On the Properties of Ball Lightning Material

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Abstract

Ball lightning (BL) phenomenon still attracts interest because of its unusual features and absence of corresponding theory describing them. BL can realize energy up to 10^{12} J /m^3 getting into a vessel with water, leaving only evident heating of water. It can leave glassy pieces of melt when it explodes and observations show that at that it impacted with ~ 0.4 m^3 of a soil and estimated energy density is up to 10^{10} J/m^3. Observations interpretation represents difficulties. It can break one after another up to 6 large trees. It can take off roofs.

A part of ball lightnings can consist of organic material, possibility of their existence was validated in many experiments: Cawood, Patterson (1931), Nauer (1953), Barry (1980), Ohtsuki and Ofuruton (1990), Emelin et al (1997), Timofeev and Bychkovs (2004). According to Bychkov (1994, 2006) organic, polymeric

composite BL lifetime is determined by time of BL heating up combustion, and energy (Bychkov, 2006) – by combustion of their material in air.

Dijkhuis (1981), Golka (1994), Emelin (Emelin et al 1997) experimentally have shown that a part of BL can have inorganic (metallic) origination. Inorganic BL were considered by Abrahamson and Dinnis (2000), it is caused by oxidation of Si nanoparticles networks from normal strikes on soil. They attempted to produce BL in experiments by electrical discharges to soil, containing carbon and silica. They obtained incandescent short lived coil. Residuals contained chains on nanoparticles. Paiva et al reported that an electric arc to silicon produced long lasting luminous white spheres 4 cm size and up to 8 s lifetime, they were heavy and fall down. Analogous results obtained Jerby and Dikhtyar (2006) at MW beam impact to silicate substrate. In work of Stephan and Massey (2008) modified experiments of Paiva and also obtained luminescent spheres that consist of burning molten silicon droplets whose combustion is initiated by the high temperature of an electric arc.

All described results that a part of BL can have inorganic metallic origination when ordinary lightning impacts earth. It can create fulgurite cavity with high temperature inside it. There, as show recent investigations, can be produced both fine (nano- and microparticles) of Si and SiO_2. These particles in non-equilibrium conditions can create silica W and flint glass. This compound is the first candidate to the BL material, because it can be completely diluted in water up to creation of acid, it releases energy in reactions with Si, C, H_2 (produced at lightning stroke into earth) with creation of a gas. At gasdynamic ejection of this material from the fulgurite cavity can be created a charged sphere (with unipolar charge transferred from the linear lightning to the excited material in the fulgurite area). Also a mixture of Si, SiO_2 Al and Al_2O_3 melted mixture can create a structure of BL.

Taking for estimates $\Delta H^o_{298K} \approx 3.2 \cdot 10^7$ J/kg (formation of SiO_2) and density $\rho \approx 2.0 \cdot 10^3$ kg/m^3 one can estimate typical energy density of BL made of such material $W \approx 6.6 \cdot 10^{10}$ J/m^3, and BL mass with radius of 0.1 m is ≈ 8 kg. For ensuring of this object

indifferent equilibrium due to electrical charge in thunderstorm conditions ($E \approx 10^3$ V/m) it has to have the electric charge of ≈ 0.8 Cu, which is rather large value. At larger radius it will represent a very heavy object, impact of which can lead to mechanical destruction. Evidently at smaller amount of material BL will represent bubble type structure. Life time represents either time of leak in charges (hundreds s) or time of combustion which is also long.

So we describe the origination of unusual heavy, melted and highly unipolarly electrically charged object.