Discharge setup for generation and study of plasmoid above the water surface: first results

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Motivation

Discharge technologies are widely used in many industries: for the synthesis of various compounds such as fullerenes, nanotubes, for the production of ozone and surface treatment. Discharge phenomena are also widespread in nature. For example, these are linear lightning and ball lightning. Many discharge processes are still poorly understood. This paper presents a discharge high-voltage pulsed installation for generating plasmoids above the water surface. This object has aroused considerable interest in the last decade due to its similarity to natural ball lightning.

Aim

To establish a physico-chemical model of the plasmoid.

Tasks of this stage

Start up and set up the discharge facility.
Find the optimum operating mode of the facility.
Develop a scheme for registering the dispersed phase inside the plasmoid.
Carry out the work aimed at finding results indicating the formation of aerosol particles inside the plasmoid.

Aerosol detection

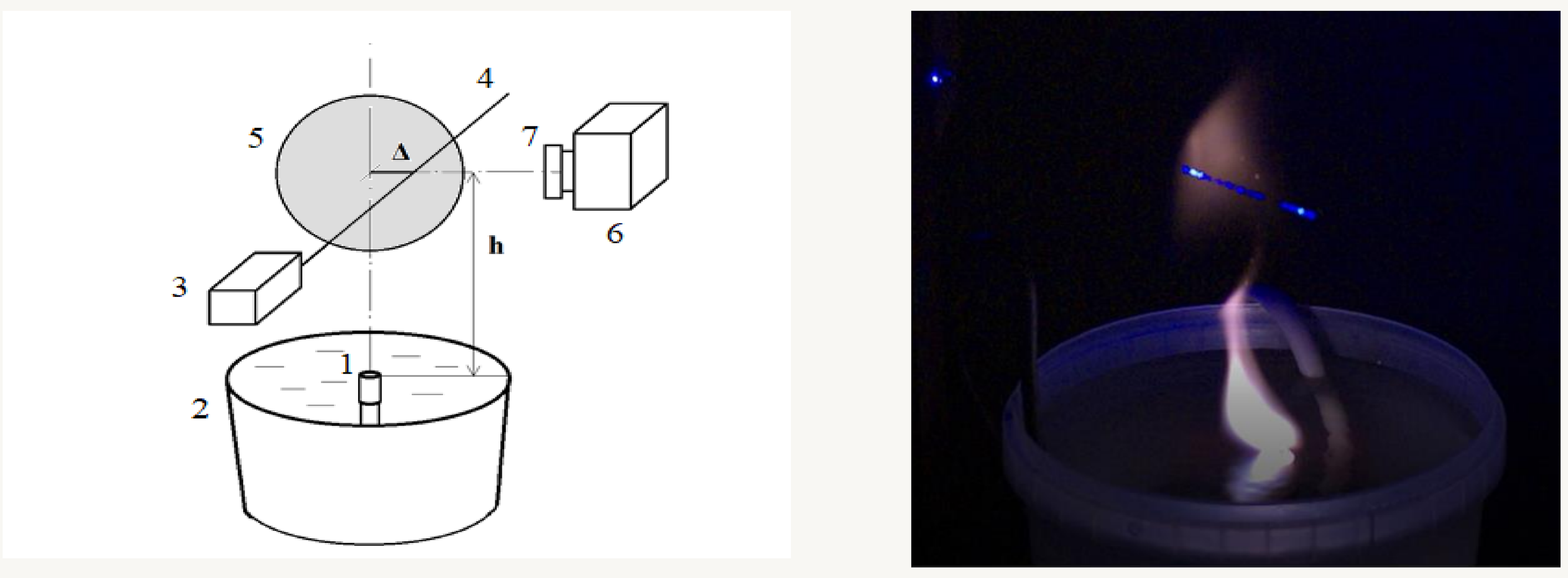

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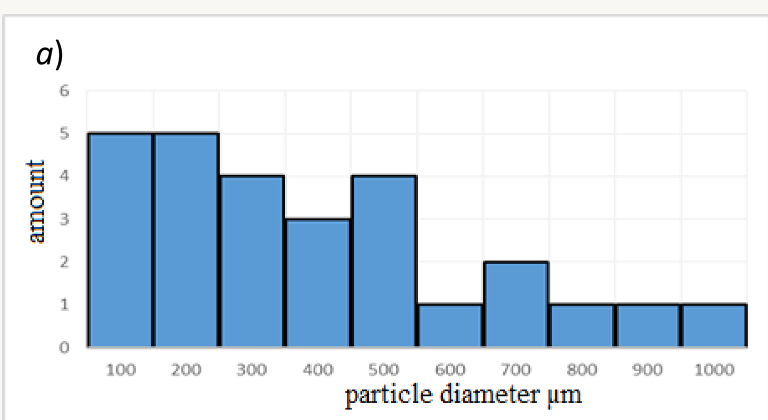
Fig.2. a) Scheme of observations of aerosol scattering in a laser beam.
1 - central electrode, 2 - discharge cell, 3 - laser, 4 - laser beam or vertical "laser knife", 5 - plasmoid, 6 - high-speed video camera, 7 - objective lens with focal length of 105 mm or horizontal microscope.
b) Observation of aerosol in scattered light of the laser beam at the moment of plasmoid extinguishing.

Distribution histograms



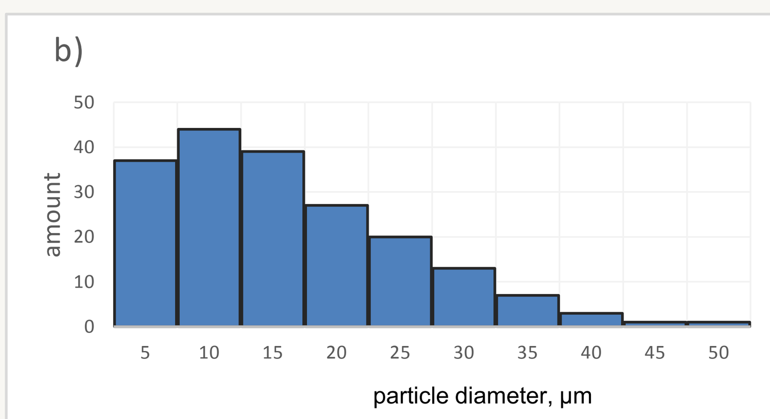
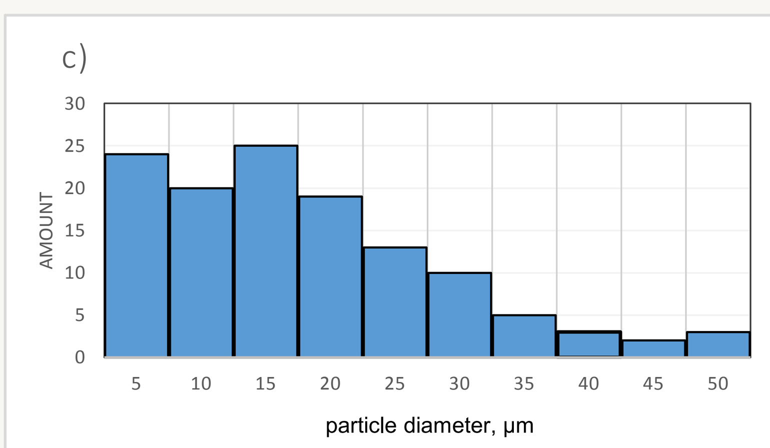


Figure 3. Histograms of distribution:
a) Sub-millimetre water droplets by size.
The average size fraction of aerosol particles in the plasmoid when using:
b) tungsten electrode
c) graphite electrode.

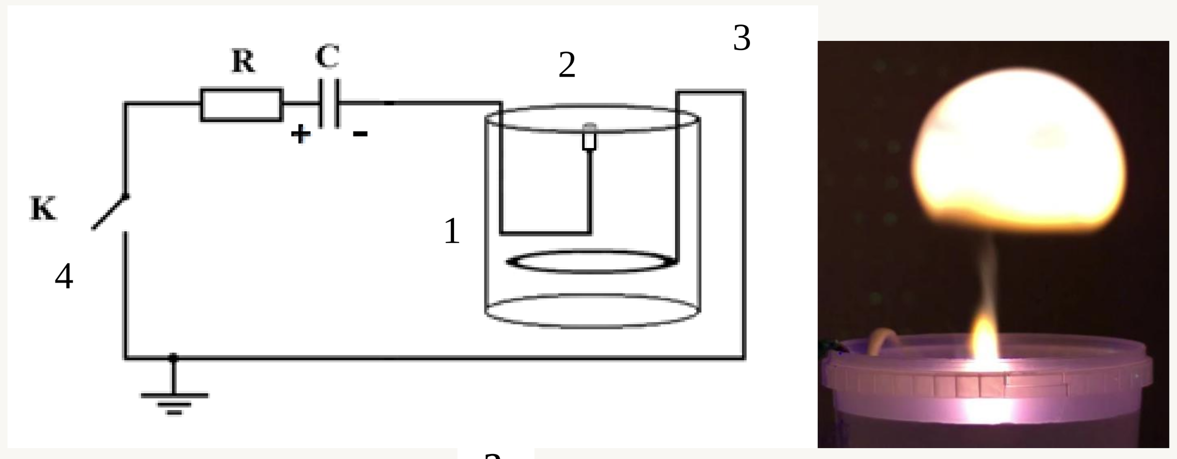


Conclusions

1. A discharge high-voltage pulsed facility for generating plasmoids with a lifetime of up to 0.6 s was created.
2. Using a high-speed video camera it is possible to observe aerosol particles of different fractions (sub-millimeter range and medium-dispersed fraction) inside the plasmoids.
3. it was found that when laser beam passes through plasmoid, scattering of laser radiation on aerosol (water) particles is clearly observed.

Discharge facility

In 2000, a special type of pulsed electric discharge over the water surface was discovered in Gatchina. With this type of discharge, a brightly glowing spherical formation is formed, called a plasmoid. This paper presents a discharge high-voltage pulse installation for generating plasmoids above the water surface.The scheme of the developed and created discharge installation is shown in Fig. 1a. The plasmoid (Fig. 1b) was created by discharging a high-voltage capacitor bank through a discharge cell. The battery voltage was 5.5 kV, the capacity was 1 mF.



a b

Fig. 1. a) Electrical scheme of the installation. b) Photo of the plasmoid.
1 - discharge cell, 2 - connection of central electrode located above water surface, 3 - second electrode submerged into water, 4 - key K; C - battery of high voltage capacitors, R-resistance limiting discharge current.

Evolution of the plasmoid

The discharge produces a brightly glowing plasmoid with a lifetime of up to 0.6 s, in the evolution of which at least three stages stand out. First, in the first stage (I in Fig. 4), (0.5-1 ms), streamers develop on the water surface. Then in the second stage (II in Fig. 4), which lasts about 100 ms, a current discharge occurs and a bright glowing spherical plasmoid with a plasma leg is formed. In the third stage (III in Fig. 4), the plasmoid develops without external energy, slowly floats up, and in 0.5-0.6 s ceases to glow brightly.

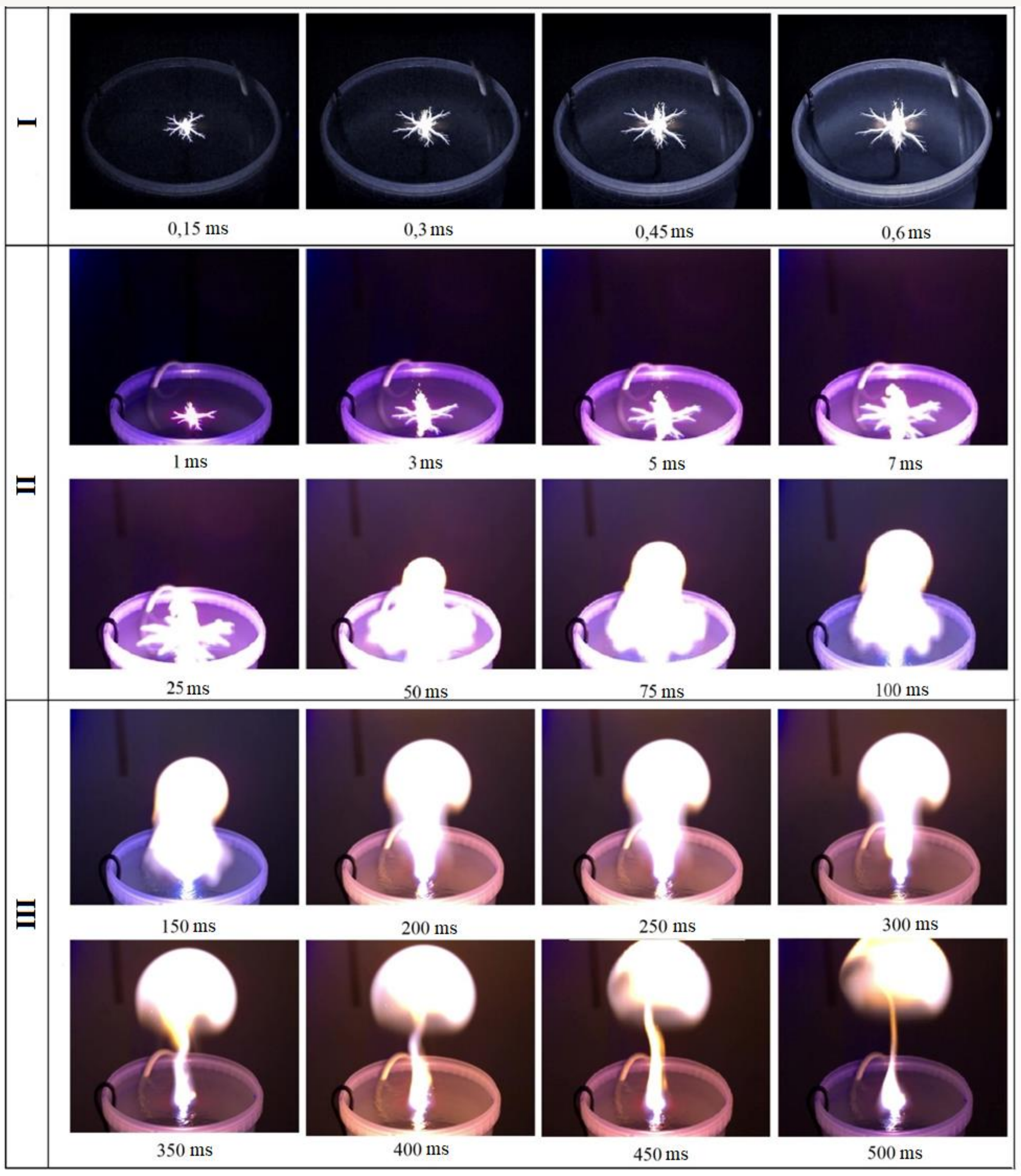


Fig. 4. Evolution of a plasmoid. Shooting parameters: (top row) shooting frequency 6400 fps, frame exposure time 60 μs; (remaining frames) shooting frequency 3200 fps, exposure time 100 μs.