Spacetime & Substance, Vol. 3 (2002), No. 3 (13), pp. 140–144

ON THE ELECTRODYNAMICS OF SPINNING MAGNETS

Jorge Guala-Valverde[1]

Confluencia Tech University-UTN- Huincul, Santa Fe 449, Neuquén-Argentina

Received July 04, 2002

This paper deals with a crucial issue left open by Einstein in his famous 1905 paper in Annalen der Physik.

1. Homopolar Induction. Historical Scenario

"The most curious electrodynamics experiments are those where a continuous rotation takes place, called unipolar experiments". H. Poincaré [1].

"It is known that Maxwell's electrodynamics-as usually understood at the present time- when applied to moving movies, leads to asymmetries which do not appear to be inherent in the phenomena... Moreover, questions as to the seat of electrodynamic electromotive forces (unipolar machines) have no point". A. Einstein [2].

"The systen of power about the magnet must not be considered as necessarily rotating with the magnet, any more than the rays of light which emanate from the sun are suppossed to revolve with the sun". Michael Faraday [3].

"This is at variance with our transformation laws for linear motion, and it is an indication that the absolute rotational motion of the disk... can in principle be detected". W.K.H. Panofsky [4,5].

"For nearly a century after its discovery... the unipolar generator was a conundrum for the theory of electromagnetism... The most vexatious question concerned the 'seat' of the electromotive force". D.F. Bartlett [3].

"The whole problem baffled the greatest electrodynamicists of the 19^{th} century". A. Miller [6].

"A warping of space which is attributted to the rotation of distant masses of the universe... shows that an 'extra current' appears and modifies the electromagnetic tensor equations", L.I. Schiff [6].

"Rotating circuits and magnets are 'hazardous' for Special Relativity". D. Webster [7].

"Kennard makes no consideration about inductions on the galvanometer. This means that he does not consider the galvanometer as a part of the seat of induction". A.K.T. Assis [8].

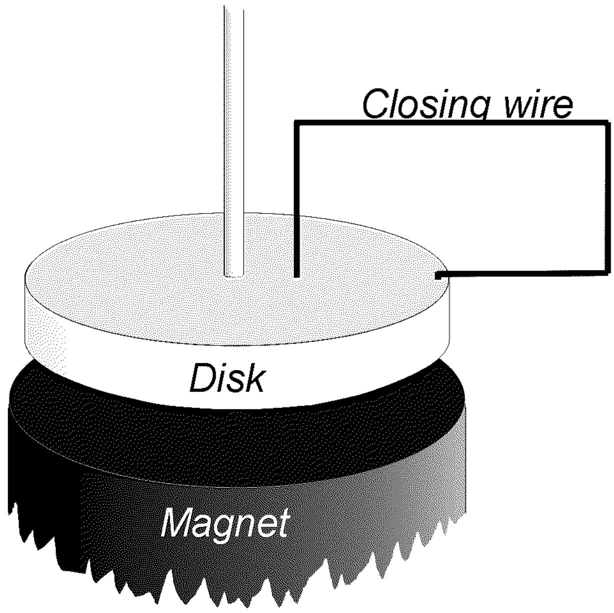

Figure 1: Faraday's Setup Magnet, Disk and Closing Wire

The essential features of the *Unipolar electromagnetic phenomena* (name coined by Weber, nowadays known as *Homopolar phenomena*) are shown in Fig. 1, which sketches the Faraday disk, the first conceived unipolar engine. A conducting disk, free to rotate in the neighborhood of a permanent magnet, is attached to a shaft. A *closing wire* provides a conducting path between two arbitrary points on the disk. Such device exhibits a *reversible* behaviour:

First case

Injecting direct current (*dc*) from an external source into the closing wire, its interaction with the magnetic field produces a *ponderomotive* Laplace force [9] $dF = I(dl \times B)$ responsible for the disk rotation in a *motor* configuration.

With the disk spun by an external source of mechanical energy, each moving charge is acted on by the

[1]e-mail: gual@ieee.org
[1]e-mail: fundacionjuliopalacios@usa.net

Lorentz force $F = q\,(v \times B)$, and an *electromotive* force *emf* appears in the bulk of the disk, in a *generator* configuration.

Second case

A seemingly curious fact occurs when the magnet is attached to the disk. In both the above configurations the system behaves as well as if the magnet were at rest. Two rival theories, a *relativistic* and an *absolutistic* one, are customarily applied to describe *unipolar phenomena*:

Relativistic view.

A generator configuration makes sense only by the motion of the magnet relative to the conductor: the disk itself in the first case, the closing wire in the second one. In a motor configuration, what matters is the *possibility* of relative motion between the magnet an the conductor: the disk in the first case, the closing wire in the second one.

Absolutistic view.

A generator configuration is enabled only because of the *absolute* motion of the conductor: the disk in both the first and second cases. Here absolute means "relative to a frame where the preponderance of the mass of the universe is at rest" [4,5] .For the present purposes, the lab frame acts as an acceptable absolute-motion reference [10,11]. From an absolutistic view, the magnet's rotation with $\partial B/\partial t = 0$ in each point of the surrounding space is unable to produce an *emf* on nearby conductors [12]. The rotation observed in a motor configuration is attributed in this framework the the magnet "dragging" effect by the conductor, with the closing wire acting as a "passive" circuit element.

Experimentation performed on the original Faraday setup is not availabe to rule out none of the two above interpretations [3]. A remarkable experimental paper stressing the true relativistic nature of homopolar induction was recently published by A. Kelly [13].

2. A modified Faraday disk

Fig. 2 shows the *asymmetrical rotor*, a modified version of the original Faraday disk, in which a region of the magnet- the *singularity* from here on- was removed in order to achieve a *B-field* inversion [14,15,16,17]. Outgoing (ingoing) B vectors are represented by the $\bullet$ ($\otimes$) symbol. The magnet is embedded in a wood cylinder anchored to a vertical shaft terminated in sharp points at both ends. While the lower one lays on a hard-polished surface, the upper one is centered by a conical bearing enabling its almost frictionless rotation. The inner and outer mercury collector rings allow to close a circuit through the closing wire. Mounted on a bearing centered with the shaft is a radial *probe* wire, whose ends are in contact with the collector rings. The probe is free to rotate about the shaft.

Fig. 3 shows the *asymmetrical rotor* as applied to

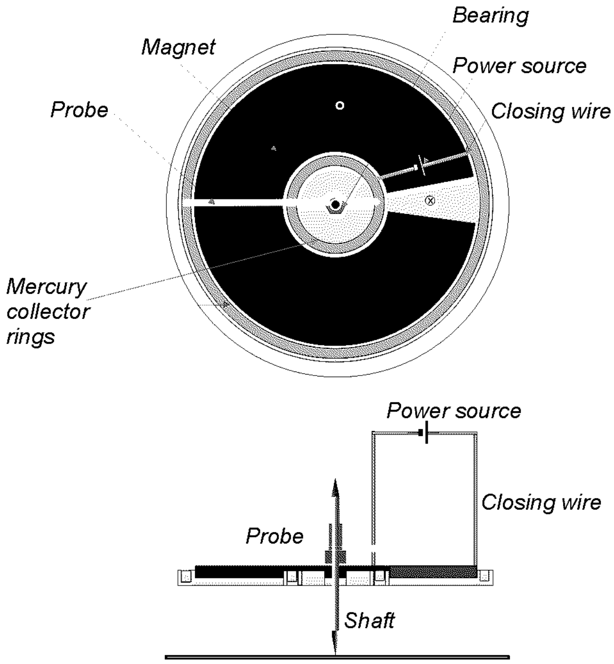

Figure 2: Layout of the Asymmetrical Rotor Applied to the Experiments

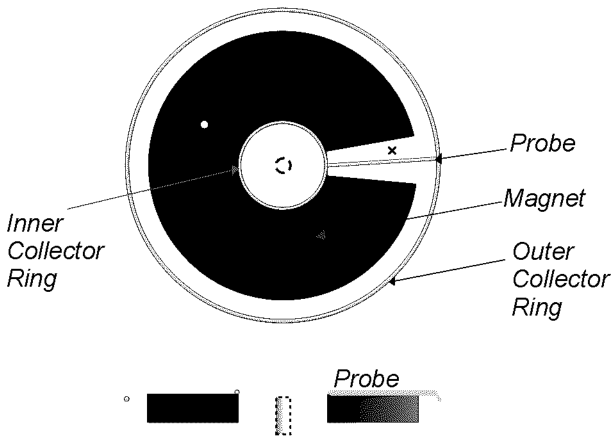

Figure 3: Asymmetrical Rotor Layout as Applied to Experiment 2

generation experiments. Here the magnet was embedded in a teflon disk and was dynamically balanced accounting for the missing mass. The inner and outer copper collector rings enable the instrument's connection closing wire, terminated in carbon-electrode sliding contacts.

3. Experimental

Along the last decade a long series of experiments were performed on unipolar induction, some of them with the aid of the asymmetrical rotor [14,15,16,17,18,19]. Since most of them has been described with much detail [14,15,16,17], we restrict ourselves here to report only two of the whole series. Many of the these experiments were successfully repeated around the world last months [20,21,22,23,24,25,26,27,28,29].

MOTOR CONFIGURATION

a) Rotor anchored to the lab, probe free to rotate above the magnet's downward magnetic field region: As expected by both, relativists and absolutists, a net probe **clockwise** rotation took place when ingoing *dc* was injected. Here the force $F = \int_{probe} I\,(dl \times B)$ is responsible for the observed rotation.

b) Probe anchored to the rotor above the magnet's downward magnetic field region, both free to co-rotate. Contrarily to the absolutistic expectation, a net rotor **counterclockwise** rotation took place when ingoing *dc* was injected. This sole experiment suffices to definitively reject the "dragging" hypothesis.

GENERATOR CONFIGURATION

a) Probe located on the rotor in the magnet's upward magnetic-field region. The rotor in **clockwise** rotation. A voltage $(V_i - V_o)_{uw} > 0$, between the inner and outer ring, was measured. Within the absolutistic framework, the above voltage is generated in the bulk of the probe due to the Lorentz force, which integrated along it gives an $emf = \int_{probe} (v \times B)\,.dr$. As it is obvious, the here involved velocity is the probe's absolute one, since magnet's rotation (provided $\partial B/\partial t = 0$ at each point in the space) is irrelevant within an absolutistic framework [3,4,6,12].

From a relativistic viewpoint, the seat of the voltage is located on the closing wire, which is at relative motion with the magnet. Again, Lorentz force is responsible for the measured $emf' = \int_{closing-wire} (v' \times B)\,.dl$, wherein v' labels the velocity at which the considered closing-wire element moves with respect to the magnet. The fundamental theorem $divB = 0$, plus some elementary symmetry considerations [19] allow us to probe that $emf' = emf$. Briefly speaking, the emf developped on the closing wire at rest in the lab with magnet and probe rotating clockwise, is identical to the emf generated on the clockwise-rotating probe with magnet and closing wire stationary in the lab. The above analysis justifies, *for the first time*, conceptually wrong calculations performed by absolutists when dealing with magnet-probe sets co-rotating in the lab.

b) Probe located on the rotor in the magnet's downward magnetic-field region. The rotor in **clockwise** rotation. Again, and contrarily to absolutists expectations, a voltage $(V_i - V_o)_{dw} > 0$ was measured, as well as in the first case. This sole experiment suffices to definitively reject the absolutistic claims.

4. Dogma versus Experiment

The author of this paper was, in the past, an enthusiastic advocate of the absolutistic paradigm concerning unipolar induction [31,32]. The above due to debatable philosophical reasons and, mainly, to his own ignorance of the powerful machinery underlying Weber's electrodynamics, a true relativistic doctrine also available in the realm of Mechanics [10,11,33]. But dogma are words, and laboratory experiments are real and, sometimes, we are compeled to change old paradigms.

5. Concluding Remarks

The reported experiments show - beyond any reasonable doubt - that a probe wire, when moving attached to the magnet, only plays a passive role (to provide a current path) in the whole phenomenom. Both the ponderomotive and electromotive observed effects are in such a case due to the magnet motion relative to the closing wire.

The key of the succes of the reported experiments lies in the topological features of the magnet's singularity. The short-range field reversion region allows the inversion of the ponderomotive and electromotive effects on the probe, **leaving** the actions on the closing wire **insensitive** to that *B-field* reversion. This very relevant fact was exhaustively checked with the aid of specific experiments [14,15].

Is indeed the Third Newton Law the crucial piece which allows us to rule out the absolutisitic view on homopolar phenomena in a motor configuration. In fact, the whole action can be splitted in two elementary interactions:

Magnet-Probe interaction:

The magnet produces a counterclockwise torque on the probe, and the probe exerts an equal but opposite torque on the magnet.

Magnet-closing wire interaction:

The magnet exerts a clockwise torque on the closing wire, and the wire an equal but opposite torque on the magnet. With the probe attached to the magnet, there is no chance for relative motion between them. Consequently, due to the action-reaction cancellation effect

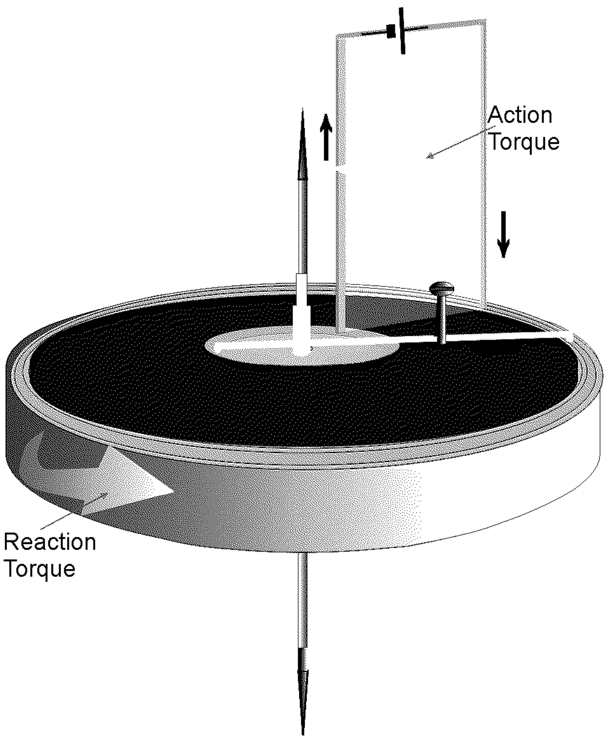

Figure 4: Rotational Torques Acting on the Rotor and on the Closing-Circuit Wire

in this case, rotation is forbidden. Conversely, with the closing wire mechanically decoupled from the magnet, relative motion of the latter is permitted. The torque exerted by the closing wire on the magnet is responsible for the observed rotation (Fig. 4).

After 170 years of controversy and bewilderment, we know that-as far as induction is concerned a wire clockwise rotation upon a stationary magnet is equivalent to a magnet counterclockwise rotation with the wire stationary in the lab (Fig. 5). The above statement, contrary to the customary belief [34], is the main outcome of our pioneering work first advanced in Apeiron [14] and in Spacetime & Substance Journal

The new experimental evidence puts the end point

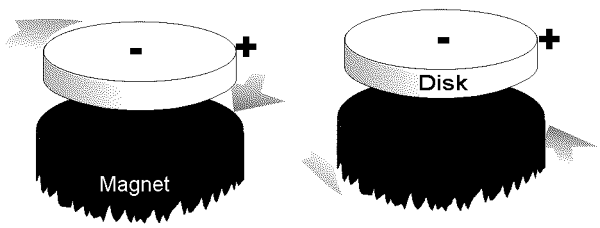

Figure 5: Homopolar induction only depends on the motion of Magnet relative to Disk

to some claims concerning homopolar engines with an efficiency greater than unity [35] and opens the way for further experimental and theoretical search. Particularly, Jehle's electron model deserves to be thoroughly reviewed [3,16].

6. Acknowledgment:

To Prof. Eng. Roberto Blas, who was able to repeat the whole series of experiments at Río IV University.

References

[1] H. Poincaré, *La Science et la Hypothesis.* Flammarion, Paris (1968).

[2] A. Einstein, *"On the electrodynamics of moving bodies"*. Dover, New York (1952). English translation of *"Zur electyrodynamic bewegter körper"*. Annalen der Physik, **17** (1905).

[3] D.F. Bartlett *et al.*, *"Spining magnets and Jehle's model of the electron"*, Phyisical Review, **16**, 3459 (1977)

[4] W.K.H. Panofsky and M. Phillips, *Classical Electricity and Magnetism*, Addisson Wesley, New York (1955).

[5] W.K.H. Panofsky, Private Communication (letter to J. Guala-Valverde, dated Jan 30, 1995).

[6] F. Muller, *"Unipolar Induction Experiments and Relativistic Electrodynamics"*, Galilean Electrodynamics, **1**, 27 (1990). See also *Progress in Space-Time Physics,* J.P. Wesley Editor, Blumberg. (1987) and *Selected topics in Advanced Fundamental Physics*, J.P. Wesley Editor, Blumberg (1991).

[7] D. Webster, *"Relativity of Moving Circuits and Magnets"*,. American Journal of Physics, **29**, 262 (1961).

[8] A.K.T. Assis and D.S. Thober, *"Unipolar Induction and Weber's Electrodynamics"*, Frontiers of Fundamental Physics, Plenum Press, New York, 409 (1994).

[9] G. Cavalleri *et al.*, *"Experimental proof of standard electrodynamics by measuring the self-force on a part of a current loop"*, Physical Review E, **58**, 2505 (1998).

[10] A.K.T. Assis, *Weber Electrodynamics*, Kluwer, Dordrecht (1994).

[11] A.K.T. Assis, *Relational Mechanics*, Apeiron, Montreal (1999).

[12] A. Shadowitz, *Special Relativity*, Dover, New York (1968).

[13] A.G. Kelly, *"Experiments on unipolar induction"*, Physics Essays, **12**, 372 (1999).

[14] J. Guala-Valverde and P. Mazzoni, *"The unipolar dynamotor: a true relational engine"*, Apeiron, **8**, 41 (2001).

[15] J. Guala-Valverde, *"The Unipolar Motor: a True Relativistic Engine"*, Spacetime & Substance Journal, No. 3(8), 144 (2001). http://spacetime.narod.ru.

[16] J. Guala-Valverde, P. Mazzoni and R. Achilles, *"The homopolar motor: a true relativist engine"*, American Journal of Physics. To be published (2002).

[17] J. Guala-Valverde, *"Spining magnets and Relativity"*, Physica Scripta. In press (2002).

[18] J. Guala-Valverde and P. Mazzoni, *"The principle of relativity as applied to motional electromagnetic induction"*, American Journal of Physics, **63**, 228 (1995).

[19] J. Guala-Valverde, P. Mazzoni and Ro Blas, *"The quasi-linear generator and* $\int \mathbf{B}.d\mathbf{S} = 0$*"*, American Journal of Physics, **65**, 147 (1997).

[20] T.E. Phipps, Jr, *Private comm.* (May 2001)

[21] R. Blas, *Private comm.* (Jun.2001).

[22] R. Achillles, *Private comm.* (Dec.2001).

[23] Hon Chang, *Private comm.* (Feb 2002).

[24] Fritz Heider, *Private comm.*(March 2002).

[25] Fernando Gonzalo Cuestas, *Private comm.*(March 2002)

[26] A.G. Kelly, *Private comm.* (Apr 2002)

[27] Centro Estudiantes Tecnolgicos UTN-Confluencia, *Private comm.* (May 2002)

[28] E. Guala and L. Cabeza, *Private comm.* (May 2002)

[29] P. Schultz, *Private comm.* (May 2002)

[30] E. Polito and J. Tramaglia, *Private comm.* (Jun 2002).

[31] J. Guala-Valverde and P. Mazzoni, *"The Unipolar Faraday generator revisited"*, Galilean Electrodynamics, **4**, 107 (1993).

[32] J. Guala-Valverde and P. Mazzoni, *"The motional electromagnetic induction revisited"*, Russian Academy of Sciences, 3^{rd} conference, St. Petersburg (1995).

[33] J. Guala-Valverde, *"A new Theorem in Relational Mechanics"*, Apeiron, **8**, 132 (2001)

[34] R.P. Feynman, *The Feynman Lectures on Physics, II*, Addisson Wesley, New York (1964).

[35] P. Tewari and Bruce de Palma, *search on Internet.*