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SCIENCE AS AN ESSENTIALLY PLURALIST ENTERPRISE: THE NEED FOR A CHOICE BY A THEOLOGY SCHOLAR

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ABSTRACT
The present paper leads to discover two basic dichotomies as the foundations of science. Their relevance is proved through an analysis of the main categories in history of science, the history of classical Mechanics by taking into account Lazare Carnot's mechanics and its anticipation, Leibniz's. Two main lines of historical development result. The relevance of the two dichotomies is proved also by the history of Western philosophy; that leads to re-evaluate Leibniz's philosophy of science. Also, the historical development of modern physics shows their relevance. The implications for the relationship ethics and science are drawn.

Keywords: *Two dichotomies; Kinds of infinity; Kinds of theoretical organization; History of science; Leibniz' mechanics; Lazare Carnot's mechanics; History of Western philosophy; Leibniz' philosophy of science; Ethics; Religion;*

1. THE DISCOVERY OF TWO BASIC DICHOTOMIES AS THE FOUNDATIONS OF SCIENCE

The relationship between theology and science is shaped by which qualification receive foundations of modern science.1 In my opinion Koyré's analysis was the best hint for revealing them.

He showed that modern science born inasmuch as it included the notion of infinity in its very structure. In fact, it is well-known that the first physical theory - Geometrical Optics - included mathematical formulas where points at infinity are put on the same foot than usual points; then, since second theory the mathematics of infinitesimals was the best support for the tremendous development of the whole science.

Moreover, Koyré evidentiated that the scientists of that times disputed a long time upon which between two notions of infinity was suitable for science. Eventually, the supporters - through infinitesimals - of actual infinity (**AI**) prevailed on the supporters of potential infinity (**PI**).

In addition, Koyré declared his interpretative categories, which are constituted by two short sentences: "Dissolution of finite space and geometrisation of space". After Newton, "space" was considered as absolute space. Instead, by Leibniz and by some subsequent scholars "space" was intended as a relative notion. An analysis of this notion in all the founders of a physical theory makes apparent that the notion of space is correlated with a foundational notion; i.e. the organisation of the theory itself; respectively, either the totally deductive one - a model of organisation which was suggested by Aristotle, who called it apodictic theory (**AO**) -, or a theory aimed to find out a new method for solving a general

[1] A. Koyré: From the Closed World to the Infinite Universe, Baltimore U. P., 1957.

problem (**PO**) - for instance, the organisation of classical Chemistry, or in more recent times the organisation of Computability Theory.2

The relevance of last dichotomy may be verified in some important cases. The first one is Galileo's attitude to present his main works by means of a dialog, i.e. in a Platonist way, the opposite tradition to the Aristotelian one. Then, d'Alembert in *Éncyclopédie Française* supported the view that "empirical" organisation - a rough approximation of the notion of PO - is better than the "rational organisation" - clearly AO -. The same was emphasised in a lucid way by L. Carnot in 1783.3 Unfortunately, in 19th Century this suggestion was missed; but in 20th Century some authoritative scholars (Lukasiewicz, Beth, etc.) put again the problem how to exit from the the uniqueness of AO.4

In sum, a slight improvement of Koyré's categories plus D'Alembert's and L. Carnot's illustrations leads us to recognise the above-illustrated two basic dichotomies as the very foundations of a scientific theory.

2. A VERIFICATION OF THE RELEVANCE OF THE ABOVE TWO DICHOTOMIES THROUGH AN ANALYSIS OF THE MAIN CATEGORIES IN HISTORY OF SCIENCE

Conversely, by scrutinising Koyré's categories one obtains that the two above-mentioned sentences constitute an implicit translation in intuitive terms of the choice for AI (geometrisation) and for AO (space), as well as the rejection of the opposite choices, PO (dissolution) and finite cosmos (PI). Since Newtonian mechanics shares the same basic choices - OA owing to its three principles-axioms, and IA owing to infinitesimal analysis -, we see that Koyré's analysis was successful inasmuch as it is functional to the dominant theory in the time at issue.

Let us investigate on the categories - truly, some intuitive, appealing terms; e.g. revolution - in Kuhn's celebrated book.5 Cerreta and myself recognised in them a new translation of the same basic choices in Newtonian mechanics; "scientific community" and "Gestalt" respectively represent the choices AO and AI. Moreover, his notions of reference system, constant velocity, force, acceleration, new constant velocity are translations in historical notions of, respectively, normal science, paradigm, anomaly, revolution, new paradigm; it may be defined as an attempt to uprising Newtonian dynamics to a historiographic paradigm.6 However, rejected choices (PI and PO) are not perceived. In comparison with Koyré's analysis, Kuhn's one is less clever and suggestive about the foundations of science.

Instead, the historiographies of science by Mach,7 of Faraday's views on electromagnetism by P. Williams8 and classical chemistry by Thackray9 do not present the

[2] A. Drago: "La storia del concetto di spazio quale rivelatrice delle scelte fondamentali di una teoria fisica: II. A. Koyré e la metafisica della scienza moderna", in F. Bevilacqua (ed.): Atti VII Congr. Naz. Storia Fisica, Padova (1986), 119-123.

[3] L. Carnot: Essai sur les machines en général, Defay, Dijon, 1783, 102-105; Principes fondamentaux de l'équilibre et du mouvement, Crapelet, Paris, 1803, p. xiii-xvii.

[4] E.W. Beth: Foundations of Mathematics, Noth-Holland, Amsterdam, 1959, ch. I, 2.

[5] T.S. Kuhn: The Structure of Scientific Revolutions, Chicago U.P., Chicago, 1962 (2° ed. 1969).

[6] P. Cerreta A. Drago: "The conceptual structure of SSR by T.S. Kuhn", in F. Krafft C.J. Scriba (eds.): XVIII ICSH, Hamburg, 1989.

[7] E. Mach: The Science of Mechanics (1878), Open Court,. 1910.

[8] P. Williams: "Faraday" in C.C. Gillispie (ed.): Dictionary of Scientific Biography, Scribner, New York, 1974, 4.

[9] A. Thackray: Atoms and Powers, Cambridge U.P., 1970, last page.

above-mentioned attitudes. By investigating on their categories I recognised in them the couple of opposite choices - i.e. PI&PO -, to the Newtonian ones.10 More historiographies of science, even less known, may be included; e.g., Sneed -. Stegmueller - Balzer's one, whose categories are recognised to refer to the couple of choices AI&AO, as well as Bogdanov's one and Prigogine's ones, both referring to PI&PO.

AUTHOR	FIELD OF STUDY	DECLARED CATEGORIES	UNDERLYING PHYSICAL-PHILOSOPHICAL NOTIONS	UNDERLY-ING BASIC CHOICES
KOYRE'	Science's birth	*Dissolution of finite cosmos and geometrisation of space*	dissolution = not organisation of finite cosmos = no finitism geometrisation = calculus space = deductive organisation	no PO no PI **AI** **AO**
KUHN SSR	Classical physics	*Normal science,paradigm, anomaly, crisis and revolution, Gestalt switch activity of scientists' community, cumulative history or not*	*v* = const, inertial system, force, acceleration, *A(c,t)*, integral or derivative on *A(c,t)*,	Newtonian mechanics: **AI&AO**
SNEED	Classical physics	*Mathematical structures, set theory, models*	set, model	Set theory: **AI&AO**
MACH	Classical physics	*Thinking's economy*	work, problems of a minimum	**PI** **PO**
BOGDA-NOV	Ancient science	*Organization of productive work*	work, problem of limitations	**PI** **PO**
WIL-LIAMS	Faraday	*Unity and convertibility of force, Boscovichtian atoms*	no force-cause, finitism	no AO **:PO** **PI**
THACK-RAY	Classical chemistry	*Against short-range forces and matter's unity*	no force-cause finitism	no AO: **PO** **PI**

[10] A. Drago: "Interpretazione delle frasi caratteristiche di Koyré e loro estensione alla storia della fisica dell'ottocento", in C. Vinti (ed.): Alexandre Koyré. L'avventura intellettuale. ESI, Napoli, 1994, 657-691.

KUHN BBT	Black-body	*Legacy, continuity, phase, group of concepts*	state transitions, phases, triple point	Therm.: **PI**
DRAGO	Carnotian theories	*Evanescence of force-cause and discretisation of matter*	evanescence = not abstractism force-cause = axiom-principles discretisation = constructivism matter = problematic organisation	not AI not AO **PI** **PO**
PRIGO-GINE	Classical physics	*complexity, non-determinism, chaos, irreversibility*	non-determinism, chaos, irreversibility	not AO: **OP**? Therm.: **PI**?

3. VERIFYING THE TWO DICHOTOMIES IN THE HISTORY OF CLASSICAL MECHANICS: TWO MAIN LINES OF DEVELOPMENT

Being Newton's mechanics an AI and AO theory, we are led to look for an alternative formulation of mechanics as a PO and PI theory. A century after (1783) the birth of Newton's theory, a fully developed alternative born through Lazare Carnot's theory, recently re-discovered. 11 Instead of the starting point of Newton's mechanics - i.e., the absolute ideas of space and time -, the starting point of Carnot's theory is the problem of an impossibility - of a perpetual motion -; that substantiates *a PO theory*.

What in Newton's theory represented a subordinate phenomenon with respect to astronomical ones - i.e., the impact of bodies - in L. Carnot's theory plays the role of the basic phenomenon for developing the whole mechanics. Whereas Newton focused the attention on a single body, L. Carnot took in account a system of bodies in presence of constraints. By dismissing the metaphysical notions of Newton's theory, in particular the notion of a force-cause,12 L. Carnot's theory was a science of the interaction among material bodies; he relied his analysis on the communication of the motion among bodies, a communication essentially performed through impacts and evaluated by means of the velocities of the bodies, not trajectories. Rather than to refer the impact of each body to a

[11] C.C. Gillispie: Lazare Carnot Savant, Princeton U.P., Princeton, 1971. See also: I. Grattan-Guinness: Convolution in French Science, 1800-1840, Birkhauser, 1980, 2 , § 5.2.6. The two works by L. Carnot are presented in footnote 3.

[12] Indeed, $f = ma$ is an a priori principle. First of all the notion of dynamic force is incorrectly defined. It is illegitimate to idealistically extend the experimental notion of a static force to a dynamic force, since the whole passage from static to dynamics depends exactly from the notion of a dynamic force. Really, all analyses of this principle conclude that we cannot define the notion of a dynamic force otherwise than by measuring *ma* - provided that the notion of mass has already defined in an independent way. About previous analysis reporting on the essentially idealistic nature of Newton's version of the inertia principle see N.R. Hanson: "Newton's first Law. A Philosopher's door in Natural Philosophy", in R.G. Colodny (ed.): Beyond the edge of certainty, Prentice-Hall, 1965, 6-28. A further analysis is A. Drago: "A Characterization of Newtonian Paradigm" in P.B. Scheurer, G. Debrock (eds.): Newton's Scientific and Philosophical Legacy, Kluwer Acad. P., 1988, 239-252. For an accurate analysis of L. Carnot's principles (L. Carnot: Principes..., op. cit., 49-53) see: A. Drago: " Le lien entre mathématique et physique dans la mécanique de Lazare Carnot", in J.-P. Charnay (ed.): Lazare Carnot ou le savant-citoyen, P. Université Paris-Sorbonne, 1990, 501-515; A Drago and D.S. Manno: "Le ipotesi fondamentali della meccanica secondo L. Carnot", *Epistemologia*, 12 (1989) 305-330.

mythical body only - i.e. the perfectly hard body, whose shape does not change irrespectively of the violence of an impact; an ideal notion rejected in 1850 -, all real bodies mattered on the same foot to L. Carnot's theory; since L. Carnot introduced first an elasticity coefficient (ranging from 1 to 2), which characterises the behaviour of every impacting body. By generalising the principle of virtual velocities, L. Carnot obtained an equation:

$$\sum_i m_i \vec{U}_i \cdot \vec{u}_i = 0$$

where the *mi* is the mass of the i-the particle composing the system at issue, *Ui* the lost velocity, that is the difference between the initial velocity *V* and the final velocity *V'*, *ui* is a geometrical motion, that is a motion which can be added to the particle i-th without changing the interaction. From it he was able to draw the laws of impact for whatsoever kind of body as the conservations of energy, momentum, momentum-of-momentum by means of a plain algebraic-vectorial calculation. For ex., a common geometrical motion *ui.*= *u* to all elementary components, gives

$\sum_i m_i \vec{U}_i \cdot \vec{u} = \vec{u} \cdot \sum_i m_i \vec{U}_i = 0$; which, being *u* an arbitrary quantity, gives

$\sum_i m_i V_i = \sum_i m_i V_i'$; that is, the conservation of momentum. That solves the specific problem of this OP theory, i.e. which invariant magnitudes exists during an impact of bodies. The same Carnot suggested the way for generalising his algebraic equation in the case of continuously varying motions.

In particular, he was able to treat the case of central forces. In total, his theory is *a PI theory*. Moreover, he was capable to characterise in general terms the two different foundations of mathematics, i.e. IP and IA.13

No wonder if a so original kind of theory was ignored by most scientists and philosophers along two centuries. By taking in account L. Carnot's formulation, mechanics results to be - contrarily to a deeply rooted and widespread paradigm -, an essentially pluralistic theory, displaying several, distinct formulations. The development of classical physics is characterised as a dominant role played by Newtonian paradigm (AO and IA) on the minoritarian model of scientific theory, i.e. the L. Carnot one (PO and PI);14 already Brown, Dugas and Brunschvigc hinted this dichotomic development.15 By taking in account L. Carnot's mechanics, thermodynamic basic notions - say, energy, work, impossibility of a perpetual motion, naive mathematics - are no more at odd with those of theoretical mechanics; it is not a chance that thermodynamics originated almost entirely from the booklet by the son of L. Carnot, Sadi. Furthermore, the strange history of electromagnetic theory is not a priori included in - or in agreement with - mechanics. Rather, an accurate study of this theory shows that the main contributions to its construction really range

[13] L. Carnot: Réflexions sur la metaphysique du calcul infinitésimal, Courcier, 1813, 217-252.
[14] A. Drago: "A characterisation...", op. cit. ; "The alternative content of Thermodynamics: Constructive mathematics and problematic organization of the theory", in K. Martinas, L. Ropolyi, P. Szegedi (eds.): Thermodynamics: History and Philosophy. Facts, Trend, Debates, World Scientific, Singapore, 1991, 329-345; "Alternative mathematics and alternative theoretical physics: The method for linking them together", *Epistemologia*, 19 (1996) 33-50.
[15] S.C. Brown: "Resource Letter EEC-1 on the Evolution of Energy Concepts from Galilei to Helmholtz", *Am. J. Phys.*, 33 (1965) 759-765; R. Dugas: Histoire de la Mécanique, Livre III, Griffon, Neuchatel, 1950; L. Brunschivgc: L'éxperience humaine et la causalité physique, P.U.F., Paris, 1949, Livre XIII.

between two polarities, again Newton's mechanics and L. Carnot's mechanics; in particular, Faraday's main notions belong to the latter one.16

4. VERIFYING THE TWO DICHOTOMIES IN THE HISTORY OF WESTERN PHILOSOPHY: A RE-EVALUATION OF LEIBNIZ'S PHILOSOPHY OF SCIENCE

It is a triviality to state that Leibniz was a great philosopher. It is a triviality that Leibniz was a great scientist since he invented infinitesimal analysis, the most fruitful mathematical theory in the history of modern science. A century ago it was a discover that Leibniz was a great logician too. All that is much more than any other philosopher - except maybe for Descartes, yet operating at an early stage of development of modern science.

What holds back this last appraisal is Leibniz' almost incomprehensible writings on mechanics. At glance, Leibniz' "reform of dynamics" constitutes an incomplete effort to build an alternative theory to the glorious Newtonian mechanics.17 Instead, it results to be a clever starting point of an alternative to the latter mechanics when one interpret Leibniz' works according to the following points: i) Against the widespread prejudice of an idealistic metaphysics pervading Leibniz' thinking, MacDonald Ross'18 stressed that in Leibniz there are two radically distinct conceptions of metaphysics, the one of the foundations of science; the other as the science of immaterial reality; and the two conceptions go on in a parallel way. ii) Against the widespread prejudice of an unconclusiveness of Leibniz' effort, L. Carnot substantiated Leibniz' program, by achieving a complete theory of impact and a well-developed mechanics, whose features are radically at variance with Newton's mechanics ones.19 iii) Instead of all writings by Leibniz, one has to take in account only those pertaining to his maturity about this subject, i.e. after 1690. The resulting reconstruction of Leibniz' mechanics is synthesised by the following list of basic features, principles and laws.20

[16] A. Drago: "A. Volta and the strange history of electromagnetism", in in F. Bevilacqua and E.A. Giannetto (eds.): Volta and history of Electricity, Hoepli, Milano, 2003, pp. 97-111. For a modern re-interpretation of electromagnetic theory according to some new basic notions which agree with those pertaining to L. Carnot's mechanics see G. Falk, F. Hermann, G.B. Schmidt: "Energy forms or energy carriers?", *Am. J. Phys*., 52 (1983) 1084-86. See also the debate between H.A. Buchdahl and G.B. Schmidt in *Am. J. Phys.*, 56 (1988) 853-5.

[17]A recent review and reformulation of past studies on Leibniz' mechanics is the book by F. Duchesneau: La dynamique et Leibniz, Vrin, Paris, 1994.

[18] G. MacDonald Ross: "The demarcation between the metaphysics and the other disciplines in the thought of Leibniz", in R.S. Woolhouse (ed.): Metaphysics and Philosophy of Science in Seventeenth and Eighteenth Centuries, Kluwer, 1988, 133-163, p. 160. For a more appropriate appraisal on Leibniz' attitude for suggesting a new mechanics, see for ex. the admirable clarity of Leibniz' purpose, as it is expressed in a letter to Honoratus Fabri of 1677. For a short introduction in Leibniz' philosophy on dynamics see E. Cassirer: Leibniz' System in Wissentschlaftlischer Gruendlagen, Marburg, 1902, sect. IV, I, 2.

[19] C.C. Gillispie: op. cit.; A. Drago: "The prosecution of Leibniz' program in Lazare Carnot's works", IX Logic Meth. Phil. Sci., 2, Uppsala, 1991 (abstract); "The principle of virtual works as a source of two traditions in 18th Century Mechanics", in F. Bevilacqua (ed.): History of Physics in Europe in 19th and 20th Centuries, SIF, Bologna, 1993, 69-80; A. Drago, F. Piro: "Perché Leibniz non credeva nel moto perpetuo meccanico?", in C. Cellucci (ed.): Prospettive della Logica e della Filosofia della Scienza, ETS, Pisa, 1998, 403-418. A new interpretation of Leibniz'astronomical works is offered by D. Bertoloni Meli: Equivalence and Priority: Newton vs. Leibniz, Claredon,. Oxford, 1993.

[20] A. Drago: "A proposal for teaching mechanics according to Leibniz-L. Carnot's mechanics", J. Sebesta (ed.): History and Philosophy of Physics in Education, Bratislava, 1996, 186-192; "The alternative science of the Enlightenment", Studies on Voltaire and the Eighteenth Century 348, Trans. Ninth Int. Congr. on the Enlightenment Münster 1995, 1997, 1081-1085; A. Drago and A. La Sala: "La meccanica di Leibniz ricostruita come coerente alternativa alla meccanica di Newton", in P. Tucci (ed.): Atti XVI Conv. Naz. Storia Fisica e

A RECONSTRUCTION OF LEIBNIZ' DYNAMICS
Principle of sufficient reason (nothing is without cause)
Contingent statements (whose contrary statements do not imply contradiction)
Non classical logic: - - A ≠ A; a problem-based organisation of the theory
Dynamics as first, not statics
Impossibility of a perpetual motion
Action-reaction
Relativity of space, time and motion; composition and decomposition of motions
Indifference of a body to rest and to move; inertia as an immanent property in the bodies
"our minds look for conservation"; invariants (symmetries)
Conservation of kinetic energy
Theory of the impact of bodies; elastic bodies (no hard body)
Principle of Torricelli; rough definition of work
Lack of: i) a mathematical version of the principle of virtual velocities (Bernoulli, 1717) ii) a mathematical derivation of invariants (L. Carnot, 1782) iii) a complete theory of impact (L. Carnot, 1782)

In particular, this reconstruction emphasizes that we have to attribute to Leibniz' mechanics - or to both Huygens and Leibniz -, the following crucial achievements: i) *Relativity of the motion*.21 ii) *Laws of elastic impact*.22 iii) *Conservation of energy*. Moreover, we have to attribute to Leibniz only the following achievements: v) *Symmetries*.23, although without a mathematical apparatus.24 v) To raise *the impossibility of a perpetual motion* to play the role of a basic principle in the physical theory.25

Previous principle is the methodological principle starting Leibniz' mechanics, in order to solve its main problem, i.e. the impact of bodies; in sum his theory is a PO theory. Moreover, Leibniz deliberately excluded infinitesimal analysis from the foundations of physics; the kind of mathematics in his mechanics is no more than algebraic calculus, i.e. his theory includes PI only. It results a consistent alternative to Newtonian mechanics, its relevance for both classical and modern physics can be hardly overestimated. In a retrospective view, the bound to Leibniz' theorisation on mechanics results to be the

dell'Astronomia, Milano, 1997, 383-402; "Presentazione ed edizione critica di *Essay de dynamique* di Leibniz", in P. Tucci (ed.): Atti XVII Congr. Naz. Storia della Fisica e dell'Astronomia, 181-198; A. Drago and M.G. La Sala: "La meccanica dell'urto in Leibniz", *Giornale di Fisica*, 40 (1999) 193-204.

[21] This point is emphasised by A. Chalmers: "Galilean Relativity and Galileo's Relativity", in S. French and H. Kamminga (eds.): Correspondence, Invariance and Heuristic, Kluwer Acad. P., 1993, 189-205. The attitude of both Leibniz and Huygens on this point is illustrated by R. Dugas: Histoire de la Méchanique du XVII Siècle, Griffon, Neuchatel, 1954, ch. XIV, § 12.

[22] *Ibidem*, ch. XIV, § 8. See also W.L. Scott: The Conflict between Atomism and Conservation Theory. 1644-1860, Elsevier, 1970. Among the works by Leibniz see in particular, Essay sur la dynamique des loix du mouvement, 1698.

[23] G.W. Leibniz: Essay sur la dynamique, 1692; A. Drago and G. La Sala: "Presentazione ed edizione critica...", op. cit.; A. Drago: La riforma della dinamica secondo G.W. Leibniz, Hevelius, Benevento, 2004.

[24] K. Mainzer: "Principles of symmetry and conservation laws", in M.G. Doncel et al. (eds.) (1987), 69-75; H. Breger: "Symmetry in Leibnizian Physics", in The Leibniz Renaissance, Olschki, Firenze, 1986, 23-42.

[25] C.C. Gillispie says that this principle plays a "demonstrative and tutelary" role in L. Carnot's theory (op. cit., p. 99); L. Carnot himself stressed this point in the preface of his second book on mechanics: Principes, op. cit.. , p. XXI. E. Mach: Principles of Mechanics, Open Court, 1960, p. 33ff.

mathematical version of the principle of virtual works - by him exploited in a merely verbal version.

A so impressive advancement in mechanics, when considered together with the marvellous advancements in both mathematics and mathematical logic - all accomplished by a professional lawyer -, results almost as incredible if not supported by a specific metaphysics of science; indeed, a reconstruction of his project of the metaphysics of science - i.e. the *Scientia generalis*, or the "science of science" - may be performed.26

Indeed, both basic dichotomies have been distinctly characterised by Leibniz. He stressed "two labyrinths of reason". The former one is the labyrinth of the dilemma between law and free will, which translate in subjective terms respectively AO and PO. The latter labyrinth concern the notion of infinity and Leibniz knew well the distinction between AI and PI. Moreover, he stressed two basic philosophical principles of our arguing, that are the non-contradiction principle and the principle of sufficient reason; the former one clearly governs an OA; the latter one governs a PO, since this principle constitutes the best guide for suggesting how to solve in a heuristic way a general problem. It is furthermore very relevant to remark that Leibniz invented calculus as a first version of a *Characteristica Generalis*; yet, he was not entirely satisfied of this version, and he then worked for inventing a new *Characteristica generalis*,27 which at present may be substantiated by the mathematical technique of symmetries.

No more divergent phenomenon in history and philosophy may occur than a difference between two theories in either the kind of organisation or the kind of mathematics shaping scientific notions.28 That suggests that the notion - suggested by both Kuhn and Feyerabend - of incommensurability between the two theories, involving a partial translatability, may receive an operative definition.[29] *Two theories are said incommensurable when they 1) are organised in a systematic way; 2) are mathematised; 3) mutually differ in at least one of their choices on the two basic dichotomies.* Both conditions 1) and 2) outline an exact field of application; this field is narrower than that approximately addressed to by both Kuhn's and Feyerabend's notions, yet it produces a well- defined list of pairs of incommensurable theories.

One may recognise the first case of incommensurable theories in the couple of Descartes' optics (PI&AO) and Newtonian optics (AI&AO); the first case which was partially perceived as such in the couple of Newtonian Mechanics (AI&AO) and thermodynamics (PI&AO); the more shocking case in the couple of Newtonian mechanics and special relativity (PI&PO); the most cumbersome one in the couple of Newtonian mechanics and quantum mechanics.

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[26] A. Drago: "The modern fulfilment of Leibniz' program for a *Scientia generalis*", in H. Breger (ed.): VI Int. Kongress: Leibniz und Europa, Hannover, 1994, 185-195.

[27] L. Brunschvigc (1949): L'éxperience humaine et la causalité physique, PUF, Parigi, 143.

[28] This difference may be proved to be equivalent to the difference between classical and intuitionistic logic, whose borderline is the failure of the double negation law. This difference cannot be overcome by means of a formal translation, which results to be a partial one - similarly to Kolmogoroff-Glivenko-Goedel's translation between classical logic and intuitionistic logic; see S. Troelstra and D. van Dalen: Constructivism in Mathematics, 1, North-Holland, Amsterdam, p. 128.

29 A. Drago: "Una definizione precisa di incommensurabilità delle teorie scientifiche", in F. Bevilacqua (ed.): Atti VII Congr. Naz. Storia Fisica, Padova (1986), 124-129; "An effective definition of incommensurability", comm. to VIII Congress on Logic, Methodology and Phil. Sci., Moscow, 1987, 4, pt.1, 159-162 and in C. Cellucci et alii (eds.): Temi e prospettive della logica e della filosofia della scienza contemporanea, CLUEB, 1988, vol. II, 117-120.

In particular, owing to incommensurability phenomena, Newtonian mechanics played a dominant role in the history of science, in such a strong way to obscure the alternative theories - or at most, leading to qualify each of them as a "phenomenological", "genetic", "immature" theory, i.e. as a first stage of a more developed theory.30 Hence, the notion of Newtonian theory substantiates what Kuhn called "a paradigm", owing to such a dominant role capable to efface all incommensurabilities.

Apparently, Leibniz was unaware of this kind of phenomenon. His peaceful attitude in international relationships wanted to conciliate all theoretical contrasts too. This constitutes the most relevant bound to his philosophical activity. It is remarkable that a century after him, his follower, L. Carnot, illustrated two distinct kinds of organisations as well as the two kinds of mathematics. He did not want to conciliate the alternatives, rather he suggested a pluralist attitude.

5. Verifying the two dichotomies in the development of modern physics

There is no space for detailing an analysis of both special relativity and quantum mechanics according to the above-mentioned two dichotomies. It is enough to remark that special relativity may be considered as a resurrection of Leibniz's viewpoint about relativity of space and time, about energy as the basic physical magnitude and about impact of bodies as the basic phenomenon of theoretical physics. It is possible to prove that subsequent L. Carnot's theory is the best basis for introducing special relativity, both in geometrical terms and in mathematical terms.31 In fact, special relativity does not make use of differential equations in essential way, being constructed by means of a group of transformations which require an algebraic formalism only; that means the choice PI. Moreover, Einstein himself stressed that his theory is a "principle theory",32 i.e. a theory similar to S. Carnot's thermodynamics; indeed, it is based upon the problem of looking for invariant laws. Hence this theory is a PO theory. Being a PI and PO theory, it belongs to the Leibnitzian-Carnotian tradition of theoretical mechanics.

In quantum mechanics a non classical logic was discovered in 1936. Actually, it is disputable which law among classical laws fails. Some authors support the view that it is the double negation law. In fact, one may reconstruct quantum mechanics, in the Heisenberg formulation - the first one in the history of quantum mechanics - according to the model of a PI and PO theory.33

About the relevance of the view on foundations of modern science given by the two dichotomies, I stress that in 1918 H. Weyl launched a program for founding anew both

[30] In The Essential tension, Chicago, 1977, T.S. Kuhn recognised this feature when recognised the relevance in the history of science of the "Baconian" theories. More accurately, I previously showed the existence of two incommensurable traditions in classical mechanics too, the alternative one starting by Huygens and Leibniz and being accomplished by L. Carnot in 1783.

[31] A. Drago: "Minkowsky, Poincaré, Lobacevskij: la via geometrica alla relatività ristretta", in P. Tucci (ed.): Atti XVIII Congr. Naz. Storia Fis. E Astr., Dip. Fis. Generale e Appl., Univ. Milano, Milano, 1998, 151-170.

[32] M.J. Klein: "Thermodynamics in Einstein's Thought", *Science*, 57 (1967) 505-516 and A.I. Miller: Albert Einstein's Special Theory of Relativity, Addison-Wesley, 1981, 123-142.

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mathematics by reducing its use of AI to almost the PI only;34 and new physics - both special relativity and quantum mechanics - upon group theory,35 i.e. this mathematical theory constitutes the typical technique pertaining to PO and PI theories.36

6. IMPLICATIONS FOR THE RELATIONSHIP ETHICS AND SCIENCE

A direct consequence of this pluralistic view on science is to eventually dismiss a representation of science as a monolith. Science is essentially severed in at least four models of scientific developments (MST), corresponding to any pair of choices upon the two basic dichotomies. The incommensurability phenomenon obstructs to consider science as a whole, if not in a highly idealised way.

It is very relevant that even in the field of study on ethics a relevant scholar recognise four models of ethics.37 One may trace back these models of ethics to two basic dichotomies, which parallel scientific dichotomies.38

This parallelism suggests that any question on the relationship between ethic and science - for instance, bioethics -, involves two whole systems of both scientific and ethical tenets; no possibility of shortcoming the question in a naive way or even in a merely empirical way.

7. IMPLICATIONS FOR THE RELATIONSHIP FAITH AND SCIENCE

Even more dramatic are the implications for the relationship between faith and science.

In our post-metaphysical age, originated by the intensive introduction of science in the intellectual life, the very metaphysics may be recognised by overall re-discovering past effective metaphysics, first of all the metaphysics of past scientific development, likely as I did previously through the basic variables of the re-constructed *Scientia Generalis*.

Moreover, no more faith have to ask science for the correct solutions to some basic questions; the very scientific solutions are essentially fourfold; they do not suppress the obligation for a theologian to choice in an ethical way and moreover to choice under the light of religious principles. Rather, faith is called to see from a wise viewpoint the fourfold development of science for advising people; then the single person has to decide by means of religious principles to which model of ethics and to which MST he wants to belong and to promote.

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