A new theory of ball lightning

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Ball lightning (BL), a fireball sometimes observed during lightning, remains unexplained for centuries. Recently, we present a comprehensive theory [1] to describe the formation of BL and explain its diverse features. In the past decade, it is established that cloud-to-ground lightning can emit a large number of relativistic electrons. In a BL event, we propose that lightning produces an intense electron bunch. The bunch strikes the ground and excites an intense microwave. The microwave in air naturally evolves into a spherical plasma bubble that stably traps the radiation. Microwave emission and bubble formation are simulated by the JPIC code [2]. This new theory can explain most properties of BL: the occurrence site, shape, size, sound, spark, spectrum, motion, injuries and damages, appearance in aircraft or far from the lightning channels, etc. It should be stressed that an explanation of fireball appearance in aircraft or far away from lightning channels are required by the BL community for a successful theory. Our theory is unique to explain such peculiarities of BL.

Our BL theory infers that someone might have detected microwave or radio waves of the same origin as proposed for ball lightning. Indeed, we find these radio signals, i.e. so-called trans-ionospheric pulse pairs (TIPPs), which are the most powerful natural radio source on Earth. They were first discovered by a USA satellite in 1993. We point out that the popular TIPP model fails to explain some critical features of TIPPs. Using the same mechanism of exciting BL, we quantitatively explain almost all the features of TIPPs [3]. The work verifies that electrons from lightning can reach the ground and emit strong electromagnetic radiation, which is a fundamental assumption in the BL theory. The existence of TIPPs and their successful explanation give a strong physical evidence to support the new BL theory.