as typical plasma (Fialkov, 1997; Vincent-Randonnier at al., 2008).

For comparison, we had determined how much methane is necessary for the similar equilibrium of hot-air balloon, which operates only the force of gravity and the force of Archimedes.

We have taken that the balloon has a radius r of 10 m, and hence its volume V is ~$4{,}2{\cdot}10^3$ $\mathrm{m^3}$ (V = $4/3\pi{\cdot}10^3$ $\mathrm{m^3}$ = ~$4{,}2{\cdot}10^3$ $\mathrm{m^3}$). Based on these parameters, we calculated the density of the air inside the balloon ρ_1 necessary for its equilibrium in flight. First, we had defined the necessary difference between the density of the outside air ρ_0 (20 °C) and the density of the air inside the balloon ρ_1: $\rho_0 - \rho_1$.

To this aim, we have made the equation:

$$M|\mathbf{g}| = (\rho_0 - \rho_1)V|\mathbf{g}|$$

$$\Rightarrow 1{\cdot}10^3\,\mathrm{kg}{\cdot}9{,}8\,\mathrm{m.s^{-2}} = (\rho_0 - \rho_1){\cdot}\,4{,}2{\cdot}10^3\,\mathrm{m^3}{\cdot}9{,}8\,\mathrm{m.s^{-2}}$$

$$\Rightarrow (\rho_0 - \rho_1) = 1{\cdot}10^3\,\mathrm{kg}/4{,}2{\cdot}10^3\,\mathrm{m^3} = \sim 0{,}24\,\mathrm{kg.m^{-3}},$$

where: M (= $1{\cdot}10^3$ kg) – the accepted mass of hot-air balloon (without internal air);
$|\mathbf{g}|$ (= 9,8 $\mathrm{m.s^{-2}}$) – the absolute value of the gravitational acceleration;
V (= $4/3\pi{\cdot}10^3$ $\mathrm{m^3}$ = ~$4{,}2{\cdot}10^3$ $\mathrm{m^3}$) – volume envelope hot-air balloon.

Since ρ_0 (20 °C, $101{,}325{\cdot}10^3$ Pascal = 1 atmosphere) is equal to ~1,2 $\mathrm{kg.m^{-3}}$ (Kuchling, 1980): ρ_1 = ~(1,2 – 0,24) $\mathrm{kg.m^{-3}}$ = ~0,96 $\mathrm{kg.m^{-3}}$.

To obtain the desired density of the air, filling the balloon envelope, its volume must be increased by 1,2/0,96 = 1,25 times. This can be achieved by heating. Since the relation of isobaric process: V/T = const (Fenn, 1982), we received:

$$V_1/T_1 = V_0/T_0 \Rightarrow V_1/V_0 = T_1/T_0 = 1{,}25 \Rightarrow T_1/293{,}15\,\mathrm{K} = 1{,}25 \Rightarrow$$
$$T_1 = 1{,}25{\cdot}293{,}15\,\mathrm{K} = 366{,}4\,\mathrm{K}\ (93{,}25\ °\mathrm{C}).$$

In our opinion, it is very high temperature. We doubt that it corresponds to reality.

We calculated how much methane is necessary to heat the air to a temperature. To do this, we first made the equation:

$$dQ = c_p{\cdot}m{\cdot}dT$$

$$\Rightarrow dQ = \sim 1{\cdot}10^3\,\mathrm{Joule.kg^{-1}.K^{-1}}{\cdot}5{,}04{\cdot}10^3\,\mathrm{kg}{\cdot}\sim 73{,}25\,\mathrm{K} = \sim 3{,}7{\cdot}10^8\,\mathrm{Joule},$$

where: dQ – the heat absorbed by the air;

c_p (~$1 \cdot 10^3$ Joule.kg^{-1}.K^{-1}) – the specific heat capacity of the air at atmospheric (constant) pressure and at 20 °C (Kuchling, 1980);

m – the initial mass of the air inside the balloon at 293,15 K: $m = \rho_0 \cdot V$ = ~1,2 kg.m^{-3}·~$4,2 \cdot 10^3$ m^3 = ~$5,04 \cdot 10^3$ kg;

dT – the difference between the primary and final temperatures of the air inside the balloon: ~366,4 K – 293,15 K = ~73,25 K.

It is known that during the combustion of methane released 192 Calorie.M^{-1} (Nekrasov, 1974) or 192·4186,8 Joule.M^{-1} = ~$5,03 \cdot 10^7$ Joule.kg^{-1}. So as to obtain an amount of heat Q = ~$3,7 \cdot 10^8$ Joule necessary to use to ~$3,7 \cdot 10^8$ Joule/$5,03 \cdot 10^7$ Joule.kg^{-1} = ~7,36 kg methane.

Divide 7,36 kg per 116,1 g: 7360 g/116,1 g = ~63,4. It turns out that described Lorenz force $\mathbf{F_L}$ may be theoretically ~63,4 times "more efficient" than the Archimedes force. Anyway, this is true for the analyzed equilibrium.

In any case, we have two theoretical explanations hot-air balloon flight. To compare their efficiency, we use them to explain the upward movement of steam (Fig. 3).

As its particles can be seen with the naked eye, they are large enough. You also have to agree that the density of the vapor particles is greater than the density of air. For this reason, the Archimedes's force is not able to overcome gravity to raise steam particles. At the same time, the vapor particles can acquire a positive charge upon contact with air. This can be explained using a rule Kyon: during contact of the two phases, receives a positive charge phase, at which the greater the dielectric constant (Nekrasov, 1974). As the dielectric constant of the hot water is in the range: 66,5 (60 °C) – 55,1 (100 °C) (Nekrasov, 1974) and the dielectric constant of air is ~1 (Kuchling, 1980), it can be concluded that the vapor particles are positively charged in contact with air. Therefore, we saggest to accept our explanation of why the steam moves up. In any case, our explanation allows us to understand significance of a positive charge for such movement of vapor.

It should be noted that the explanation of the movement of steam up due to warm air is not very satisfactory. Such explanation is un satisfactory because steam evaporates even from the surface of ice, i.e. in the absence of rising warm air. However, this steam also has a positive charge (Krasnogorskaja, 1984). So its upward movement can be explained by the action described Lorenz force $\mathbf{F_L}$.

Does the positive electrification of the plane during the flight? To answer this question you need to use a rule Kyon (Nekrasov, 1974) and dielectric constants of air (~1) and typical metals (∞) (Kuchling, 1980).

How does the positive electrification on the lifting force of the plane? In our opinion, you can now answer this question yourself. Before you answer this considerable question, you can try to explain the motion of the particles of cigar smoke (Fig. 5). Because they are hard, it is most likely that their density is greater than the density of air.

Fig. 5. Tobacco smoke contains solid particles, the density of which is greater than the density of air.

CONCLUSION

During the diurnal motion of the Earth, the lower layers of its atmosphere intersect constantly the horizontal lines of geomagnetic field. For this reason, at the earth's surface there is an up-directed Lorenz force. This force may increase the lifting force of positively charged flying objects.

REFERENCES

Feinman, R., Leiton, R., & Sands, M. (1965) *FLP 5*, Moscow: Mir

Fenn, J.B. (1982) *Engines, Energy and Entropy*. New York, San Francisco: W.F Freeman & Co

Fialkov, A.B. (1997) Investigation on Ions in Flames. *Prog. Energy Combust. Sci. 23*, 399–528

Israel, H.R. (1961) *Atmospharische Electrizitat 1*. Leipzig Akad. Verlag

Krasnogorskaja, N.V. (1984) *Electromagnetic fields in the earth's atmosphere and their biological significance, 1*. Moscow: Nauka

Kuchling, H. (1980) *Physik*. Leipzig: VEB Fachbuchverlag

Nekrasov, B.V. (1974) *General chemistry 1*. Moscow: Chemistry

Pivovarenko, Y. (2015) A Charge Distribution in the Earth's Atmosphere. *American Journal of Physics and Applications. 3(3)*, 67-68

Pivovarenko, Y. (2016) Diamagnetism Flame. Faraday Mystery. *GJSFR. 16(1)*, 53-55

Stepanov K.M., & Diachkov G.G. (1968) *Ionization in the flame and electric field*. Moscow: Metallurgy

Vincent-Randonnier A., and Teixeira D. (2008) Plasma assisted methane diffusion flame. *International Journal of Plasma Environmental Science and Technology, 2(2)*, 119-127