ON GENERATION OF BALL LIGHTNINGS

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Abstract. On the basis of laboratory experiments the model of generation of ball lightning is developed. It is shown, that a ball lightning is the electric domain, which has spherical geometry. The explanation is given to significant time of life of such lightning.

1. Introduction

The electric discharges in a gas under low and middle pressures are of definite interest for solving a number of problems. A number of works is devoted to a phenomenon of a ball lightning. However there is no model of generation of such lightning. Existing works do not allow to explain significant time of a life a ball lightning.

2. Experimental results

The experimental results, received at breakdown near the surface of a dielectric (Fig.1) [1] and in a capillary discharge (Fig.2) [2], give the basis to consider that the ball lightning (BL) is the electric domain of a spherical configuration.

![Fig. 1. The generation of anomalous formations in space under breakdown near surface of dielectric for four intervals of time. An exposure – 20 ns.](image)

It consists of a nucleus with an excessive negative charge and a ringular external layer (REL) having an excessive positive charge. There are ambipolar and radial electric fields between the rotating nucleus and the REL. According to the Maxwell equation

\[ \text{rot} \mathbf{E}_r = -\frac{1}{c} \frac{\partial \mathbf{B}}{\partial t}, \]

the rotor of an electric field generates a magnetic field.

![Fig. 2. The images of luminosity in space for two intervals of time in initial stage of a capillary discharge. An exposure – 20 ns.](image)

Fig. 2. The images of luminosity in space for two intervals of time in initial stage of a capillary discharge. An exposure – 20 ns.

A rotating system of charges generates a magnetic dynamo. Such dynamo is available and in radiating stars [4]. The magnetic field lines surround the REL from outside, and inside they are localized between the REL and the nucleus. In the ball lightning there is such a charges and an electric field distribution under which the magnetic field strength minimum principle is realized – REL is magnetized, being in the zone of a strength minimum. Such distribution of charges and fields slows down diffusion of ions across a magnetic field. And thus it is possible to explain significant time of life of ball lightning.

3. Theoretical background of the mechanism generation of a ball lightning

Available data allow to generate following model of generation BL in an atmosphere. It is born at an...
instant preceeding the breakdown. Ions and electrons emerge in the "nearelectrode" zone under the field strength growth. A break in the continuity occurs because of a high electron mobility in comparison ions. The departure or a displacement of the group electrons by a characteristic size exceeding the length of screening results in the generation of a “nearelectrode” flat domain [3]. Its birth is accompanied generation of a transversal electromagnetic wave [1] with which the captured electrons and ions acquire energy which exceeds a value corresponding to the applied voltage. The dispersion equation for the driven transversal electromagnetic waves in plasma is given [1]

\[ \omega_{shf}^2 = k^2 c^2 + \omega_{wsc}^2, \]

where \( \omega_{wsc} = \omega_{pe} + \frac{e}{3 m_e \mu_d} = \omega_{pe} + \frac{\omega_{pe}^2}{12 \pi \sigma_d} i. \)

The qualitative profile generated at the birth of the domain of the transversal electromagnetic wave is given on Fig.4,b.

![Fig. 4. Optical image at the time interval preceeding breakdown - (a) and qualitative profile of the generated transversal electromagnetic waves – (b).](image)

Under interaction of fast electrons in air the dissipation of their energy occurs. The ionization cross-section reaches a maximum at some values of energy and consequently, as a result of the electron thermalization, the zone with an excessive negative charge - a nucleus of a ball lightning emerges. Since the nucleus production time is less than the time during which the system is able to neutralize appeared on some distance from electrodes a excessive negative spatial charge in a result electrical conductivity, a circular external layer – zone with an excessive positive charge - practically simultaneously around of a nucleus due to a photoionization. The step-like character of the domain generation is experimentally confirmed in [5].

### 4. Generation of big ball lightning

The experiments with the big laboratory ball lightning generation were made on the facility “Prometeus - M”. The energy in the capacitor storage was equal 30 kJ, the charge was equal 12 Q. The voltage pulse, 5 kV in amplitude, was applied to the discharge cell electrodes. The cell used in the spark discharge and the conical collapsotron were used as a work cell. The main measure were directed to the production of the intense fast electron flux at the initial stage which was injected into the continuously water vapor saturated near -electrode space. For an effective ball lightning generation only the high frequency zone of a discharge Volt-Ampere characteristics with the maximum voltage and current drops were used. It was achieved as a result of the discharge “break” with the exploding wires set along the high voltage line and the “earth”. The circuit commutation was realized with a specially designed discharger. The break-down initiation in the discharger was performed by injection of a fast electron microbeam into the interelectrode space at the atmosphere conditions. The Voltage, current and luminosity in the ball lightning birth zone and the time of its life time existence were registered.

### References


