(2002)

ON ABSOLUTE AND RELATIVE MOTIONS IN PHYSICS

A. K. T. Assis[1] and J. Guala-Valverde[2]

ABSTRACT

The authors present the Newtonian definitions of *absolute* and *relative* motion. The idea is defended that only relative motions of matter relative to matter can be detected and lead to measurable effects. Phenomena is analyzed depending on velocity and acceleration in electromagnetism and mechanics.

NEWTON ON ABSOLUTE AND RELATIVE MOTIONS

Isaac Newton (1642-1727) presented in his book *Mathematical Principles of Natural Philosophy* (1687) the basis of classical mechanics, [Newton, 1934]. In the *Scholium*, after the Definitions in the beginning of this book, Newton defined absolute time, absolute space and absolute motion – the concepts to be employed in his laws. According to him, absolute time flows equably without relation to anything external, while relative time is some sensible and external measure of duration by means of motion of bodies. To Newton absolute space remains always similar and immovable without relation to anything external, while relative space is some movable dimension or measure of the absolute spaces which our senses determine by its position to bodies. And finally, Newton defined that absolute (relative) motion is the translation of a body from one absolute (relative) place into another. It can be said that relative time is a measure of duration by the means of motion of material bodies (like the angle of rotation of the earth relative to the fixed stars). Relative space is a measure of spatial dimension by means of material bodies (as the distance between two bodies measured by a material rule, or the relative order of three bodies in a straight line, like ABC or ACB).

In this work the authors utilize these Newtonian definitions of motion. Moreover, the idea is defended that all measurable or detectable physical effects depend on the relative motions between material bodies and not on the absolute motion of bodies relative to empty space (vacuum).

PHENOMENA DEPENDING ON VELOCITY

Most forces in mechanics depend only on the relative position of bodies, like the gravitational force of Newton, the elastic force of Hooke, or contact forces between bodies at rest (like capillary forces,

[1] Permanent address: Instituto de Física "Gleb Wataghin", Universidade Estadual de Campinas – Unicamp, 13083-970 Campinas, São Paulo, Brasil, email: assis@ifi.unicamp.br
homepage: http://www.ifi.unicamp.br/~assis

[2] Subsecretaria de Energia, MHOySP- Gobierno de la Provincia del Neuquen, 8300 Neuquén, Argentina.
E-mail: fundacionjuliopalacios@usa.net Also at Universidad Tecnológica Nacional Plaza Huincul, Neuquén, Argentina.

forces due to pressure or pressure gradients, van der Waal forces etc.) These forces are not problematic as regards to absolute and relative motion.

Forces depending on velocity arise usually in mechanics connected with friction between the test body and a material medium. Typical examples are the static and kinematic frictional forces between solid surfaces touching one another. In this case the frictional force is represented by μN, where μ is the coefficient of static (or kinematic) friction, and N is the normal force acting on the test body in the direction orthogonal to the surface at the point of contact. Although the magnitude of this force does not depend on velocity, its direction is such as to prevent the relative motion between the surfaces (in the case of static friction) or to decrease the relative motion between the surfaces when they are sliding relative to one another (in the case of kinetic friction). This force does not depend on the absolute velocities of the surfaces relative to vacuum, nor on their velocities relative to the observer.

Another example is the dragging force acting on a body moving in a gas or liquid. In this case, the magnitude of the force is in general a complicated function of the velocity, but reasonable approximations can be utilized with a linear or quadratic component. The important point is that once more only relative velocities between the test body and the surrounding medium at the location of the test body are relevant here, so that when this relative velocity goes to zero the dragging force also goes to zero.

The ohmic resistance in a metallic conductor can be understood microscopically as a dragging force acting on the conduction electrons proportional to their velocity relative to the metallic lattice. No absolute velocities are relevant here, only the relative velocity between a conduction electron and the surrounding metallic lattice.

In electromagnetism there are other phenomena depending on velocity but unrelated to friction: Ampère discovered between 1820 and 1826 that electric currents in metals attract or repel one another with a force proportional to the product of the intensity of each current. Wilhelm Weber could derive in 1846 Ampère's expression for the force between current elements based on a more basic expression for the force between point charges. (For references and discussions about Weber's law, see Sokolskii and Sadovnikov, 1987 [20], Phipps, 1992 [19], Galeczki, 1993 [5], Assis, 1994 [1], Galeczki and Marquardt, 1995 [6], Kinzer and Fukai, 1996 [14], Guala-Valverde, 1998 [7], [Assis, 1999 [2], Wesley, 1999 [21], Mikhailov, 1999 [16], Guala-Valverde, 1999a [8], Guala-Valverde, 1999b [9], Mikhailov, 2001 [17] and Bueno and Assis, 2001 [4].) Supposing each current element to be composed of positive and negative charges it is possible to derive Ampère's expression and to show that it is proportional to the relative velocity between the positive and negative charges of one current element, times the relative velocity between the positive and negative charges of the other element (see Assis, section 4.2, p. 86, Eq. (4.22) [1].) When these relative velocities go to zero in one or in both current elements, the ponderomotive force between the circuits also goes to zero.

Another phenomena depending on velocity was discovered by Faraday in 1831: Electromagnetic Induction. By approaching a magnet to a stationary circuit in the laboratory, an electric current was induced in the circuit. Exactly the same induction occurred if the magnet remained at rest in the laboratory, and the circuit approached the magnet with an opposite velocity of the same magnitude. The amount of electric current induced depended only on the relative velocity between magnet and circuit.

PHENOMENA DEPENDING ON ACCELERATION

Contrary to the authors of this paper, Newton believed in absolute motion and considered that it could be discovered when bodies were accelerated. In order to distinguish absolute from relative motions he performed the famous bucket experiment also presented in the *Scholium* of the *Principia* [18]. Newton partially filled a bucket with water and hung it by a rope. When the bucket and the water were at rest relative to the earth, the surface of the water remained flat and horizontal. However, when the bucket and the water rotated together relative to the earth with a constant angular velocity, the water ascended toward the sides of the vessel forming a concave figure. According to Newton this real and observed curvature was due to the absolute rotation of the water relative to absolute space and this effect would not depend on the relative rotation of the water relative to ambient bodies (earth and distant stars).

Leibniz, Berkeley, and Mach were against these concepts and proposed that only relative time, relative space, and relative motion could be perceived by the senses and generate observable effects. Accordingly only these relative concepts should appear in the laws of physics. For references and discussion see Assis [2] and Guala-Valverde [9]. Mach expressed these ideas clearly in his book *The Science of Mechanics*, in 1883 [15]. Instead of Newton's absolute space, Mach proposed the frame of distant stars, that is, the frame in which the distant stars are seen as at rest, (Mach [15] pp. 285-6 and 336-7). Instead of Newton's absolute time, Mach proposed the angle of rotation of the earth relative to the fixed stars (Mach [15] pp 273, 287, and 295). According to Mach, the curvature of the water in Newton's bucket experiment arose only due to its rotation relative to the distant stars and not due to its rotation relative to absolute and empty space (Mach [15] pp. 279 and 283-4]). According to Mach's ideas the same curvature of the water surface should arise if the bucket and water remained at rest relative to the earth, while simultaneously the remainder of the universe (distant stars) rotated around the bucket axis in the opposite direction with the same angular velocity relative to the earth as in Newton's original experiment. No curvature of the water surface should appear in this thought experiment, according to Newton's ideas. Two important statements of Mach in this connection are the following: "Try to fix Newton's bucket and rotate the heaven of fixed stars and then prove the absence of centrifugal forces;" and "The principles of mechanics can, indeed, be so conceived, that even for relative rotations centrifugal forces arise" (Mach [15] pp 279 and 284). The ideas expressed by Mach became generally known by the name "**Mach's principle**." The main ideas are that only relative motions of bodies relative to one another should enter in the laws of physics, only these relative motions can lead to measurable or detectable effects. No effects should arise due to the absolute motions of bodies relative to empty space. The authors agree with these ideas of Leibniz, Berkeley, and Mach.

Many other phenomena can be quoted showing the effects due to acceleration. One is the flattening of the earth at the poles due to its diurnal rotation around its axis. Rotating a plastic or elastic ball also produces the flattening of the ball. Another phenomenon is the precession of Foucault's pendulum depending on its latitude in the earth's surface. Newton would say that these phenomena prove the acceleration of these bodies relative to vacuum. Mach [15] and the others would say that they prove the relative rotation between the test body and the distant bodies in the cosmos.

Mach's ideas were implemented mathematically utilizing Weber's law applied to gravitation and the principle of dynamical equilibrium (Assis [2] and Guala-Valverde [9]). It is then possible to show, theoretically, that when there is no relative rotation between the test body and the distant stars and galaxies, the physical effects in the test body (like its flattening) disappear. Or if the test body remains at rest relative to a frame of reference S, while the distant stars and galaxies were able to rotate as a whole around the axis of the test body, it can be shown that, theoretically, the same effects in the test body should appear, as in the case in which the distant stars and galaxies are at rest relative to the frame of reference S, while the test body rotates relative to them, provided the relative angular rotation between the test body and the distant galaxies is the same in both cases. For a detailed mathematical derivation, the reader is referred to the references above [2,9].

An example of a measurable phenomenon depending on acceleration in electromagnetism is that of homopolar or unipolar induction, a special case of induction also discovered by Faraday himself in 1832. The whole issue remained rather confusing matter for 170 years, and troubled many important thinkers (Panofsky, Feynman, ...). Nevertheless, recent easy-to-repeat experimental work shows that both electromotive and ponderomotive observable effects only depend on the active conductor motion with respect to the magnet (Kelly, 1999 [13], Guala-Valverde and Mazzoni, 2001 [10], Guala-Valverde, Mazzoni and Achilles, 2002 [11] and Guala-Valverde, 2002 [12]). Here, active applies to the conductor which moves relative to the magnet (generator) or to the conductor able to move as regards the magnet (motor). The metallic pieces co-moving with the magnet only play a passive role, namely, to provide a suitable path for charge conduction. Thus, recent experiments on homopolar phenomena give strong support to Weber's relational electrodynamics (Assis and Thober, 1994 [3]).

ACKNOWLEDGMENTS

One of the authors (AKTA) wishes to thank the Alexander von Humboldt Foundation of Germany for a research fellowship during which this work was written. Thanks also go to the Organizing Committee of the International Workshop Physics as a Science (Arrecife, Spain, July 2002) for financial support to participate in the Workshop.

REFERENCES

1. A.K.T. Assis, Weber's Electrodynamics (Kluwer, Dordrecht, 1994), ISBN: 0-7923-3137-0.
2. A.K.T. Assis, Relational Mechanics (Apeiron, Montreal, 1999), ISBN: 0-9683689-2-1.
3. A.K.T. Assis, D. S. Thober, "Unipolar induction and Weber's electrodynamics," in Frontiers of Fundamental Physics, M. Barone and F. Selleri (editors), (Plenum Press, New York, 1994), pp 409-414.
4. M. d.A. Bueno, A.K.T. Assis,, Inductance and Force Calculations in Electrical Circuits, (Nova Science Publishers, Huntington, New York, 2001), ISBN: 1-56072-917-1.
5. G. Galeczki, "The limit speed and Weber's potential," *Physics Essays*, vol 6, p 86 (1993),.

6. G. Galeczki, P. Marquardt, "Über die longitudinalen Ampèreschen Kräfte und Webers Elektrodynamik," *Fusion*, vol 16, p 15 (1995).
7. J. Guala-Valverde, "Gravitational Mutual Energy in Weber-type Mechanics," *Physics Essays*, vol 11, pp 164-165 (1998).
8. J. Guala-Valverde, "Inertial Mass in Mach-Weber-Assis Theory," *Apeiron*, vol 6, pp 202-204 (1999a).
9. J. Guala-Valverde, Inercia y Gravitacion (Fundacion Julio Palacios, Neuquén, 1999b), with the collaboration of J. Tramaglia and R. Rapacioli, ISBN: 987-97703-0-7.
10. J. Guala-Valverde, P. Mazzoni, "The Unipolar Dynamotor: a Genuine Relational Engine," *Apeiron*, vol 8, pp 41-52 (2001).
11. J. Guala-Valverde, P. Mazzoni, R. Achilles, "The Homopolar Motor: a True Relativistic Engine," *American Journal of Physics*, vol 70, pp 1052-1055 (2002), .
12. J. Guala-Valverde, "Spinning Magnets and Relativity: Jehle vs. Bartlett," *Physica Scripta*, vol 66, pp 252-253 (2002).
13. A.G. Kelly, "Experiments on Unipolar Induction," *Physics Essays*, vol 12, pp 372-382 (1999),.
14. E.T. Kinzer, J. Fukai, "Weber's Force and Maxwell's Equations," *Foundations of Physics Letters*, vol 9, pp 457-461 (1996).
15. E. Mach, The Science of Mechanics – A Critical and Historical Account of Its Development, (Open Court, La Salle, 1960).
16. V.F. Mikhailov, "The Action of an Electrostatic Potential on the Electron Mass," *Annales de la Fondation Louis de Broglie*, vol 24, pp 161-169 (1999).
17. V.F. Mikhailov , "Influence of an Electrostatic Potential on the Inertial Electron Mass," *Annales de la Fondation Louis de Broglie*, vol 26, pp 33-38 (2001).
18. I. Newton, Mathematical Principles of Natural Philosophy, (University of California Press, Berkeley, 1934).
19. T.E. Phipps Jr., "Derivation of a Modernized Weber Force Law," *Physics Essays*, vol 5, pp 425-428 (1992).
20. A.G. Sokolskii, A.A. Sadovnikov, "Lagrangian Solutions for Weber's Law of Attraction," *Soviet Astronomy* (Astronomical Journal), vol 31, pp 90-93 (1987).
21. J.P. Wesley, "Weber Electrodynamics, Part I: General Theory, Steady Current Effects," *Fondations of Physics Letters*, vol 3, pp 443-469 (1999).