The construction of the Pure homopolar generator reveals physical problem of Maxwell's equations.

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ABSTRAKT

In this article, we present a part of the research results during 2012-2015, which shows that there must exist another description of Faraday's homopolar generator than the generally acknowledged one. For example, as a device that simulates necessary and sufficient condition for induction. This paper presents the experimental pure homopolar generator (PHG, defined as a generator that does not need any brushes, electronics or semiconductor to ensure the generation of direct current) as a proof that the movement of an electrically neutral conductor in homogeneous circles of magnetic field does not induce any voltage. It is happening in spite of all physical/technological alterations for the sake of theoretical functionality. In the experiment described here, these theoretical requirements are achieved through an effective shielding by high-temperature superconductors. The reason for this negative result may be the fact that PHG only complies the necessary but not sufficient condition. In contrast, the relativistic explanation of Faraday homopolar generator (hereinafter referred to as FHG) seems to be misleading and unrealistic in the context of the article on the experiment described. If we still insisted on the correctness of Maxwell's concept, we would have to admit that the heterogenous field can be shielded from a perspective of any outer system of reference, but such a system of reference for homogenous circles of magnetic field would not exist.
Part of this article is an analysis which shows that the current electrodynamics achieves good agreement between theory and practice, mainly due to the use of tabular electromagnetic constant. These constants represent redundant linear transformations. We shall show that knowledge of the average field declivity can simplify attainment of the compliance of theory with practice. We introduce a novel conception that improves the experimental prediction. The theoretical impact of the experiment described in this article is fatal with significant practical potential. Despite partially antagonistic results of the experiment with contemporary theoretical ideas, both concepts can coexist in practice with a wide range of value conformities, and need not be necessary to make correction for practical use of current electrodynamics.

Introduction

2015 was the year of the 150th anniversary of the genesis of classical Maxwell equations. We therefore decided continually step by step to confront academic public with the results of our research and analysis. Nowadays we have come to the strong opinion that it is necessary to acquaint wider professional community with negative results of the experiment carried out on superconductor shielded PHG and familiarize with the design of concept that can explain this negative result. Our view and results point out contradiction in the physical essence of so-called Faraday's Law describing emergence of electromotive force (EMF) as consequence of the time change of the magnetic flux. The result also shows that the relativistic explanation of Faraday generator can only be modern, but not physically relevant. We show that Faraday's paradox [1] has two explanations: The traditional relativistic approach using the continuity equation [2] and a non-traditional one, which shows that the validity of Faraday's law is not a sufficient condition for occurrence of electromagnetic induction as it does not explain the non-functionality of shielded PHG. In this paper, we provide an analytical proposal of a dual theory based on a more complex interaction between wire and field. We eliminate on of the myths of current electro-dynamics, which says that there could be an FHG solution independent on brushes.

Results

Motivation and performed experiments

In 2012, we made an attempt to revive industrial applications based on FHG. The drawback of FHG is the necessity of using brushes. Therefore, an experimental homopolar generator was designed to eliminate this drawback.

Our proposal exactly corresponds to the contemporary theoretical ideas of FHG function. Mathematically it is described by the well-known equation formulated by James Clerk Maxwell around 1865 [3, 4]

$$\mathscr{E}_m = -\frac{d\Phi}{dt} = \oint_l \vec{E}_m \cdot d\vec{l} = \int_S rot\vec{E}_m \cdot d\vec{S}, \qquad (1)$$

where index m means determination of origin: *Maxwellian value*. Figures 2, 5, 6 and 7 show the way of brush elimination. In PHG, as shown in Fig. 2, the conductance path enters the isomagnetic radials of the magnetic field perpendicularly at two opposite, axially magnetized, synchronously rotating rings. The output of conductivity path is provided by the central conductor passing through the hollow shaft as shown in 7. Assuming that we provide superconductor shielding of a wire $\vec{j}$ of measuring circuit inlet, S, PHG function in Figure 2 will theoretically be similar to the brush solution of FHG [5, 1]. To achieve correct function of such shielding, a YBaCuO crystal based superconductor was selected [6]. Shielding has two aspects:

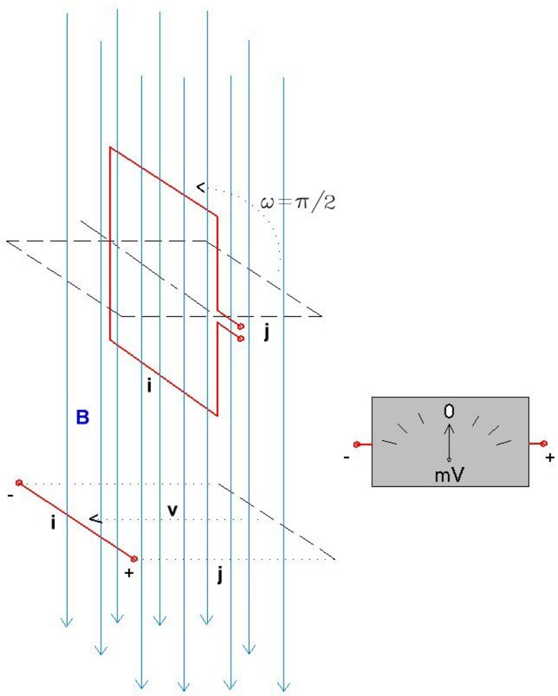

Figure 1. The Upper part of the image graphically illustrates the special case of a rectangular loop rotation of angle $\pi/2$, which causes a change of homogenous magnetic flux $\Phi = \vec{S}.\vec{B}$ from maximum to minimum, and which is equivalent to the movement of the conductor of length $\vec{i}$ the path $\vec{j}$ at the bottom of the image. In both cases, the same mean EMF $\mathscr{E}_m$ should be induced.

- It provides a comparison of activity between PHG and FHG from the point of the Lorentz force creation [7] - the shielded part of the wire will not interact with the external moving field alike the inner part of the FHG disc. Deformation of the surrounding field adjacent to the superconductor shielding has no impact on the final stability of the field with respect to the closed loop $l = i + j + k + i' + k'$.
- It ensures theoretical induction unbalance between positive and negative contributions of EMF on the loop of length l according to the integral of length from equation (1). This will allow assessing the induction occurrence in PHG from viewpoint of equations derived from the continuity equation.

In theory, the function brushless model of Faraday's generator should be equivalent to the brush solution. Current theory is based on the fact that the cause of induction can be explained, in terms of general geometry, using the Stokes's theorem. This theorem converts the length integral of electrical intensity $\vec{E}_m$ over length of conductive coil to a surface rotation integral $rot\vec{E}_m$ over the surface delimited by the coil ohraničuje dle (1). The emergence of electric intensity $\vec{E}_m$ should therefore be conditioned by direction and velocity $\vec{v}$ of elementary lengths of winding in a homogeneous magnetic field of magnetic

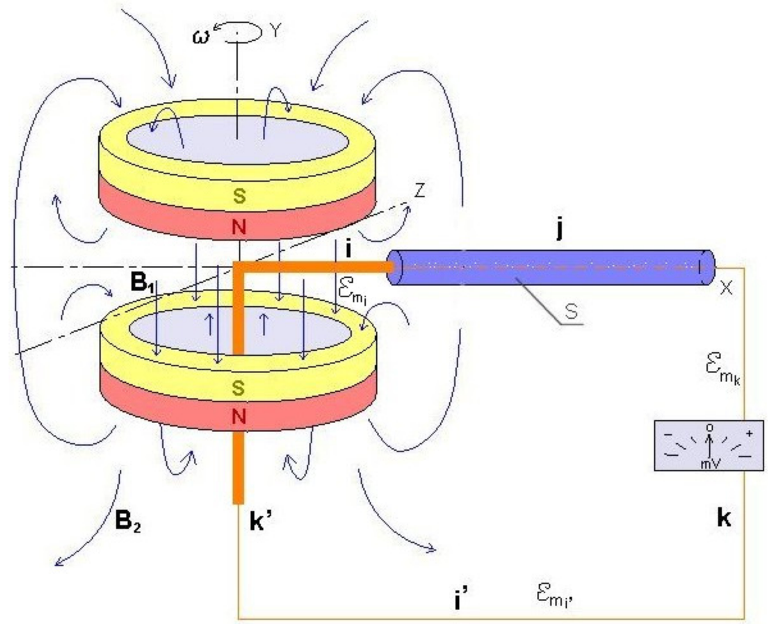

Figure 2. Axonometric illustration of PHG function: Neodymium magnetic rings rotate at the angular velocity of ω with respect to a fixed enclosed wire $l = i + j + k + i' + k'$. The scheme shows the superconductor shielding S, which prevents the external magnetic field from entering the wire segment $\vec{j}$.

induction $\vec{B}$, or equivalently by changing of magnetic flux $\Phi = \vec{S}.\vec{B}$ through the surface $\vec{S}$ encircled during time Δt. Ultimately, this situation can be simplified and represented as shown in Figure 1, where in the upper part, the loop performs axial rotation by a quarter of the period. This partial turn of one winding creates a relative change in area $\vec{S} = \vec{i}.\vec{j} \rightarrow 0$ against the magnetic induction $\vec{B}$ during time Δt, which is encircled by the winding, and which the imaginary magnetic flux Φ of homogenous magnetic field passes. A mean $\mathscr{E}_m = \Phi/\Delta t = \vec{i}.\vec{j}.\vec{B}/\Delta t = \vec{i}.\vec{v}.\vec{B}$ should thus be induced. According to this theorem, it is therefore equivalent to moving of the wire with length $\vec{i}$ along the path $\vec{j}$ with the speed $\vec{v} = \vec{j}/\Delta t$. So, even in the latter case, EMF $\mathscr{E}_m = \vec{E}_m.\vec{i} = \vec{v}.\vec{B}.\vec{i}$ should be induced with the same mean value as in previous case. According to Figure 2, it is obvious that the conductor $\vec{i}$ at PHG performs similar relative movement as in the bottom of Figure 1 with the fact that this movement is circularly oriented.

Now, let us analyse the application of current theory to

PHG as shown in Fig. 2 without shielding S: For the surface integral, we consider the plane $[x,y]$, which is parallel to the measuring loop; thus we obtain $\Phi = 0$ for surface $\vec{S} = (\vec{i} + \vec{j}) \times \vec{k} = \vec{i'} \times \vec{k'}$ delimited by this loop. The induction flux in the unshielded PHG will be constant, inducing no voltage. With respect to the length integral, the external magnetic flux lines are opposed to the internal flux lines by direction (vector orientation) and their impact the wire loop is inverse. Due to the Lorentz force, which - in theory - influences free electrons by the relative motion of arm $\vec{i} + \vec{j}, \vec{k}, \vec{i'}$ of the closed loop l (the segment $\vec{k'}$ being neutral) with respect to the magnetic induction vectors $\vec{B}$, the positive and negative EMF contributions are theoretically in balance, in accordance with the assumption $div\vec{B} = 0$ and with the experimentally compiled chart shown in Fig. 3: $\mathscr{E}_m = \int_0^l \vec{E}_m \cdot d\vec{l} = 0$.

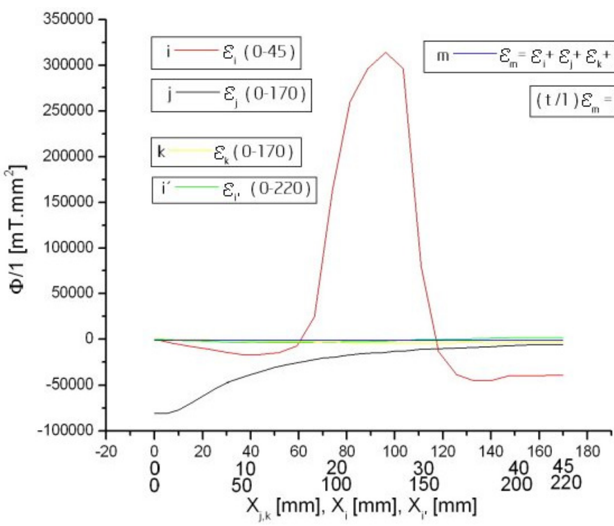

Figure 3. Chart of inductive flows per one turn that occur in closed PHG loop without shielding. The blue line represents the resulting sum of the $\mathscr{E}_m$ at one revolution per second. The red line represents the course of contributions $\mathscr{E}_{m_i}$ on the path $\vec{i}$ between the magnets. The black line represents the course of the largest external contributions $\mathscr{E}_{m_j}$ of the loop part $\vec{j}$, which is undesirable and we need to shield it off. The yellow line represents the course of small contributions $\mathscr{E}_{m_k}$ of the loop part $\vec{k}$. The green line represents the residual course of contributions $\mathscr{E}_{m_{i'}}$ of the part of the loop $\vec{i'}$. The graph was created by the sum of measured values in accordance with the length integral in equation (1)

Therefore, there is a theoretical as well as experimentally proven equivalence between the induction flux through the loop area and the assumed voltage induced in the wire loop delimiting that area as per (1). Fig. 3 shows the results of measurement made at positions close to the PHG magnets.

For the compilation of Chart 3, perpendicular component of each magnetic induction $\vec{B}$ with respect to wire l was conveniently selected. When measuring using a 3D teslameter, the most convenient way was reading the value directly on the display. This can be achieved by aligning one of the teslameter coordinates with the wire axis, while the second coordinate is aligned with the velocity vector and the third one is used to create the chart as shown in Fig. 3 or 4, respectively.

To be certain about Maxwell's equations (1), we need to test the induction by moving the wire at least within the homogeneous radials of the magnetic field. Let us focus on the occurrence of Lorentz force in PHG, which is theoretically purer and more interesting in technical terms, as shown in Fig. 2. Thus we ensure the induction misbalance between the positive and negative EMF contributions in the closed loop as shown in the chart in Fig. 4.

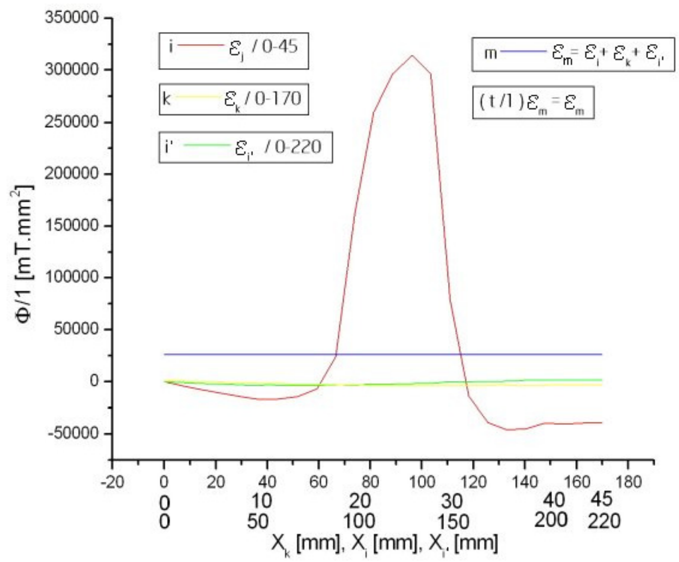

Figure 4. Similar to the previous graph of inductive flows per one revolution, which occur in closed PHG loop at the shielding of undesired return wire $\vec{j}$. The blue color represents the resulting sum of the EMF $\mathscr{E}_m$ at one revolution per second, which can be assumed for a PHG adjusted in such a way.

The sectional magnetic flux cannot be used in PHG in this case because by shielding the external part of the wire using the massive YBaCuO crystal based superconductor shielding up to 100 [mT] [6], we actually obtain an open circuit[1]. Similarly, the circuit is also open in these terms in FHG, where - on the contrary - the internal part of the conductance path represents a similarly shielded segment because the technical solution of this part cannot contribute to the EMF creation. The difference between PHG and FHG consists in the fact that in FHG, it is the external flux lines of magnetic induction of a circularly homogenized magnetic field which are in relative motion with respect to the external frame with the brush

[1] The circuit is open in terms of external field generated by the neodymium magnets.

[2] In technical practice and in media, we usually see the contrary description, which says that the Lorentz force is generated directly in the FHG disc[8]. In terms of Maxwell's equations, this description is not complete but leads to identical mathematical results - this is caused by preserving the continuity for both internal and external magnetic flux [2] $\Phi_{\mathbf{B}_1} = \Phi_{\mathbf{B}_2}$. This description involves secondarily applied equivalence only with the internal flux $\Phi_{\mathbf{B}_1}$ through the area delimited by the rotating disc. Thus the existence of the external flux is omitted and the description is incorrectly simplified. As per this logic, the unshielded PHG should be functional as well, which is not true.

and measuring loop wire. The internal part of FHG is still with respect to the magnet's flux lines as both parts are fixed together[2]. In PHG, though, the external flux lines move in the area of vectors $\mathbf{B}_1$[3] of the circularly homogenized magnetic field with respect to the internal wire $\vec{i}$. The external area of vectors $\mathbf{B}_2$ in the vicinity of the external part of wire $\vec{j}$ with the most intensive magnetic field is shielded from the theoretical effects of the relative motion of flux lines. The shielding is over-dimensioned[4] because the measured induction values of the external magnetic field amounted to an average of 23,76 [mT].

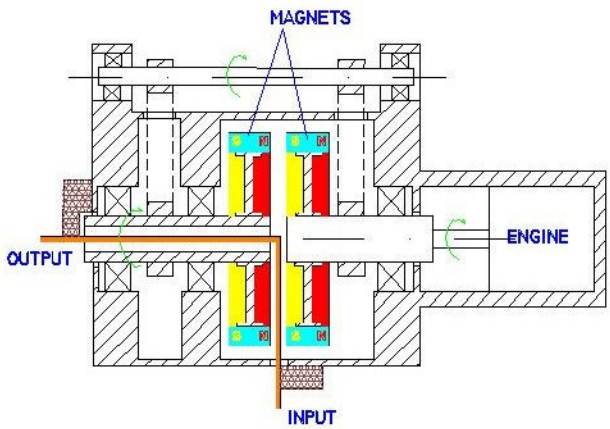

Figure 5. Schematic cross-section through technical solution of PHG, which allows to put in practice the principal arrangement of two opposite and axially magnetized neodymium rings and the wire entering between these rotating ring and going out, as shown in Figure 2.

The maximum measured value was 96,6 [mT]. This means that the superconductor shielding must lead to the result of deflecting the magnetic field, which flows around the wire without influencing it. For the circuit (coil) length l in consideration, as shown in Fig. 2 and in accordance with the chart in Fig. 4, the theoretical induction balance between positive and negative EMF contributions must be disturbed, i.e. $\mathscr{E}_m = \int_0^l \vec{E}_m \cdot d\vec{l} \neq 0$. There must be a surplus measurable induced voltage as a part of the circuit with a length of j does not contribute to the induction. Equivalence with the induction flux as per (1) is not possible as the shielding forms an open loop for the magnetic field. In terms of occurrence of Lorentz force, the differential voltage induced in shielded PHG must be equivalent to FHG. The blue line in Fig. 4 show the potential level, which we should theoretically obtain from experimental data after shielding the return line $\vec{j}$. It is this very experiment, which must determine the final decision as to the physical validity of the Maxwell's equation (1).

Here we could elaborate in more detail on the topic of preserving continuity, which forms a base for mathematical theorems used in electro-dynamics. The main assumption for using these theorems is the validity of the continuity equation [2], which preserves both the input a output flux. We know though that the magnetic field actually does not represent any real flux. It is rather an oriented field, which diminishes with growing distance from both poles. If we use a comparison to

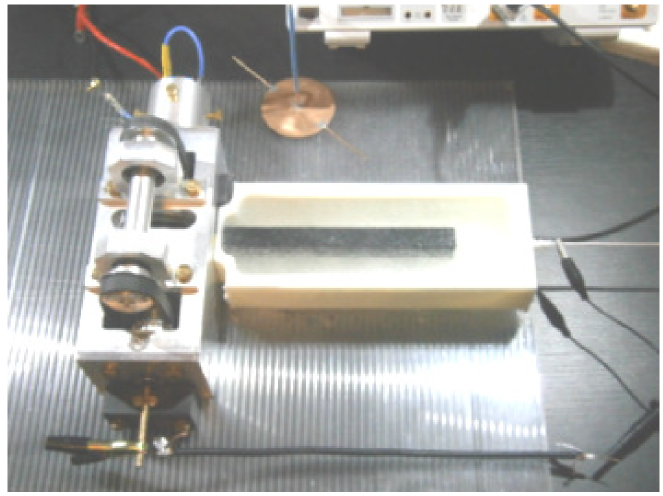

Figure 6. Brushless homopolar generator docked onto the superconductor shielding system in liquid nitrogen - real experimental model.

Figure 7. Detail of the conductive path with output through the hollow shaft.

a flux and define a direction, it appears in such a way that the flux is diluted in the space and thickens again at the second pole[5] as if the field flew from the previously defined initial pole to the defined counter-pole without any losses. The dilution and thickening of the field flux should occur with a simple limitation that $div\vec{B} = 0$ in any measured area [2]. If this limitation did not exist, than the field flux should decrease in the space with growing distance ($div\vec{B} < 0$) and increase again symmetrically to the original value when approaching the second pole ($div\vec{B} > 0$). In this case, in the unshielded PHG as shown in Fig. 2, a non-zero EMF should be theoretically induced with respect to the asymmetrical position of the

[3] Area of short flux lines between the magnet rings, which mainly emanate from the axial surface of pole N and enter symmetrically into the counter-pole S.
[4] The manufacturer declares a shielding efficiency of 100 mT.
[5] This comparison is rather suitable for gases than liquids as in liquids, we speak on changes of velocity, not changes of density.

wire loop l. The equivalence (1) would not be valid in such a case. It is out of scope of this paper to present a table of experimental values, namely due to the apparent remarkable coincidence with the assumption $div\vec{B} = 0$. The slight surplus $\mathscr{E}_m$ on the external loop shown in the chart in Fig. 3 is, in this case, rather caused by measurement error.

We can conclude that the physical application of the continuity equation to a magnetic field actually only describes the theoretical course of flux lines as an analogy with liquid flow. However, this description does not imply, in logic terms, the ability of direct induction cause by mere movement of the wire in an idealized homogeneous field. It just corresponds, in mathematical terms, with the equivalence of surface integral. For example, the analogy of the Biot–Savart law, which describes the movement of an electrical charge in a homogeneous magnetic field, is also applied to an electrically neutral conductor - which is indeed not a direct logical way. The only class of experiments, where the consequences of movement of conductor in an invariable magnetic field is objectively measurable, is based on PHG, which does not included any brushes. (FHG-based experiments are disputable as the brushes can have a physical impact on the process.) It is the only experiment class, which can objectively prove the validity of Maxwell's equations. The reason is simple: we are only able simulate homogeneous radials of the magnetic field. All other experiments are based on heterogeneous fields. Theoretical accordance with practically measureable electrodynamics is achieved using various electromagnetic constants e.g. In the form of environmental permeability. This could lead to a false physical notion of induction occurrence.

Tests on PHG with shielded measuring wire did not prove induction of any voltage at the level of one millivolt. We have repeatedly used a shielding technology as follows: At first, there was performed hypothermia of low temperature superconducting shielding of the measuring wire by means of liquid nitrogen at a distance of about 4 [m] from permanent magnets of PHG. In the next step, the PHG was slowly drawn near and conductively docked to the shielded wire with connected millivolt oscilloscope using an oscilloscopic probe. When connected, the oscilloscope recorded closing of the circuit that has been verified by ohmmeter. After starting PHG up, there on the model it began the synchronous rotation of the two opposing magnets against the relatively rigid unshielded wire. Synchronous movement of both axial magnets is achieved by connecting of toothed pulleys according to Figures 5, 6. In order to make sure how the induction is preserved in the reference system that is moving in relation to the frame, we have repeatedly conducted moving closer of the non-homogenous magnetic field of the neodymium magnet in relation to the measuring conductor $\vec{j}$ on different places: Induction did not occur at points with shielding but did occur at places without shielding. This demonstrates the ability and relevance of usage of shielding. For comparison of the induced values between FHG and PHG, the PHG model was temporarily connected and tested as an FHG. In the FHG wiring, the induction amounted to 60 [mV]. Based on the data for the chart in Fig. 4, it was found out that the shielding in this PHG circuit eliminated 61 % of the external magnetic flux, which influences the external part of the wire loop. By its structural solution, FHG is able to eliminate up to 100 % of the overall internal magnetic flux (this can be achieved by an appropriate diameter of the copper disc). Comparison of this data shows that the PHG should induce the minimum value of 36 [mV]. Since PHG does not have any brushes, this value should be considerably higher with respect to the low efficiency of FHG due to mainly friction and heat losses on the brushes used. The overall progress of the experiment is available on [9].

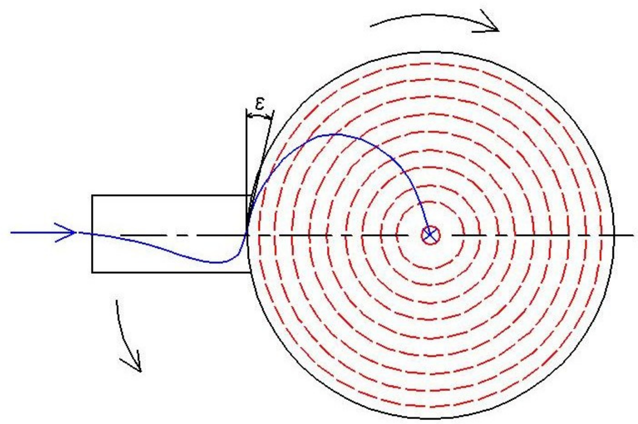

Figure 8. The notion of middle track of the conductivity path in the rotating FHG.

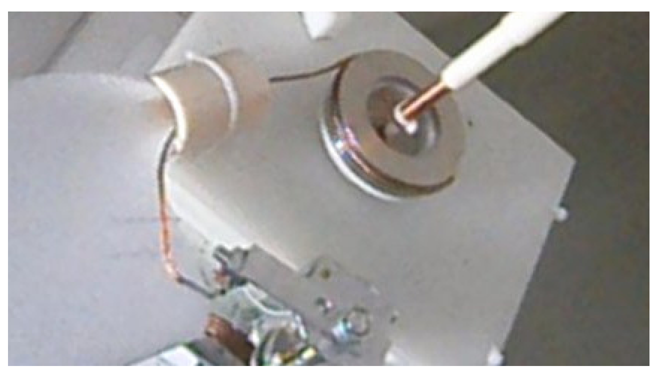

Figure 9. The experimental model with the flexible conductor, which is winding up on the axially magnetized magnetic disc.

The experiments carried out in this matter lead us to the following unambiguous opinion: It is impossible to reach the phenomenon of the homopolar induction without using such output and input conductors, specifically, that do not pass through the permanent magnetic field gradient4 in the perpendicular direction to a nonzero vector component $\vec{B}$ of magnetic induction. In other words, which do not intersect the *transverse slope (crosswise gradient) of magnetic induction*. We have found out that the simulation of the continuous passing through a transverse slope of the magnetic induction must be ensured by brushes. The brushes probably represent an equivalent simulation which can be achieved, for instance, by winding up or unwinding a wire on the peripheral surface of the rotor of the Faraday disk - during winding up or unwinding, DC current will be induced in this wire[6]. Experimental device simulating this fact is shown in Fig. 9. We believe that the experiment, which at some point is disproving more than 150 years old theory, is a sufficient reason to rethink the understanding of the induction. (The concept of magnetic flux/flux lines creates a false notion of the magnetism being immanent to the Euclidean space and conceals the actual dynamic properties of the magnetically influenced physical space.) Regardless the explanation itself, it must be more complicated than Maxwell has declared by using simple mathematical logic.

Let us present an example how the situation might appear in a brush FHG: Connection of the load, which connects the circuit to the FHG centre, creates the conductivity path with the potential differing from the conductive vicinity. During the rotation of the disc, this path with the shortest potential track, due to the relatively opposite movement of the brush and the surface of the rotor, begins to rip off and tilt to angle $\pi/2-\varepsilon$, in contact surfaces. It is schematically shown by the blue curve in Fig. 8. In this way, a similar floating relative movement of the conductor is simulated, like during winding up or unwinding the springy cord. Continuous passing across the magnetic induction change is thus primarily ensured[7]. A response follows in accordance with the Lenz law[8][10]: an increase of electric intensity causes current and potential channel. Free electrons from the surrounding areas are subsequently collected in this potential channel. These electrons accumulate into a wave that is synchronous with the relative motion of the brushes. This newly generated electron wave includes a stabilized surplus of charge, which can be measured. We think that this explanation closely corresponds to the physical reality, although it does not appear to be very elegant. In this case, the Lorentz force is generated by mere motion of a conductor through of heterogeneous area within the field. In other words, a conductor moving in a hypothetical homogeneous field does not generate any Lorentz force, not inducing any voltage - just as in the used brushless experimental device. We think that the experiment based on homogeneous circles as in Fig. 6, is more credible than experiments based on Helmholtz or improved Maxwell coils. These coil systems achieve good axial homogeneity, but circle homogeneity is worse. Even relatively negligible gradient can generate induced voltage. The same is surely valid for small areas of strong reference fields, for example neodymium magnets. All of these fields in certain locations may have a negligible value of the gradient with respect to the induction. But the gradient exists and therefore the measured induced voltage also exists under the influence of possible changes in cross-section of a loop placed in this field. This could again lead to illusive and false confirmation, that the flow change is necessary and sufficient condition of the inception of electric induction. Absolute prediction of the measured values of the induced voltage is a consequence of tabular constants, which have always been set in a standardized gradient. It is certainly not necessary to mention that predictions of these absolute values are not too reliable, yet regarded as a good result.

Transformation of the Faraday's law from idealisms to realisms

The magnetic induction change is only a necessary condition, but not a sufficient one. Similarly, the transverse slope of the magnetic induction is also a necessary and insufficient condition. Both of these conditions together ensure necessary and sufficient condition: a temporal change of the transverse gradient of the magnetic induction.

In differential form, the Maxwell's interpretation of the Faraday's experiment is defined (Faraday's law)[9]:

$$rot\vec{E}_m = -\frac{\partial \vec{B}}{\partial t} \tag{2}$$

In the context of the experiment above, we try to establish a relation which includes both of these necessary conditions and which could express physical nature of the induction. We believe that the best candidate is the following formula:

$$\vec{E} = \left| -\frac{\partial \vec{B}_\perp}{\partial t} \right| \mathbf{e}_E, \tag{3}$$

where $\mathbf{e}_E$ [10] is the unit vector which takes over the role of polarity and determines the direction of the intensity $\vec{E}$. The partial derivative $\partial\vec{B}_\perp/\partial t$ represents the time change of the magnetic induction during movement of the perpendicular component of the wire velocity $\vec{v}$ to the vector $\vec{B}$. The

[6] If the conductor is under electric current, automatic winding up of flexible wire takes place inversely, as well.

[7] The magnetic disc shows field declivity in the perpendicular direction to the axis - in radial direction - between the adjacent isomagnetic circles. This ensures that during brushes movement, the average conductive path relatively leans of the angle $\pi/2-\varepsilon$ and the simulation of the conductor passing crosswise the field declivity occurs.

[8] The law does not originally specify what kind of change it is - the magnetic flux change is attributed to it later in modern times.

[9] In this differential form of the Faraday's law, please not that the absolute value does not change for a homogeneous magnetic field $\vec{B} \Rightarrow d\vec{B} = 0$. In stationary position of $\vec{B}$, this fact would imply (2) zero rotation and thus zero contribution to electromagnetic induction. Partial changes of vector $\vec{B}$, however, ensure as per the analogy with a flowing liquid (Stokes' theorem) the flow line and vortex changes of position of vector $\vec{B}$. These hypothetical and unverifiable position changes of $\vec{B}$ also ensure the theoretical usability for non-existing magnetic field.

[10] Maxwell's mathematical determination of the intensity direction by adding the vectors $\vec{B}$ and $\vec{v}$ also reflected in the unit vector $\mathbf{e}_E$. Experiments have led us to a completely new methodology of physical determination of the intensity direction. It is more complicated and it is possible to reliably determine it only from the transverse gradient. For simplicity, it is advantageous to preserve current mathematical convention.

perpendicularity sign $\perp$ means that the crosswise induction declivity exists in the direction of this perpendicular component of the conductor movement. It means that in the field with a certain density of hypothetical induction lines, two adjacent lines have different values of induction and that the path of the moving conductor crosses these induction lines.

The electric intensity vector $\vec{E}$ is generated perpendicularly to the plane formed by the two vectors $\vec{B}$ a $\vec{v}$. According to this formula, the initiation of the electric intensity is caused by:

- Existence of the cross declivity $\partial\vec{B}_\perp/\partial\vec{x}$ in the direction $\vec{x}$ perpendicular to $\vec{B}$ of the moving conductor
- Time change of this cross declivity towards the wire

Assuming that the actual physical reason for the generation of the electric intensity $\vec{E}$ is described by equation (3), we have to find a mathematical relation to the present hypothesis, i.e. to $\vec{E}_m = \vec{B}\times\vec{v}$ [3, 4]. In the relation (3), which count with time change of the cross declination, we can, in the spirit of existing conventions, substitute the orthonormal base $\mathbf{e}_E = \mathbf{e}_B \times \mathbf{e}_v$. So, we can define a mathematical equivalence $\partial\vec{B}_\perp/\partial t \Leftrightarrow \partial\vec{B}/\partial t$, because from one side, the general formula $\partial\vec{B}/\partial t$ includes values of the time change of the cross declination $\partial\vec{B}_\perp/\partial t$ and on the other hand, at violation of orthogonality, for determination of its value there is relevant mutual relationship of the direction and magnitude between $\vec{B}$ and $\vec{v}$:

$$\vec{E} = \left| -\frac{\partial\vec{B}}{\partial t}\right| \frac{\vec{B}}{||\vec{B}||} \times \frac{\vec{v}}{||\vec{v}||} = \left| -\frac{\partial\vec{B}}{\partial t}\right| \frac{\vec{E}_m}{||\vec{B}||\;||\vec{v}||}. \tag{4}$$

In the case of integration, (2) according to the area we come to relation (1) and in the case of integration (4) according to the wire length we come to formally similar equation for EMF:

$$\mathscr{E} = \oint_l \vec{E}\cdot d\vec{l} \tag{5}$$

Vector $\vec{E}$ is oriented just as $\vec{E}_m$, but with different values. Besides the angle between both vectors $\vec{B}$ and $\vec{v}$, the values of the vector $\vec{E}$ are influenced by $\partial\vec{B}/\partial t$. We can show the relation between $\vec{E}$ and $\vec{E}_m$ in differential form if we define immediate unit declination of the magnetic induction in the direction of path $\vec{x}_i$ (Cartesian coordinates) of the conductor movement

$$\gamma(i) = |(\partial\vec{B}/\partial\vec{x}_i)|/(||\vec{B}||) \tag{6}$$

where $\vec{B}$ is the function of the vector argument of the spatial radius $\vec{r}_i$ (spherical coordinates). The radius $\vec{r}_i$ is oriented towards the beginning of the path $\vec{x}_i$ of the conductor movement in the magnetic field with induction $\vec{B}(\vec{r}_i)$ [11].

For the immediate induction we obtain a relation that expresses the relationship between the Maxwell's conception of electric intensity $\vec{E}_m = \vec{B}\times\vec{v}$ and the interpretation in context of the experiment described here.

$$\vec{E} = \gamma(i)(\vec{B}\times\vec{v}) = \left|\frac{\partial\vec{B}}{\partial\vec{x}_i}\right| \frac{\vec{B}}{||\vec{B}||}\times\vec{v} = \tag{7}$$

$$\left|\frac{\partial\vec{B}}{\partial\vec{x}_i}\right| |\vec{v}| \frac{\vec{B}}{||\vec{B}||}\times\frac{\vec{v}}{||\vec{v}||} = \left|\frac{\partial\vec{B}}{\partial t}\right| \frac{\vec{E}_m}{||\vec{B}||\;||\vec{v}||}.$$

We have achieved the final compliance with (4) due to the application of the vector product definition and to the fact that $\vec{x}_i$ has the same direction as $\vec{v}$. It should be pointed out that the general equations (4) and (7) only represent a general mathematical convention. Physically relevant are just interactions according to (3), hence only the movement of the wire through the crosswise declivity of the magnetic induction is relevant. It is beyond the scope of this article to solve the physical aspect of the influence of the declivity orientation. Therefore, for brevity, we always use an absolute value of the declivity and the orientation of the intensity is mathematically determined by the vector products $\vec{B}\times\vec{v}$.

Furthermore, for the sake of simplicity, we set the coefficient $\gamma_\phi = (\int_S \gamma(i)\cdot d\vec{S})/\vec{S}$ throughout the integration area $\vec{S}$ as an average unitary declivity of the field in the direction of the moving conductor. Then we can write

$$\gamma_\phi \int_S rot\vec{E}_m(\vec{x}_i)\cdot d\vec{S} = \oint_l \vec{E}(\vec{x}_i)\cdot\, d\vec{l}\,. \tag{8}$$

When we integrate both sides (8) the left hand side according to the area closed with conductor and the right hand side according to the conductor length, we get scalar result:

$$\gamma_\phi\ \mathscr{E}_m = \mathscr{E}. \tag{9}$$

For the technical practice that has created a set of constants and coefficients on the basis of the Maxwell equations, this result does not mean any change, as the crosswise declivity occurs in the methodology of their specification. The result may be relevant only for the non-standard industrial applications. This illustrates that if there does not exist any average value of the gradient according to (3), (4) a (7), then it means that there must be $\gamma_\phi = 0$ and, in compliance with the phenomenon of the without brush homopolar generator, no homopolar induction occurs.

For values γ_ϕ in the interval $0 < \gamma_\phi < 1$ a new relationship gives necessary correction with physical practice. For the values $\gamma_\phi = 1$ it will be given the same value for both relations (1) and (5). It should be noted that each value of the average unit declivity (and thus also the value of 1) binds itself a large class of values of absolute declivities, from very low up to extremely high values - it follows from the unit declivity definition (6). It would be surely interesting to examine which of the average unit declivities occur mostly in practice. If we define $\gamma_\phi > 1$ it means that the gradient is high, for example for neodymium.

At this point, a false impression could arise that weak fields can have high gradient and thus could cause induction with high acceleration, which would be in contradiction to the practice. A good example, that the declivity of the field is dependent on the magnitude of the magnetic induction (or magnetic flux density), is the magnetic field around a long wire $B = \mu I/2\pi r$. The value of the current determines the magnitude of the magnetic induction and thence the flatness and steepness of the declivity, as shown by the derivative by r, which is $(\mu I/2\pi)/r^2$. The declivity at a given distance r is proportional to I and hence to the magnetic induction B. Thus, it cannot happen that weak fields achieve higher inductive effects than strong fields. However, strong fields with a locally weak gradient may reach only small inductions in this location.

Discussion

The Maxwell's mathematical insight with emphasis on the time change of the magnetic induction flux predicts functionality of the homopolar brush generator, which is thus mistakenly taken as the evidence that the change in the flux of magnetic induction is sufficient physical quantity for realization of electric induction. For this reason, it mistakenly predicts that a similar realization without brush design should be functional as well.

However, in the context of the findings above, the temporal change of the inductive flux does not lose its physical meaning - that consists primarily in showing the speed, in which the conductor is passing through gradient of the field.

In accordance with the above experiment, equations (8), (9) predict that by the movement of electrically neutral wires in a homogeneous magnetic field happens nothing at all - no Lorentz force will be generated and therefore no voltage will be induced. In this text, equation (3) adopts the status of a physical law. The relation (2) herein considered is physically non-essential (from standpoints of induction) and creates hypothetical and unverifiable idea of swirly magnetic field. It describes time changes only of geometric quantities in 3D space. Equations (7) and (8) indicate a necessary theoretical correction of the contemporary equations in order to predict the described experiment correctly.

Values of the transverse declivity of the reference fields were covertly embedded into tabular quantities. Tables can thus be used in further decades with Maxwell platform as well, without loss of accuracy, at least if that will deal with ordinary project calculations.

If we let according to the result (9) $\Delta t = konst > 0$ and fix the non-zero increases of both surface $\Delta\vec{S}$ and length $\Delta\vec{l}$ of the conductor, we get two linear relations, see Fig. 10. The graph shows the difference between the values of EMF for the concept with relation $E(\Delta\vec{B}_\perp) = \Delta\mathscr{E}$ derived from (3) and (5) and current conception with relation $E_m(\Delta\Phi(\Delta\vec{B}_\perp)) = \Delta\mathscr{E}_m$ derived from (2) and (1). The change of transverse slope causes a change of magnetic flux, however, the change of magnetic flux does not theoretically have to cause the change of transverse slope.

There are five advantages of the presented concept:

- It implies the prediction of the PHG behaviour and thus respects the results of wider range of experiments
- It is fixed on the integrating constant $C = 0$
- It unquestionably eliminates Faraday's paradox [1]
- It can give equivalent results consistent with the previous practice, because the average declination γ_ϕ is related to the non-closed area $\vec{S}$ likewise the magnetic flux
- It reveals a wide range of up to now hidden possibilities of new technical realizations.

The diagram shows that the Maxwell electromotive voltage EMF $\mathscr{E}_m$ assumes non-zero values also for zero slopes. It is obvious that if we consider the presented proposal assuming $E(\Delta\vec{B}_\perp)$ to be the most appropriate with the physical reality, and at the same time we defend the Maxwell's concept as a best proven practice, using the methodology of electrodynamic constants, it must lead to more realistic current Maxwell concept $E_m(\Delta\Phi(\Delta\vec{B}_\perp))$ in the whole scale of declivity values. Similarly, it is shown by the green curve (in some parts asymptotic) that it is consistent with the result (9).

The existence of Stokes's theorem encourages the illusion that the electromagnetic induction is caused by a change of electromagnetic flux in time. The Stokes's theorem also includes time changes of magnetic induction $\vec{B}$ in the form of the rotation vector $rot\vec{E}_m$. False notion of the physical correctness of this concept is therefore perfect. The physical incorrectness is detectable only in the proximity of the limiting zero-point of the transversal declivity, thus, only by a real simulation of a movement in a homogeneous magnetic field.

This article describes a brushless homopolar generator. The same formula applies to the inverse phenomenon in the Pure homopolar motor PHM[11] To demonstrate the collision of contemporary theoretical electrodynamics with practice, it is possible to use presented generator as a motor.

Demonstrations, when the theory is not consistent with practice, are as follows: e.g. The grant of patent in Czech Republic PV 2011-293 (DC electromotor) or the patent US5977684(A) in USA, which at first glance appear to be functional only in theory. Upon closer examination, they cannot be functional even from the perspective of Maxwell's electrodynamics and in this case they would be contrary to the

[11] Meant as Pure Homopolar Motor: i.e. motor that does not need any brushes, electronics or semiconductor to ensure the directly of connection a direct current.

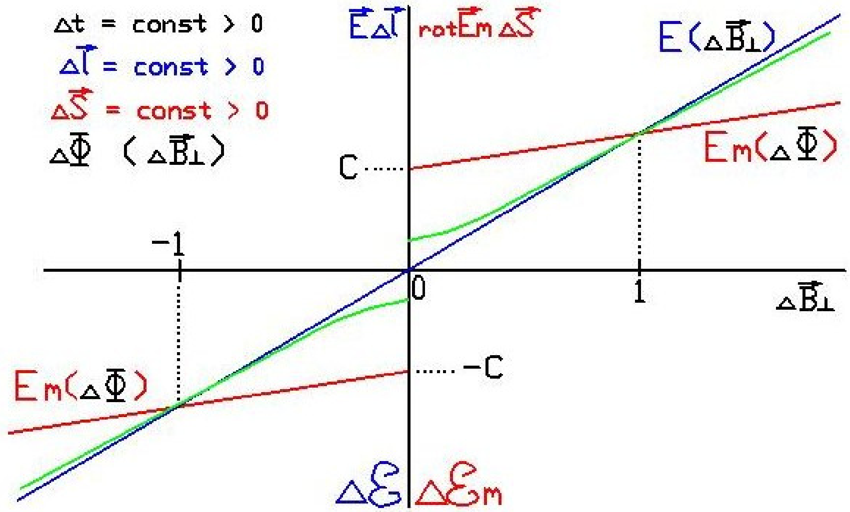

Figure 10. A graphical study of comparison of the course of Maxwell's prescription E_m and herein proposed concept of E with common vector variable of crosswise declivity $\Delta\vec{B}_\perp$ at constant and non-zero increments of $\Delta t, \Delta\vec{l}, \Delta\vec{S}$

law of continuity, not to say the energy. That is clear as soon as the DC coils would replace the permanent magnet. Very basic search pointed at least on the next six patents. The experiment described in this article could theoretically get all of these solutions into operation. The reality, however, proved different. Assertions in the preceding sentences can be proven by demonstration of purchased dysfunctional model, which is for the purpose of commissioning equipped with electronics and violates an advantage declared in PV 2011-293. After removing the electronics, the device disfunctionality is evident. As the significant support for finding discrepancy between theory and practice we consider the fact that despite the advantages of similar solutions, none appears in practice. For example, there is no wind power plant, which would favourably take advantage of similar solutions and produce directly the brushless direct current. Classic high performance commutating (brushed) DC generators are commonly used. Brushless AC generators with electronic rectification for subsequent further processing into the distribution network come to the forefront during last years.

The goal of this report is to point out a deeply rooted myth of contemporary theoretical electrodynamics, that there can exist a technical solution that would use a homopolar induction (or inverse action) without brushes, without electronic and without semiconductors. And the induction (or inverse action) should take place in a homogenized electromagnetic field (for example in homogenous circles). This article aims to point out that there cannot exist functional solutions of generators or motors within the meaning of definitions of PHG/PHM. Acquisition of the patents for these solutions pose for authors award, honour, social and career motivation. If a real model is not constructed, the author may never get to know about the error. Even a company that purchases such a patent and is actually misdirected, does not have any meaningful interest to publish the situation. Conversely, such a company is motivated to get a nonfunctioning solutions into operation by using of a proven extension. The company can be presented by the patent at most in terms of marketing. Feedback from industry to academic sub-consciousness is basically blocked by this.

Methods

The paper clearly shows that we used the oldest physical methods, i.e. methods of model construction for functional demonstration. We used our own idea of identical simulation of the theoretical assumptions of function of FHG on PHG. At the end, we used the current method of shielding with high-temperature YBaCuO superconductors, whose efficiency - as declared by the manufacturer - exceeds 100 [mT]. To maintain the appropriate temperature, the standard cryogenic technology based on liquid nitrogen was used. The measurement itself did not required any special equipment or methods. For the sake of simplicity, we compared the induction values on FHG with dimensions and parameters identical to PHG. The resulting values on FHG exceeded 10 [mV] by far. The measurement on PHG was carried out using millivolt oscilloscopes HMO722 or HMO2008 with a resolution of 1 [mV]/Div (HMO722 has 1 Div=50 px, diagonal $16,5$ [cm] $\Leftrightarrow$ 8x12 Div) with probes HZ154 or HZ200 and a 3D teslameter Helimag MP-1 with complementary software for processing of the measured values. The chart was created using the previous version of the physical SW. We actively investigated what was happening in the demonstration devices down to the level of [mV]. Further specification was pointless with due to the noise amounting to $\pm$0,25 Div at these low voltage values. The result of this experiment is noticeable. In the analysis, we have used the description variant that preserves the vector nature. It is easy to see that this analysis continues in so called

Faraday low. Furthermore, in the boundary point it explains the cause of its failure and corresponds with reality.

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Author contributions statement

P.I. designed the study, performed the experiment, analysis and wrote the paper. I.V. performed a complete translation from the perspective of an electrical engineer. M.I. Performed a final proof reading work and an English translation from the perspective of mathematics. All authors reviewed the manuscript.

Additional information

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