Experiments for Artificial Ball Lightning by Using Microwave Localization in a Waveguide

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Many theoretical models and experiments have been made to solve the ball lightning phenomena and many books on ball lightning were published[1-2]. For more than fifteen years, we made experiments by using microwave interference. The theoretical model of electromagnetic interference was proposed by Kapitza[3]. Our artificial plasma fireball corresponded to eyewitness reports of ball lightning in nature[4]. Our experiments are also available to confirm the theory of Tanaka and Tanaka[5]. They proposed that ball lightning in nature was caused by electromagnetic wave localization. They calculated the intensity of localized electromagnetic field in quasi one dimensional system, and showed that very high intensity could be obtained. We calculated the intensity of electromagnetic wave by using two types of one-dimensional disordered system such as Fibonacci chain (a quasi-periodic system) and Cantor bar (a fractal system). The Fibonacci chain was also used a model of acoustic band gaps in periodically and quasi-periodically modulated waveguide[6]. In both systems, we found that the intensity of the electromagnetic wave is considerably enhanced in restricted regions. Sometimes the enhancement of intensity exceeded a hundred times[7].

In order to obtain some experimental conditions for artificial fireball, we tried a fundamental experiment in one-dimensional system. We used a 2.45 GHz microwave oscillator (magnetron). The microwave radiation was guided through a rectangular waveguide. The cross-section was 109mm×55mm. The power of incident microwave was 1kW or 2kW and our power meter was able to measure the forward and the reflective powers separately. Isolator set up between the magnetron and the power meter gave the magnetron less damage. Ceramic plates (2.25 mm thick), which were the same size as the cross-section of the waveguide, were put in the waveguide. The direction of the propagation of the microwave was perpendicular to the ceramic plates.

Furthermore we made another experiment to examine the effect of the randomness of the waveguide wall. Several ceramic plates were set on the both side of the wall of the waveguide. The ceramic plates on one wall were fixed and they on another side were movable. The power of incident microwave was 1 kW. We measured the power of the microwave which passed through the waveguide and the power of the incident and reflected microwave. When the ceramic plates were shifted by a half or three fourth of the plate length, the lowest power was measured and sometimes the sound of the discharge which was a sign of plasma production was heard. In this condition, it is possible that the energy of the microwave was concentrate in the waveguide. However, a fireball not produced because the intensity of microwave was lower than needed.

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1 S.Singer, *The Nature of Ball Lightning*, Plenum Press,N.Y., 1971

2 J.D.Barry, *Ball Lightning and Bead Lightning*, Plenum Press, N.Y. 1980

3 P.L.Kapitza, *Dokl. Akad. Nauk.* (in Russian), 101, pp. 245-248, 1955 (*Collected Papers of Kapitza*, Vol.2, ed. D.Ter Haar, Pergamon, N.Y., pp.7 76-780, 1965)

4 Y.-H.Ohtsuki, and H.Ofuruton, *Nature*, 350, pp. 139-141, 1991

5 K.Tanaka, and M.Tanaka, *Appl. Phys. Lett.*, 71, pp. 3793-3795, 1997

6 P.D.C.King, and T.J.Cox, *J.Appl.Phys.*,102, 014902 pp. 1-7,2007

7 M.Kamogawa, H.Tanaka, H.Ofuruton, and Y.-H. Ohtsuki, *Proc. Jpn. Acad.*,75, Ser. 8, pp. 275-280, 1999