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Time and Temperature Variations of Dark Electric Current in Liquid

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ABSTRACT : *Electric current is influenced by the electromagnetic field, temperature and other processes taking place in environment. Referring to the initially periodical influence arising everyday, it was possible to show that variations of the dark electric current in liquid are caused by changes of the temperature.*
KEYWORDS: *Dark current, Voltage, Temperature, Fourier analysis, Oscillations.*

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I. INTRODUCTION

In physics and in electronic engineering, dark current is the relatively small electric current that flows through photosensitive devices such as a photomultiplier tube or photodiode 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 aluminum electrodes immersed in water [2]. In this case the value of dark electric current can achieve 0.1 mA without external voltage [3].

External electric and magnetic fields, including ones of Earth, can affect on usual electric current and on dark current as well. On the other side, the electric and magnetic fields of Earth experience short-time daily variations which can be registered measuring the value of the dark electric current in liquid. Remembering that the temperature of environment is also varies within day, it gives a possibility to know the external conditions affect on the dark electric current or not.

II. MEASUREMENTS OF LIQUID TEMPERATURE AND DARK ELECTRIC CURRENT

In order to separate the process of heat transfer created by the laboratory environment in the liquid from the external influence on the electromotive force created two asymmetric aluminum electrodes immersed in the water, measurements of these two values should carry out simultaneously [3].

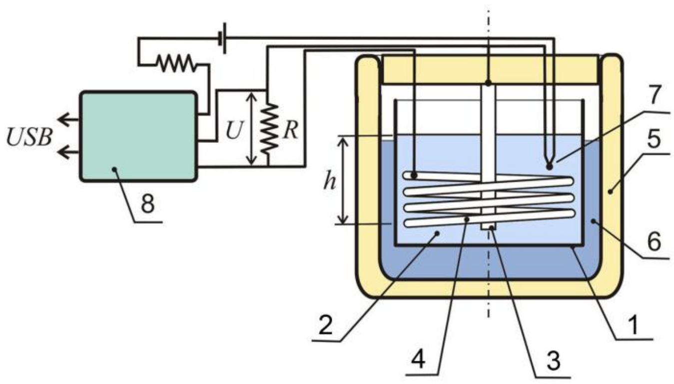

Fig. 1. Experimental setup

The setup shown in Fig. 1 enables to do it with high accuracy. The main part of this device is a cell (1) filled with distilled water (2). Two electrodes (cylindrical (3) with diameter 7 mm and spiral-shape outward (4) 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 *h* was 4 cm. The cell with distilled water is inside of a thermostat (5) filled with usual water (6). Also immersed in distilled water is an electrically insulated temperature-sensitive resistor (7). Voltage *U* on the load resistance *R*=500 kΩ simultaneously with the temperature *T* of the liquid is registered each 10 seconds using a memory oscilloscope (8).

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.

There was a suspicion that this experiment enables to detect variations of the voltage *U* ant temperature *T* caused by the electric and magnetic field of Earth. Therefore details of the experiment must be described. Measurements were started in the Laboratory 12A of Faculty of Physics of Southern Federal University (Rostov-on-Don, Russia, northern latitude $47^{O}13'$, eastern longitude $39^{O}43'$) at 19 o'clock (local time) 16 August 2020 and continued for 2 weeks.

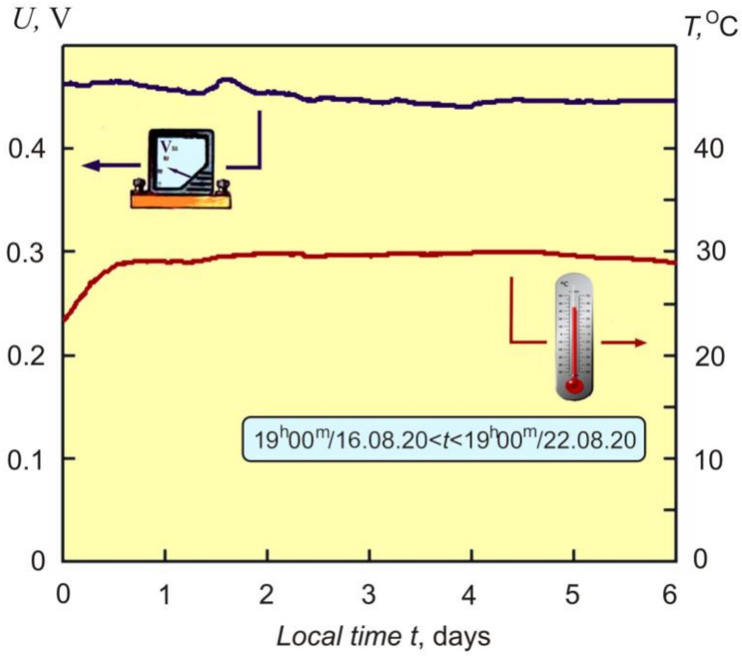

Fig. 2. Typical dependencies of the voltage *U* and the temperature *T* of liquid on time *t*

Shown in Fig. 2 a 7-day fragment of experimental results on the time dependencies of the voltage and the temperature demonstrates the daily variations of these values. Variations are indeed present however their parameters together with relations between them can be established after processing experimental data.

III. PROCESSING EXPERIMENTAL DATA

First of all, one should remove the long-time trend created by change of environment. A way to do this is to use the so-called smoothing procedure [4]. In processing experimental data, to smooth a data is to create an approximate function that attempts to capture important patterns in the data, while leaving out rapid phenomena. Therefore one can save rapid fluctuations after removing the result of the smoothing representing the trend. If U_k is the sequence of experimental data on the voltage, T_k is the same of the temperature and *s* is the window of smoothing, that

$$\delta U_j = U_j - \sum_{k=-s/2}^{s/2} U_{j+k} / s,$$

$$\delta T_j = T_j - \sum_{k=-s/2}^{s/2} T_{j+k} / s,$$

are the sequences which describe variations of the voltage and temperature without the trend.

It is expected that a time scale of daily variations of the voltage and the temperature is about a part of day. This means that the width of the smoothing window *s* must be order of the same time interval. The smoothed experimental dependencies on the voltage and the temperature of the liquid are shown in Fig. 3.

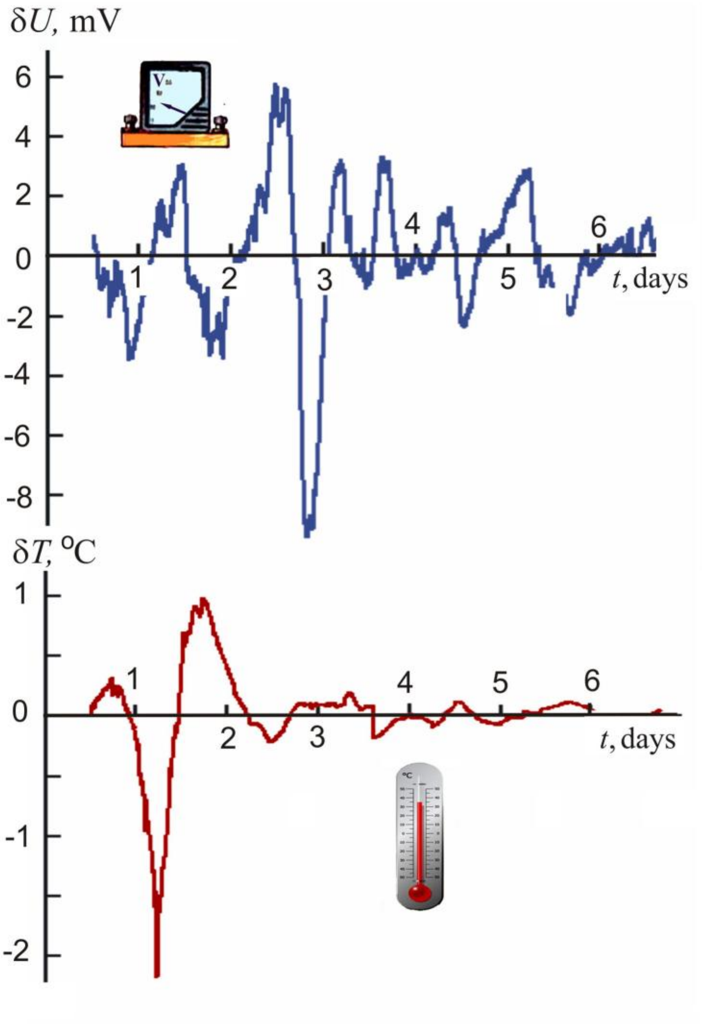

Fig. 3. Variations of the voltage δ*U* and δ*T* with time

With all desire, it is impossible to connect the variations of the voltage δU with that of the temperature δT. An increase of the temperature does not lead to the variation of the voltage. Paying attention to voltage, the variations of this value should be investigated independently with respect to temperature of the liquid. After considering the dependence of variations of the voltage one may suspect that the values of δU versus time t depend periodically with period of order 1 day. One cannot test it without Fourier analysis [4] which enables to determine the period of such oscillations τ.

Fourier analysis represents the sequence δU by sums of simpler trigonometric functions

$$\delta U_j = A\cos(\frac{2\pi t_i}{\tau}) + B\sin(\frac{2\pi t_i}{\tau}),$$

with unknown value of period τ.

This means

$$A = \frac{2}{n\tau}\Delta t\sum_{k=1}^{n}\delta U_k \cos(\frac{2\pi t_k}{\tau}),$$

$$B = \frac{2}{n\tau}\Delta t\sum_{k=1}^{n}\delta U_k \sin(\frac{2\pi t_k}{\tau}),$$

where $\Delta t = t_{j+1} - t_j$ and n is the maximal number of periods in the sequence. Calculations of the amplitude $(A^2+B^2)^{1/2}$ at various τ show that the oscillations of the voltage arise with the periods τ differ from 1 day and half of day (Fig. 4). Too few days in two weeks of exposition in order to expect that the values of τ will coincide with 12 hours and 24 hours but the periodicity of the dark electric current is established.

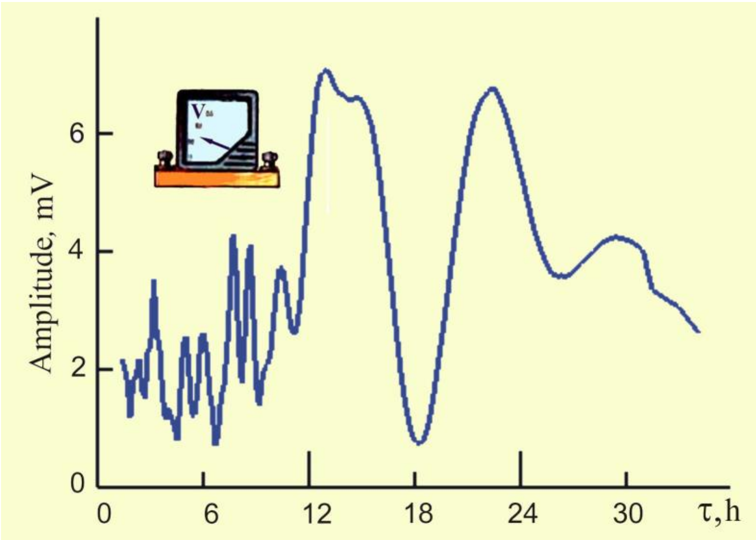

Fig. 4. Fourier analysis of the time variations of the voltage δ*U*

A different method is needed to find out whether the voltage depends on the local daily time or not. Sometimes the simples method demonstrates more reasonable results.

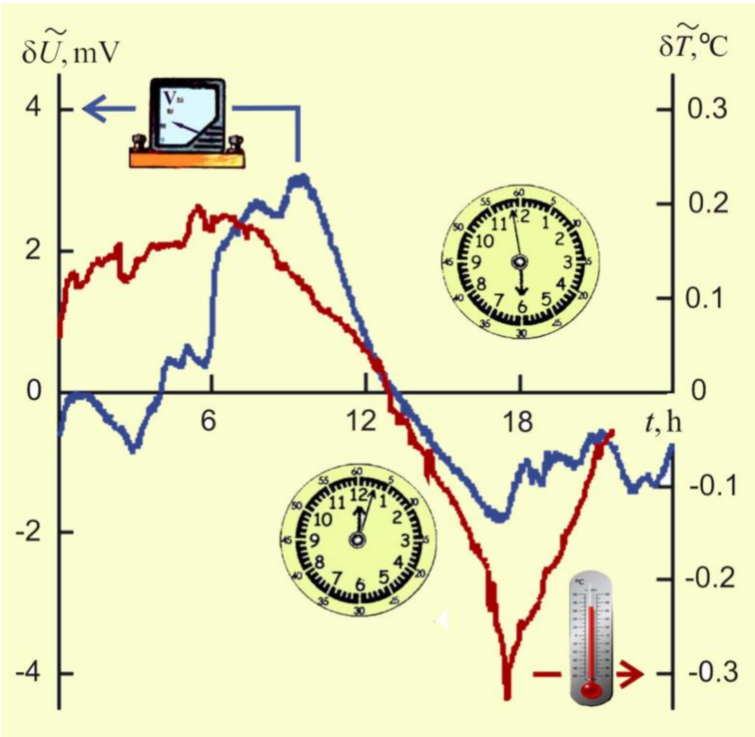

Fig. 5. Daily variations of the voltage and the temperature

A simple and appropriate way to study the daily variations is curry out convolution [5] of the sequence δU and δT for the size N=24 hours/Δt:

$$\delta \tilde{U}_k = \frac{1}{n}\sum_{k=1}^{N} \sum_{j=1}^{n} \delta U_{k+N(j-1)},$$

$$\delta \tilde{T}_k = \frac{1}{n}\sum_{k=1}^{N} \sum_{j=1}^{n} \delta T_{k+N(j-1)}.$$

This method is wrong with presence of trend which does not apply to δU and δT. The time dependence of the daily variations $\delta\tilde{U}$ is shown in Fig. 5. This dependence is independent with respect to that shown in Fig. 4. First of all, the time interval between maxima of the daily variations of $\delta\tilde{U}$ is about 12 hours that can be explained as a result of the daily changes of the environment temperature.

IV. CONCLUSION

This is another step toward explaining what creates the dark electric currents in liquid. Without such understanding it is almost impossible to improve parameters of the source of the dark electric energy in the liquid.

After considering an initially periodical process, it was possible to separate variations of the voltage due to an external influence from that created by the changes of the environment temperature. The use of the Fourier transformation of the measured dependence of the voltage versus time enables to determine the period of oscillations of the electric current in the liquid.

In fact, this work confirms that this energy source is not a closed system. The second law of thermodynamics accordingly which heat flows from high-temperature regions to law-temperature ones for such system is not required [6].

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