

Dark Electric Current in Liquid and Second Law of Thermodynamics

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Abstract: *The principle of nondecreasing entropy in unclosed system, which is one of the formulations of much-talked-about second law of thermodynamics, can be violated. It turns out that the entropy of a quantum system can decrease with time. Perhaps that is why the strength of the dark current in a liquid in contact with two unequal aluminum electrodes depends on the ambient temperature. The environment simultaneously affects two sources of dark current. Chemical reactions between aluminum and distilled water are not involved in the formation of the dark current.*

Key Word: *Voltage, Electric current, Water, Aluminum, Simultaneous measurements, Correlation, Time dependence of voltage, Violation.*

Date of Submission: 12-03-2021

Date of Acceptance: 27-03-2021

I. Introduction

In physics and in electronic engineering, dark current is the relatively small electric current that flows through devices even when no photons are entering the device. It consists of the charges generated in the detector when no outside radiation is entering the detector. Physically, dark current is due to the random generation of electrons and holes within the depletion region of the device [1]. If voltage applied to two electrodes of such devices, value of the dark electric is typically 10^{-7} A. Another thing if a photosensitive device consists of two metal electrodes immersed in water [2]. In this case the value of dark electric current can achieve 0.1 mA without external voltage [3]. There is every reason to suspect that the dark electric current in liquid is of thermodynamic origin. The fact is that the strength of the dark current depends on the ambient temperature, which in turn is somehow connected with the violation of the second law of thermodynamics. The second law of thermodynamics states that one cannot get work by transferring heat from a place of low temperature to one of high temperature by any inanimate agency. If this law were not true, one could use the heat in the atmosphere's air to move bodies. In order to move the energy is necessary. The moving body losses energy, its energy, in one way or another associated with temperature, decreases. True, all this applies to classical thermodynamics [4]. In quantum physics and in physics of unclosed systems, not everything is so simple.

Classical mechanics predicts that particles that do not have enough energy to classically surmount a barrier cannot reach the other side. In quantum mechanics, these particles can, with a small probability, tunnel to the other side, thus crossing the barrier. Quantum tunneling is not predicted by the laws of classical mechanics where surmounting a potential barrier requires potential energy. If the barrier is a thin oxide film of aluminum, then the charged metal particles, having passed the barrier, appear inside the metal. Charged particles of the medium, having passed the barrier, appear inside the metal [5]. The total charge of two dissimilar aluminum electrodes immersed in a liquid becomes nonzero. The electric field created by these charges is not electrostatic one, therefore, it can create an electromotive force and a electric current if the asymmetric electrodes are shunted by some non-infinite resistance.

Such a simple hypothesis, arguing for the appearance of a dark current, requires confirmation. It's not about whether it's fair or not. To tell the truth, this hypothesis seems doubtful, but the dark current in a liquid in contact with two aluminum electrodes flows without noticeable attenuation for a very long time, weeks or even months [6]. Can an aluminum-water condenser located in a heated environment produce electrical energy, violating the classic version of the second law of thermodynamics [7]? This is the question that needs to be answered.

Chemical reactions occurring in one cell with two dissimilar aluminum electrodes in the liquid have nothing to do with what happens in the other. Therefore, the voltages created by two approximately identical cells with aluminum electrodes immersed in a liquid should be measured simultaneously. If electrical energy is generated by the environment, this will be recorded. If these are two ordinary chemical sources, then there should be no correlation between voltages in principle.

II. Measurements

The setup shown in Fig. 1 enables to measure simultaneously voltages created each sources. The main part of the each source is a cell (V) filled with distilled water (L). Two electrodes cylindrical (C) with diameter 7 mm and spiral-shape outward (S) with average diameter 70 mm and with step between wraps of 10 mm are immersed in the water. The diameter of aluminum wire of the aluminum electrode is 4 mm, the high of the spiral is 40 mm. The depth of immersion was 6 cm. The cell with distilled water is inside of a thermostat (T) filled with usual water. Voltages U_1 and U_2 on the load resistances $R=50\text{ k}\Omega$ are registered simultaneously each 100 seconds using a memory oscilloscope (O). At first glance it seems that a thermostat is surplus detail in this equipment. Not certainly is that way. As a mater of fact, the radiator played a role of a damper smoothing random fluctuations of temperature.

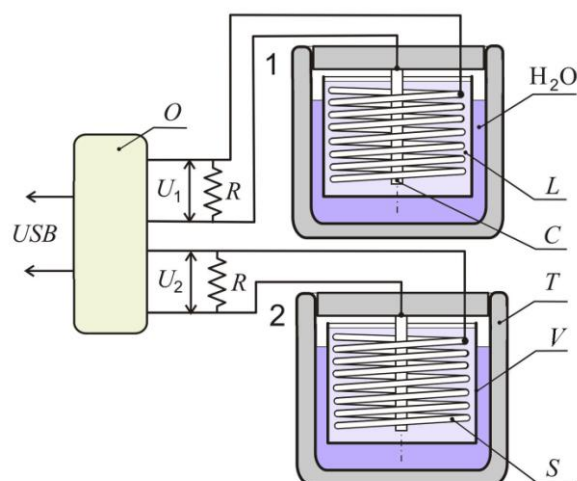


Fig. 1. Simultaneous measurements of voltages U_1 and U_2 .

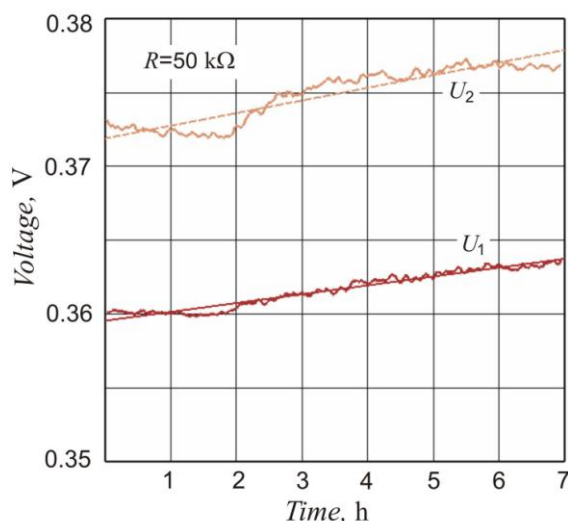


Fig. 2. Time dependencies of voltages and their approximations.

What is shown in Figure 2 means that the voltages are dependent on the external environment. An increase in the voltage created by one source is accompanied by an increase in the voltage recorded by the second channel of the electronic oscilloscope. In other words, a simple solution to the problem, assuming the dominant role of chemical reactions, did not take place.

III. Correlation

The results shown in Fig. 2 do not make it possible to reliably exclude chemical processes from the formation of the dark current. Correlation is visible but not confirmed. To make sure that there is a correlation, it is necessary to consider the dependence of one voltage on another. If chemical processes are present, this dependence should differ from the proportional one. Proportionality is the only condition for the independence

of sources from each other. To make sure that there is a correlation, it is necessary to consider the dependence of one voltage on another. If chemical processes are present, this dependence should differ from the proportional one. Proportionality is the only condition for the independence of sources from each other. The dependence of U_2 on U_1 should be the same as U_1 on U_2 . This is possible only if $U_2 = \alpha U_1$. Chemical processes in sources, if they exist, should violate this proportionality.

The each time dependence shown in Fig. 2 can be approximated by

$$U_i = a_i + b_i t,$$

that means

$$U_2 = a + bU_1, \tag{*}$$

with

$$a = a_2 - b_2 a_1 / b_1, b = b_2 / b_1.$$

Now there is everything to pay attention to the dependence of one voltage drop on another (Fig. 3). The dependence of U_2 on U_1 is not only linear (*), but also proportional: $U_2 = \alpha U_1$. Small, but significant differences between these dependencies are quite comprehensible by variations in voltage drops, not only stochastic, but also periodic. This is not the influence of the chemical processes in the sources, it is the error of the approximation method and lack of a limited number of experimental data.

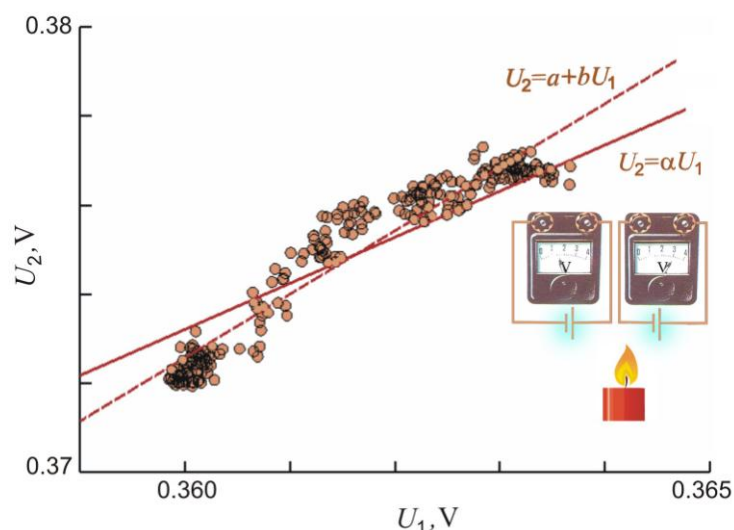


Fig. 3. Correlation between voltages.

IV. Conclusion

Simultaneous changes in the dark current occurring in two independent sources cannot be explained by chemical processes that occur when a liquid is in contact with a metal. The strength of the dark current in one source is proportional to the strength of the current in the other. The only reasonable explanation for this effect is the influence of the environment. The microscopic transfer of energy from one body to another is called heat transfer. So it turns out that the second law of thermodynamics in its classical formulation does not agree with the existence of a dark current in a liquid in contact with aluminum. This is an experimental fact that confirms the quantum nature of such a dark current.

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