Journal of Theoretics
Volume 6-4, Aug/Sept 2004

Updating Panofsky's Views on Distant Matter in Physics

Jorge Guala-Valverde
Subsecretaría de Energía
Neuquen Government
8300- Neuquen, Argentine
Email: fundacionjuliopalacios@usa.net

Abstract: "Which frame is an inertial frame is presumably defined by gravitational forces, and therefore "a preferred frame as to rotation" is defined by the location of the bulk of the masses ion the universe" wrote W.K.H Panofsky in his masterful treatise on electricity [1]. The elucidation of motional electrodynamic induction [2,3,4,5,6,7] allows us to update Panofsky's fine insight in the light of the recently implemented Mach's Principle [8,9,10,11,12,13,14,15,16,17].
Keywords: inertia, gravity, Panofsky.

I. NEWS ON ELECTRODYNAMICS

Regarding Electrodynamics, it was recently proven that motional electromagnetic induction is a true relativistic phenomenon [2,3,4,5,6,7] despite involving rotations (i.e. non-inertial frames) [18]. In fact, since 2001 we know that a spinning magnet induces a Lorentz-type electric field responsible for a motional Hall effect [3] in the bulk of nearby conductors (figure 1). The figure corresponds to a clockwise north pole rotation beneath two conducting wires: a *probe* and a *closing* (circuit) *wire*.

Each wire becomes an electromotive force (emf) source. If the ends of the wires are connected, the whole circuit behaves as two identical emf sources connected in opposition and current cannot flow. If, enabling electrical continuity between the wires, the probe is anchored to the magnet, then direct current flows through the whole circuit. When the probe is at rest relative to the magnet, induction only takes place on the closing wire, which is in motion relative to the magnet. The probe plays a passive role: to provide a current path. It is worthwhile to stress that induction takes place despite the fact that $\partial \boldsymbol{B}/\partial t$ *is zero* at every point in the wires.

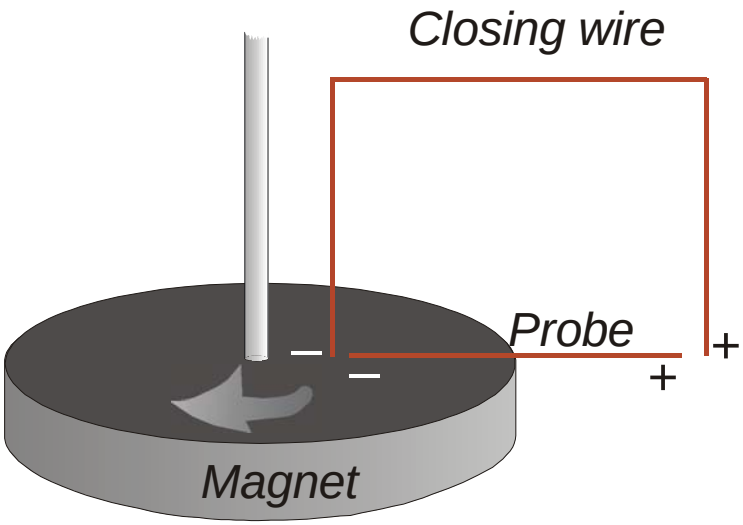

Fig. 1

Homopolar Setup Magnet, Probe and Closing Wire

II. INERTIA AND GRAVITATION: AN HISTORICAL ACCOUNT

The strict proportionality between inertial and gravitational masses (verified with a relative uncertainty below 10^{-11}) intrigued Mach all his life. It led him to suggest that distant matter might inertially regulate local interactions[8,9,10,11]. As is well known, the above proportionality appears only fortuitously in Classical Mechanics. Moreover, it is a well known empirical fact that the best inertial frames employed today are those anchored to distant galaxies. Once, Classical Mechanics is unable to answer the question since distant matter doesn't enter into its formulation.

In 1925 E. Schrödinger sought the origin of inertia by modifying Newtonian mutual gravitational energy (potential energy) in a suitable manner[12,13]. Guided by heuristic considerations he wrote, for two interacting point gravitational masses M_g and m_g :

$$U = - (M_g m_g /r)[1 - \varepsilon \dot{r}^2 /c^2]. \qquad (1)$$

In Eq. 1 $\dot{r} \equiv dr/dt$, c is the velocity of light in vacuum, and ε is a dimensionless parameter that becomes 3 in order to fit the observed planetary precessions.

Using its own energy, Schrödinger calculated the energy of interaction of a spherical shell (gravitational mass M_g , radius R) with an internal point mass m_g , moving in the vicinity of the shell's center with a velocity v relative to the shell. He obtains $U=-(M_g m_g/R)[1–v^2/c^2]$.

He identified the velocity-dependent component of the potential energy with the particle's kinetic energy. That is, $M_g m_g v^2 /Rc^2 = m_i v^2/2$, where m_i signifies inertial mass. It

then follows that $m_i=(2M_g/Rc^2)m_g=(8\pi\ \sigma R/c^2)m_g$, where σ is the (assumed constant) surface density of gravitational mass.

Subsequently, Schrödinger adapts this result for a spherical shell to a "world" of radius R_o, where he assumes a constant mass density. He concludes that if the radius and the mass density of our own galaxy are used, one obtains a value for G (the gravitational constant) some 10^{11} times smaller than what is actually measured. He concludes that the inertia of particles in the solar system must primarily be due to matter external to our galaxy.

III. INERTIA AND GRAVITATION: A RECENT ACCOUNT

The pioneering work of Schrödinger was recently improved by Assis[9,10,11] who was able to implement Mach's ideas in a rigorous, entirely general way. Departing from Schrödinger, Assis begins with the formulation of a Weber-like force law that reads, for point masses 1 and 2,

$$F = -H_g(m_{g1}m_{g2} / r^2)[1 - \xi\ \dot{r}^2/2c^2 + \xi\, r\ddot{r}/c^2]. \qquad (2)$$

In Eq. 2, $\ddot{r} \equiv d^2r/dt^2$ and H_g and ξ are constants. ξ is dimensionless and becomes 6 in order to fit the observed planetary precessions. H_g becomes 1 and is also dimensionless when working with any coherent system of standards such as the cgs and the MKS ones[14, 17]. The outstanding mathematical property of Eq.(2) is that it is *invariant* (frame independent), which means that each term in the Weber-Assis force has the same value for *all* observers, even for non-inertial ones[9,10,11].

With the aid of Eq.(2) and the Principle of Dynamical Equilibrium ("The sum of all forces of any nature acting on a body is always zero in all frames of reference") Assis was able to explain the origin of inertia and the reality of the so-called fictitious forces of inertia (-$m\boldsymbol{a}$, *centrifugal*, *Coriolis*, etc.). In short, Assis was able to develop a true relativistic mechanics which complies with Mach's requirements. He coined the name *Relational Mechanics* for his model.

The reactive force, exerted by the whole isotropic universe on an accelerated test particle k (gravitational mass m_{gk}), has a magnitude[14, 15, 16, 17] $\boldsymbol{f_r} = - m_{gk}\Phi\ \boldsymbol{a}$. This reactive force opposes the active, local force $\boldsymbol{f}_a$ that accelerates the test particle. Here $\Phi=(2\pi\ \xi\ \rho_g\ /3H_o^2)$, where ρ_g signifies the mean density of gravitational mass in the universe and H_o signifies Hubble's constant. It follows from the Principle of Dynamical Equilibrium ($\boldsymbol{f}_a+\boldsymbol{f}_r=0$) that $\boldsymbol{f}_a=m_{gk}\Phi\,\boldsymbol{a}\equiv m_{ik}\boldsymbol{a}$, where the inertial mass of the test particle is defined by $m_{ik}=m_{gk}\Phi$ in order to recover Classical Mechanics.

Assuming the (mean) density of inertial mass in the universe scales like inertial mass ($\rho_i=\Phi\ \rho_g$ and $m_g=\sqrt{G}\ m_i$,) we derive $G\approx H_o^2\,/\,\rho_i$, a result first advanced by Dirac, based on numerological considerations[19].

IV. CONCLUDING REMARKS

At present the role of a preferred frame of reference, in which "the preponderance of the mass of the universe is at rest" [20], cannot be discounted when considering the inertial reaction of the whole universe, in opposition to locally applied active forces on an accelerated test body [21]. In this sense (we feel) must be interpreted the pioneering

Panofsky's statements involving distant matter in physical phenomena. Going into a Lorentz-based equation of motion, $q(\boldsymbol{v}\times\boldsymbol{B}) = m_i \boldsymbol{a}$, there are two main options in order to include distant matter in a whole coherent formulation, satisfying thus Panofsky requirement:

a) To consider $\boldsymbol{v}$ as being the velocity of the wire relative to the Panofsky's cosmological preferred frame.

b) To consider *m* as being a physical property related to the cosmological frame *"in which the preponderance of masses of the universe are at rest"* [20]. In this case $\boldsymbol{v}$ labels the velocity of the active wire relative to the magnet (the source of ***B**-field*).

Recent experimental evidence appears to reinforce option b) over option a) with which eletrodynamic phenomena rescue its truly relativistic nature [22].

V. REFERENCES

1. W.K.H. Panofsky & M. Phillips, *Classical Electricity and Magnetism*. Page 343. Addison Wesley, New York (1955).
2. J. Guala-Valverde & P. Mazzoni, "The Principle of Relativity as applied to Motional Induction". Am. J. Phys. **63**, 228-229 (1995).
3. J. Guala-Valverde & P. Mazzoni, "The Unipolar Dynamotor, a True Relational Engine". Apeiron, **8**, 41-52 (2001).
4. J. Guala-Valverde, P. Mazzoni & R. Achilles, "The Homopolar Motor, a True Relativistic Engine". Am.J.Phys., **70**, 1052-1055 (2002).
5. J. Guala-Valverde, " Spinning Magnets and Relativity". Physica Scripta, **66**, 252-253 (2002).
6. J. Guala-Valverde, " Feynman Lectures, ***A-field*** and Relativity in Rotations". Spacetime & Substance Journal, **3** (2), 94-96 (2002).
7. J. Guala-Valverde, " On the Electrodynamics of Spinning Magnets". Space-time & Substance Journal, **3** (3), 140-144 (2002).
8. E. Mach, *The Science of Mechanics- a critical and Historical account of Its Development*. Open Court, la Salle (1960).
9. A.K.T. Assis, " On Mach's principle". Found. Phys. Lett.**2**, 301-318 (1989).
10. A.K.T. Assis, *Weber's Electrodynamics*. Kluwer, Dordrecht (1994).
11. A.K.T. Assis, *Relational Mechanics*. Apeiron, Montreal (1999).
12. E. Schrödinger," Die erfüllbarkeit der relativitätsforderung in der klassischen mechanik". Annalen der Physik, **77**, 325-336 (1925).
13. J.B. Barbour & H. Pfister, "Mach's Principle - From Newton Bucket to Quantum Gravity", pages 147-158, Birkhäuser, Boston (1995).
14. J. Guala-Valverde, "Inertial Mass in Mach-Weber-Assis Theory". Apeiron, **6**, 202-(1999).
15. J. Guala-Valverde & J.E. Guala, Jr., " Again on Inertial mass and Gravitational Mass". Physics Essays, **12**, 785-787 (1999)
16. A.K.T. Assis & J. Guala-Valverde, " Mass in Relational mechanics". Apeiron, **7**, 131-132 (2000).

17. J. Guala-Valverde, " A New Theorem in Relational Mechanics". Apeiron, **3**, 132-138 (2001)**.**
18. R. Feynman, *Feynman Lectures*, Vol.2, Chapter 13 (1964).
19. P.A.M. Dirac, " A New Basis for Cosmology". Proceedings of the Royal Society of London A, **165**, 199-208 (1938).
20. W.K.H. Panofsky, "Private communication". Letter to J.Guala-Valverde (1995).
21. A.K.T. Assis & J. Guala-Valverde, "Frequency in Relational Mechanics", Annales de la Fondation Louis de Broglie, **28**, 83-98.
22. F. Rohrlich, "Private communication". Letter to J. Guala-Valverde (2002).

Received February 2004

Journal Home Page