Radiation Properties of New Laser based on Electric Chemical Luminescence of Weak Electrolytes with Activators

B.P. Yefimov, M.O. Khorunzhiy, A.N. Kuleshov
Institute for Radiophysics and Electronics of NAS of Ukraine
12 Ac. Proscura st., 61085 Kharkov, Ukraine, e-mail: jean@ire.kharkov.ua

***Abstract*— The experimental results of new laser based on electric chemical luminescence effect in weak electrolytes are given in this paper. We described the model and measuring method of discharge processes taking place in active medium. The radiation in visible range and the radiation of hard photons were experimentally observed. It is shown that discharge processes leads to the creation of plasmoids with spherical form in the air above the model.**

***Index Terms*— Active medium, radiation, electrical discharge, plasmoid, lens.**

I. INTRODUCTION

THIS work is dedicated to experimental investigations of radiation properties of new laser based on weak electrolytes, which are the active medium. Such electrolytes' pumping is produced by electrical energy reserved in capacitors battery. To obtain a weak electrolyte we added small quantity of acids and salts in distilled water, which act as activators in electric chemical reactions and displacement reactions. Water presence in weak solutions had an influence on discharge characteristics and radiation parameters, particularly, on discharge duration and pick value of discharge current.

It is well-known fact [1] that radiation spectrums corresponding to active medium of complex molecules in comparison with linear spectrum have wider structure. It is explained due to a complex character of inside motion in molecule. It means electronic, oscillatory and rotatory spectrums. In our experiments due to the complex behavior dynamics of water solution of acids and salts, which are the active medium of new laser, we paid much attention to an explanation of radiation mechanisms from the position of creation of conditions to make population inversion on rotatory and oscillatory molecule levels corresponding to radiation spectrums in visible and infrared wave ranges.

Given research can be useful not only from practical point of view. It extends fundamental knowledge on the nature of discharge processes taking place in complex liquid mediums, which are accompanied by all kinds of ionizing and electromagnetic radiation.

II. MODEL DESCRIPTION

The model described in [2, 3] served as a basis for our research. Our experimental model for discharge process investigations is shown in fig. 1. The difference between our model and model described in [2, 3] is other placement of electrodes and their dimensions. Considering a necessary of high electric stability of electrode 3 we changed its placement. It is put into water medium through the container bottom as it is shown in fig. 1. It allows us to save the electrical symmetry of electrodes in solution. The placement of another (ring) electrode 2 can be varied in solution limits. A polyethylene container is clear for visual observation with the same dimensions (diameter 170 mm and height 200 mm) as in [2, 3].

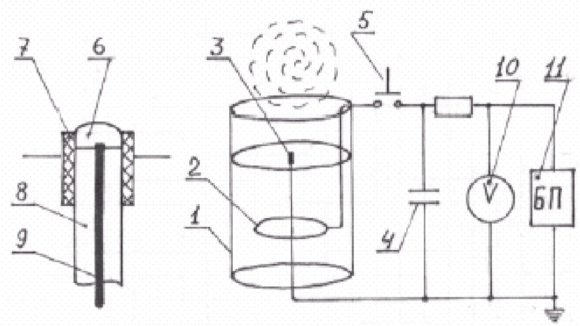


Fig. 1. Plasmoid creation device: 1 – polyethylene container, 2 – ring electrode, 3 – central electrode, 4 – capacitor battery, 5 – switch, 6 – solution drop, 7 – quartz tube, 8 – conductor insulation, 9 – cuprum conductor, 10 – kilovolt meter, 11 – constant voltage model.

Another difference is the possibility of ring electrode placement variation along vertical symmetry axis. It means that we can change the distance from ring electrode to liquid-air boundary and container bottom. We can vary electrical resistance of discharge interval "ring electrode – liquid surface" by these variations of electrode placement in container volume. The electrical scheme using in research, its compounds and requirements for them (allowable voltage and current values) are the same as in [2, 3]. The capacitor battery with capacity 500 micro Farads was charged by constant voltage model 11 up to 6 kV that corresponds to potential energy 9 kJoules. The discharge of capacitor battery was between electrodes 2 and 3 by circuit closing through discharger 5.

III. Experimental Results

The research of new sources of electromagnetic radiation in short wave range from infrared to roentgen frequency spectrum allow us to detect new laser effect appearing in electrolytes that is based on electric chemical luminescence. In this connection we have carried out experiments of discharge processes in weak electrolyte solutions with impurities. As the result of these experiments we observed new physical phenomena unknown in scientific literature. It lies in:

--The radiation in the form of distant light beam appeared as the result of electrical discharge process in a container with electrolyte that is registered by digital camera (fig. 2).

Fig. 2. The radiation from the electrolyte container (convex lens).

--Further investigations showed that the radiation is a beam of corpuscles (particles) with significant penetrability in different materials such as Cu, Pb, Fe, St etc. and also dielectrics.

--The property of corpuscular radiation focused by the variation of the form of container with electrolyte. It is shown that the radiation from a container in the form of convex lens is focused and the radiation from a container in the form of concave lens is defocused (fig. 3).

--Electrical discharge in electrolyte is accompanied by electromagnetic radiation of roentgen range.

New laser principle is based on a mechanism of electrical discharge influence on a medium, which is a weak electrolyte with activators (impurities). This regime is similar to electric chemical luminescence occurring in three stages:

--Dissociation of electrolyte molecules with activators in solution under the action of electric field.

--Further chemical energy liberation caused by molecule recombination and excitation of activator molecules.

--Excited molecule return to basic state with a radiation of electromagnetic field quantum.

The mechanism of corpuscular radiation is more complex and need further researches.

The analysis of experimental results allows us to make following conclusions:

--Distilled water with low conductivity (resistance is 300-500 kOhms) as dielectric does not demonstrate both creation of plasmoid and radiation.

--Insertion of small quantity of impurities (donors or acceptors) creates needed conditions to get optimal electrical discharge. In our experiments we used impurities Cl, Mg, Cu, S etc. resulting electrolyze reaction in water with some drops of acids (sulfuric, hydrochloric etc.). Obtained values of conductivity and water molecule mobility create optimal conditions for discharge accompanied both spherical plasmoid and corpuscular radiation of strange nature.

--In experiments we observed whole water volume glowing that can be explained as population inversion of electronic, oscillatory and rotatory levels of water molecules resulting electrical pumping and further radiation.

Fig. 3. The radiation from the electrolyte container (concave lens).

IV. The Phylosophy Of Experiments

There were two regimes of discharge:

1) If central cuprum electrode 9 overflows the drop surface 6 then electrical discharge occurred above the water surface with both light and acoustic energy liberations recalling blast. There was considerable quantity of ozone in the air. To photograph this process we have to use collection of light filters. Discharge photos are shown in fig. 4. The discharge was uniformly glowing plasma creation with a life time about several milliseconds. Gas was heated up to 5000 – 6000 K. We suppose that such great discharge power connected with water molecule dissociation on atomic hydrogen and oxygen with presence of air components (nitrogen, carbon etc.). Bonding energy of water molecule is 0,5 eV corresponding to gas temperature of splitting about 6000 K.

2) The central electrode 9 is inside the drop. Closing the discharge switch whole potential energy of capacitor battery concentrates in a drop. At the same time the leader stream forms and propagates along solution-air boundary. The plasma

blast is released from solution volume and further glowing plasmoid separates form this plasma blast and flies in the air. This process was registered by digital camera with 25 frames

Fig. 4. The discharge on the electrolyte-air boundary with two voltages: left picture – 4.6 kV and right picture – 6 kV.

per second (frame width is 40 ms).

The dynamics of plasmoid development is shown in fig. 5. Life time of visible plasmoid equals 6 frames, i.e. 0,24 s. There are four frames satisfactory illustrating this process. Favorable regimes of plasmoid creation is in a discharge voltage range from 3,5 to 4,6 kV. We experimentally investigate regimes accompanied by plasma blowout in a range from 2 kV to 6 kV. The discharge process decelerates in low voltage that was registered on oscilloscope current curve. It was established that both the duration of plasmoid creation process and its life time depends on not only electrical regime. It depends on electrolyte volume, ring electrode 1 square, temperature of surrounding air and liquid medium. We carried out in experiments in active medium varying its temperature from 273 K to 343 K. It was established that plasmoid life time was in 2 – 3 times greater when electrolyte temperature is 273 K.

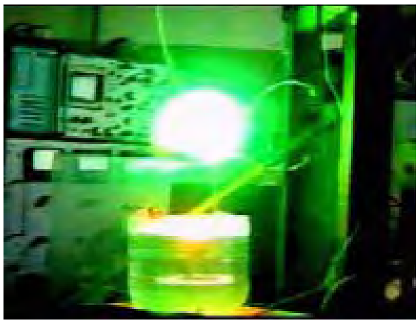
At a high temperature the plasma blowout is faster and the plasmoid form is not exactly a sphere. Increased life time of plasmoid at a low water temperature can be explained as in summary of [2, 3]. Hydrated plasma as puff of hot and moist air with lower temperature then surrounding air replenishes its internal energy from more hot air that allow them to make their life time longer.

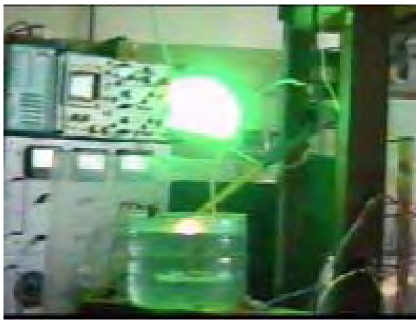
It should be noticed that discharge process depends on charging circuit time constant. Both parallel connection and a concatenation of noninductive resistances with the same conductivity as water were investigated. In the case when electrical charge partially leaves capacitor plate (about 1/6 stays) then discharge time can be determined as

$$i = \frac{dq}{dt} = -\frac{q_0}{T}\exp\left(-\frac{t}{T}\right) = -\frac{u_0}{r}\exp\left(-\frac{t}{T}\right)$$

where t – current time, T – circuit time constant, r – discharge interval resistance, q – capacitor charge.

Used water resistance is in the range 1 – 1,2 kOhms. Circuit constant is 0,5 sec for r=1 kOhm and C=0,5 mFarads. Then time of discharge from q to $q/6$ is 0,9 sec (U=6 kV *and* U=1 kV). This discharge time can be two times shorter with parallel switched resistance 1 kOhm and it can be two times longer with the same boosting resistance. At that the discharge power changes and can be adjusted by value U_0.





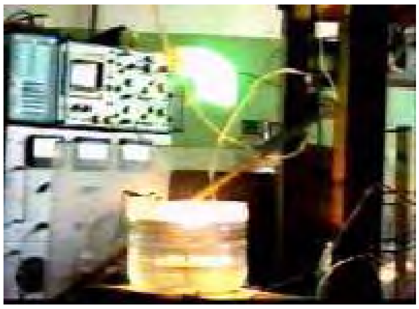


Fig. 5. The dynamics of the spherical plasmoid creation registered by digital photo camera with 25 frames per second.

It was imperative to detect the radiation of the electrical discharge on the electrolyte-air boundary. Toward this end the discharge placement was surrounded by opaque envelopes with photo paper. It is clear that visible radiation from polarized water (weak electrolyte) in clear polyethylene container can not spoil this photo paper. Experimental results show that the discharge creates a radiation of not only visible range, which is registered in photo paper as spots and tracks of different configuration. It is clear that this radiation is harder then the radiation of visible range. It must be the soft roentgen. Several photos of radiation are shown in fig. 6.

We should notice that such radiation was registered only above water container (above discharge) and from the bottom of container. It is necessary to use specific devices and methods for more detailed measurements of radiation properties and its parameters. Now we are carrying out such experiments and measurements.

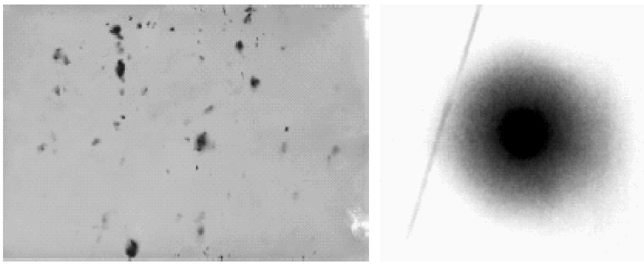


Fig. 6. Typical tracks of radiation registered in photo paper: left picture – discharge voltage is 4,6 kV and right picture – discharge voltage is 6 kV.

Also there is another main question about the intensity of liquid medium glowing. Authors of [2, 3] consider this glowing as the result of the recombination of ions concentrated in hydrated clusters of spherical plasmoid and there is no information about liquid medium glowing. In the other hand great number of our experimental results show that the process of liquid medium glowing starts long before plasmoid creation as it is shown in our photos. Liquid medium polarization, which is registered by visible glow, appears not in the form of cone (from ring electrode base to the vertex of cone in the point electrode 2). Liquid medium polarization appears as glowing disks in whole volume of a solution from the container bottom to a surface (fig. 7). At the moment when whole cylindrical spout is in the form of single glowing object the liquid medium is ready to create a plasmoid. This mechanism acts even if ring electrode diameter is less then the container diameter.

Fig. 7. One of the final states of liquid medium polarization and its glowing at the moment of plasmoid creation.

V. Conclusion

Given experimental research shows that hydrated plasma is not good studied matter state. It depends on surrounding air, many other parameters of discharge medium, particularly, its temperature and conductivity. We carried out experiments in a wide energy range from 9 to 2 kJoules with voltages up to 6 kV. The focusing property of discharge process defined by electrolyte container form is found out. Both ionizing and electromagnetic radiation with hard photons are detected. To explain discovered properties of discharge process we apply electric chemical luminescence phenomenon.

References

[1] *Physical encyclopedic dictionary*/ ed. A.M. Prokhorov. M.: Sov. Enc. – 1984.

[2] A.E. Yegorov, S.I. Stepanov, "Long-living plasmoid – an analogue of ball lightning in moist air," *JTF*., vol. 72, n. 12, 2002, p.p. 102-104.

[3] A.E. Yegorov, S.I. Stepanov, G.D. Shabanov, "Demonstration of ball lightning in the laboratory," *UFN*, vol. 174, n. 1, 2004, p.p. 107-109.

[4] G.N. Gestrin, A.N. Kuleshov, B.P. Yefimov, "On Conditions of Creation of Long-Living Electron Bunches in Motz Undulator and Other Systems," *Conference Digest of the 2004 Joint 29th Int. Conf. on IRMMW and 12th Int. Conf. on THz Electronics*, Sept. 27 - Oct. 1, 2004, Karlsruhe, Germany, p.p. 611-612.