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Which Hermeneutical Method Is Suggested by the New Historiography of Science

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Abstract

Whereas "Science does not think" (Heidegger), the "new historiography of science" – mainly Koyré's and Kuhn's ones – has addressed our minds to think about science in a new way. Recently Heelan suggested taking this new viewpoint for conceiving hermeneutic method in a more adequate way to present scientific practice. By an interpretative analysis of the categories of the above two historians, the present paper suggests a new way to conceive the foundations of science. Two basic dichotomies result: on the kind of logic and on the kind of mathematics. They generate four models of scientific theory, sharply severed by the radical differences in their respective choices; that offers an accurate definition of incommensurability and even of an alternative scientific theory to a dominant one, which can be properly called a paradigm. In the past hermeneutic scholars gave negative appraisals on Western science; according to the new viewpoint recognising pluralism in the foundations of science, these appraisals concern the dominant paradigm only. In the light of the basic dichotomies a new way to define hermeneutics is suggested; it can be qualified in short by the following words: 'The understanding of science is the science of understanding'.

Keywords: hermeneutics, method, historiography

1. Heelan's proposal for a hermeneutics of science

In recent times[1], one of the most authoritative interpreters of the hermeneutic method as applied in science, P. Heelan, has recognised that:

> Many important writers, including Gadamer, Apel and Habermas, are too imbued with the classical science as uniquely explanatory (which for historical – and perhaps also practical – reasons characterises the culture of empirical research) to be open exponents of a hermeneutic philosophy of natural science (Heelan 1998: 274, fn. 2).

> The *hermeneutic* orientation is contrasted [by the above mentioned writers] with the explanatory tradition which in the English-speaking world is simply called "science". Explanatory method [of this tradition] aims to the construction of a mathematical model comprising measurable (theoretical) variables, to be accepted or rejected by reason of its ability under laboratory circumstances to predict and control, the causal outcomes of assigned initial conditions. Such is in general the methodological profile of the natural sciences (274).

Heelan has suggested to take into account what rather "new historiography of science" achieved as a more appropriate image of science.

[1] This paper is a translation and a slight mprovement of "Il metodo ermeneutico suggerito dalla storiografia della scienza". In G. Cacciatore, P. Colonnello, D. Jervolino, eds. (2001), *Ermeneutica, Fenomenologia, Storia*. Napoli: Liguori, Napoli, 459–479.

Not that the human sciences have to be exclusively interpretative, nor the natural sciences exclusively explanatory. In fact, during the past fifty years […] scholars have began to use both hermeneutics and empirical social sciences methods to study the actual and historical profiles of activities of communities of scientific researchers. One outcome was the strong claim that the march of science was not continuous but rather characterised by abrupt theoretical discontinuities or (what T.S. Kuhn called) "scientific revolutions". Similar discontinuities were shown to exist even among co-existing explanatory theories. Other studies have convincingly uncovered a diversity of external and internal cultural goals in scientific research. The outcome of this research was brought philosophers of science to a moment of reflection about identity and goals of explanatory science. This perplexity has affected the status of the natural sciences in a special way, since, because of their success, they were assumed to provide a privileged route to knowledge, a route that became exemplary for all the other sciences, and even for philosophy of science itself.

The received tradition of the philosophy of science […] is now deeply divided upon how to respond to the picture of scientific culture newly laid out by the best scholarship in the empirical social and historical sciences. The story they tell about the natural sciences can hardly be reconciled with the noble ideals of knowledge and reality stemming from the philosophical tradition just mentioned. Whence comes an embarrassing dilemma: either natural science is not worthy of the name of 'knowledge' and deserves no more than to be called 'useful opinion', or the philosophical analysis of

knowledge and reality needs to be revisited and reviewed (274–275).

The last task leads Heelan to enquire: "how the current logical empiricist and the hermeneutic tradition relate one to another with respect to the short term explanatory goals of science and the long term goals of knowledge" (276).

2. The new historiography of science

By accepting Heelan's suggestion, let us inspect accurately the new historiography of science.

In the past, an academic discipline of historiography of science has been conceived in agreement to a positivistic philosophy of science. Such a traditional historiography dealt with the historical hard facts labelled by historical dates; it essentially gave an account of the accumulation of scientific results; its characteristic problem was to decide the priority question regarding each scientific discovery; and moreover it assumed the viewpoint of present-day science as a yardstick; as a consequence, it considered the final result of a historical development as the last word on the whole, historical debate in previous times, by disregarding both mistakes and potential alternatives in the historical course.

Some decades ago a "new historiography" has been first suggested by Koyré (Koyré 1939, 1957) and then by Kuhn (Kuhn 1962). By addressing radical criticisms of the positivistic attitude in historiography of science, both introduced as essential elements of their historical accounts new historical notions; i.e. the particular culture pertaining to the time of the case-study at issue; in Koyré's account it is the Platonic attitude included in the mathematical tools pertaining to theoretical physics; in Kuhn's account it is the historical context, psychological notions, sociological notions.

The new historiography of science obtained great success, not only in terms of numbers of books sold (Naughton 1982: 3702) but also in its impact on thinking; the new image of the scientific development as suggested by Koyré and Kuhn was accepted by philosophers and laymen too. The word "paradigm" – suggested by Kuhn – entered in common language. Hence, Heelan correctly advises philosophers to take into account the new way of presenting science.

However, precisely just the word "paradigm" made apparent the weakness of the new historiography. A well-known, and really a very easy analysis of the meanings of this word in all its occurrences within Kuhn's book, recorded more than twenty meanings which are contextually different (Mastermann 1970). In reply, Kuhn defended at least two meanings, without removing the ambiguity in his notion (Kuhn 1970). It was easy to recognise that the other basic notions of Kuhn's historiography not belonging to natural sciences, resulted to be ill-defined notions even in their specific scientific disciplines – e.g., the notion of "scientific community" in sociology of knowledge.

An unsatisfactory situation affects Koyré's historiography too; his categories – "Geometrisation of space and dissolution of finite cosmos" – have been often reiterated by him but they received explanation by neither Koyré nor subsequent scholars.

Thus, at present time this "new historiography of science" is positively appreciated, since it suggests a new picture of science development in an appealing, novelized style; yet, this kind of historical account may be charged to constitute an evasion from the duty of presenting facts according to that rigorous method which characterises hard sciences (Naughton 1982: 3703). To make the situation worse, some notions suggested by the new historiographies – e.g., incommensurability, non-cumulativity, etc. – meet a charge of "irrationalism"; for ex., in Kuhn's account, the revolutionary periods of science development would abruptly change the human reason – as it

is embodied by scientific community – without any awareness on this change, just likely as a Gestalt phenomenon.

3. My interpretative hypotheses on historiography of science

All this makes it apparent that the change introduced by "new historiography" started a cultural process which, in its turn, has yet to be still interpreted. It is no surprise if hermeneutic philosophers did not positively react to "new historiography" before Heelan's paper. In the following I will suggest a new interpretation of this historiography.

My first interpretative hypothesis on "new historiography" takes seriously its dominant motto: "Philosophy of science without history of science is pointless. History of science without philosophy of science is blind" (Lakatos 1976: 102). In the light of this strong link between history of science and philosophy of science *I suggest seeing the development of "new historiography" as representing a major hermeneutic, though indirect, effort to achieve a better understanding on the foundations of science.* However, owing to the above-mentioned vagueness of the categories introduced by the more representative authors of "new historiography", this effort did not result as decisive (on the other hand, in the same span of time no better results have been obtained by philosophers of science).

My second interpretative hypothesis specifies those *foundations which new historiography looked for*. Koyré's historiography emphasised that mathematics played a crucial role in the starting period of modern science, and one can trivially add, in its whole development. I generalise this point by stating that *the foundations of science are constituted by mathematics; moreover, I complete this hypothesis by adding to foundations of science, logic too*. Evidence for its relevance comes from the discovery that at least quantum mechanics is governed by a non-classical logic (Birkhoff and von Neumann 1936).

My hypothesis is not a trivial one when the following qualification is added. Recent formal analyses on the foundations of both mathematics and logic recognised in both mathematics and logic *a pluralism of attitudes* (Bishop 1967; Prawitz 1976; Dummett 1977).

Indeed, I recall that Koyré interpreted the birth of modern science by means of a dichotomy regarding the mathematical notion of infinity[2]. Accordingly, *my third hypothesis* is the following one*: the pluralistic role played in the foundations of science by each of these two sciences – mathematics and logic –, may be presented in a first instance by means of two possibilities only, constituting so a dichotomy*.

As a consequence, all that in the above amounts to consider the following two dichotomies as the foundations of science: (1) a dichotomy on the kind of mathematics – either classical mathematics, which includes actual infinity, *AI* –; or constructive mathematics – which is bounded to make use of potential infinity only, *PI* –; and moreover (2) a dichotomy of the kind of logic – either classical logic, which governs by means of deductive method the process of drawing laws from a few axiom-principles, i.e. a pyramidal organisation, just that Aristotle suggested first, *AO;* or the intuitionistic logic, leading to discover a new method for solving an universal problem, i.e. a problem-based organisation, *PO* (Drago 1993a, 2013)[3].

Let us remark that these dichotomies pertain at the same time to philosophy – inasmuch as no present or even future experiment will be able to decide them –, and science – inasmuch as no construction

[3] T.S. Kuhn (1977, chap. 1, § 3) recognised a radical division between classical physical theories when he emphasised in the history of science "Baconian" theories in opposition to Newton's theory. In 20th Century Einstein (Klein) and Poincaré (Poincaré) recognised two kinds of organisation of a scientific theory. In a more accurate way I showed the existence of two incommensurable traditions even inside classical mechanics, i.e. Newton's mechanics one and the alternative one started by Huygens and Leibniz and then accomplished by L. Carnot in 1783 (Drago 1993b).

of a scientific theory can avoid to decide them. Owing to their double nature – i.e. both philosophical one and scientific one –, these dichotomies offer a greater explicative power than all previous notions – such as space, determinism, etc. – previously employed for interpreting the foundations of science.

In the past, no one philosopher of science or scientist – except for Galilei – was aware of such two basic dichotomies. Rather, scientists' common custom was to take as foundations of science some intuitive notions – such as space, time, cause, etc. Surely, each of these notions synthesizes many objective facts and ideas pertaining to a scientific theory; and moreover their intuitive language make easier to approximately understand the *objective realm* of the scientific technicalities.

Yet, these notions pertain to a *subjective realm*, which cannot be considered as sufficient for representing the variety of foundations in all physical theories; to show it, let us compare the foundations of Newton's mechanics with those of classical thermodynamics; they do not share hardly any common notion. Rather, let us consider in the two previous theories some of these notions as they are usually intended in a subjective context; e.g., respectively absolute space and relative space; continuous time and before-after time. One easily recognises that they rather play the role of surrogating the alternative choices regarding the basic dichotomies – respectively the dichotomy on the kind of organisation and the dichotomy on the kind of infinity. In other terms, subjective notions surrogate the effective realm by means of a speciously operative philosophy.

In conclusion, three kinds of representations of science are obtained: the objective one, the subjective – or intuitive – one and the effective – or foundational – one.

4. Comparison with the hermeneutical method

Let us now compare the above interpretation of the "new historiography" with the most authoritative scholars of hermeneutics. It is well-known that Heidegger wanted to capture the "fore-structure of understanding", i.e. the "hermeneutic cycle" (Heidegger,ù 1953: 98–114, 188–195). In this cycle is

> hidden a positive possibility of the most primordial kind of knowing. To be sure, we genuinely take hold of this possibility only when, in our interpretation, we have understood that our first, last and constant task is never to allow our fore-having (*Vorhabe*), fore-sight (*Vorsicht*) and fore-conception (*Vorgriff*) to be presented to us by fancies and popular conceptions, but rather to make the scientific theme secure by working out these for-structures in terms of things themselves (195).

According to my viewpoint it is a very relevant fact that this Heidegger's presentation of the hermeneutic cycle illustrates three kinds of knowledge. In a paper aimed to illustrate the hermeneutic interpretation of science, Heelan synthesised them in the following way:

> (1) *Vorhabe*, a set of praxes, embodiments, skills, etc. that mediate applications of the descriptive categories or terms to that to which they refer; (2) *Vorsicht*, or a set of common descriptive categories, a common descriptive language, as it were and (3) *Vorgriff*, i.e. a particular hypothesis about the subject matter in hand (Heelan 1988: 79).

In fact, these three kinds of knowledge parallel the three representations of scientific knowledge I illustrated in previous section. Indeed, the reader easily recognises in what Heidegger called *Vorhabe*, the objective representation of science; both notions intend what the mind has to accumulate in order to understand a generic text; Heidegger's notion adds an irrelevant note with respect to the objective representation of science, i.e. *Vorhabe* constitutes a mediation between descriptive categories and the inner reality.

Likewise, the reader easily recognises in Heidegger's *Vorsicht* the subjective representation of science. Heidegger qualifies this kind of understanding through the tools – i.e. mainly communicative languages – by means of which they are plunged inside social relationships; my characterisation qualifies the same understanding in the case-study of science; there, scientists mutually communicate by means of at least two languages, i.e. the natural language, relying upon intuitive notions, used by them for going beyond the formal technicalities – and the formal language of mathematics; according to my characterisation, the former one only, pertaining to subjective science, equates Heidegger's language; he seems to ignore the latter one, indispensable to modern objective science.

A merely partial agreement results by comparing Heidegger's "fore-conception" with the effective representation of science. Whereas Heidegger's attention is focussed on the specific task of understanding a particular text, the basic choices of my effective representation are instead referred to a whole scientific theory, whose formal structure requires much more ingenuity than that producing – or selecting – an "ad hoc" intuitive hypothesis. In other words, I suggest that when dealing with a systematic complex of mathematical laws – by which a scientific theory is constituted – our mind has to appeal to a specific structure, like that suggested by the above two basic di-

chotomies. In fact, when relativized to Heidegger's particular situation of a literary text, this structure may collapse into a mere hypothesis.

Let us remark that my interpretation of Heidegger's scheme corresponds to a method of hermeneutic work which overcomes – according to Heelan and Schulkin (Heelan, Schulkin 1998: 276) – its early positive historical phase, in which one attributed private mental entities to the meanings; rather, meanings are here intended as "shared social entities embodied in language…, used to affirm or deny some content that finds itself fulfilled in public experience." In other words, the meanings conveyed by the language agree with Heelan and Schulking's requirements, i.e. they constitute a "construal of human cultural communities" (277); in the case of scientific theories, this is a construal of scientific community. The agreement is apparent when we consider the two dichotomies as constituting the crucial notions of a specific language, suitable for foundations of science. In conclusion, all in the above fulfils the necessary requisites for to "the hermeneutic method is recognised as a valid tool of modern scientific method applicable even to the natural sciences" (276).

5. The structure of our understanding science

Let me proceed in the illustration of the resulting structure of foundations of science. The outcomes from the two choices on the two above-mentioned dichotomies constitute four "models of a scientific theory" (*MSTs*). In order to avoid some complexities in representing all four MSTs, only two are illustrated by the following table; which however, by disentangling each MST in a list of characteristic features, offers many elements manifesting the distance between two different MSTs.

TABLE 1. THE TWO MAIN MODELS OF SCIENTIFIC THEORY

	Effective repr. (as determined by scientific geniuses)	**Subjective representation** (as scientists conceived it through surrogatory notions)	**Objective representation** (as teachers formalise it through tools of reasoning)
NEWTONIAN MST	AO + AI	Space, time, force-cause, continuum, determinism, etc. *Koyré's synthesis*: 'Dissolution of the finite cosmos and geometrisation of space'	Classical logic Analytic method Infinitesimal analysis (main instance: 2° order differential equations)
CARNOTIAN MST	PO + PI	Energy, work, balance, conservation, atomism, etc. *Koyré-like synthesis*: 'Evanescence of the force-cause and discretisation of matter'	Non-classical logic Synthetic method Symmetry or cycle (main instance: S. Carnot's cycle in thermodynamics)
Time span for a change	*Some centuries*	*One century*	*One generation*

N.B. The multitude of intuitive notions pertaining to the subjective representation are summarised by means of two intuitive statements; at the top, Koyré's synthesis of all subjective notions concerning the birth of modern science; at the bottom, a corresponding synthesis for Carnotian theories.

According to Heelan and Schulkin ,"Rational hemeneutical enquiry acknowledges the existence of *traditions of interpretations*…Within the sciences such traditions of interpretations are the basis of what Kuhn called "paradigms" (Heelan, Schulkin 1998: 278). These "traditions" well-correspond to my MSTs.

Actually, Kuhn considers paradigms one after another only; instead, "[…] in the work of hermeneutics […] a radically new meaning needs not expel the old, because each, though different, may be a valid historical and cultural perspective" (*Ib.*); exactly as in my interpretation the birth of thermodynamics did not had to expel Newtonian mechanics.

6. Husserl's and Heidegger's interpretations of science

In the light of the above table one may revisit both Husserl's and Heidegger's interpretations of modern science, in order to get a deeper insight on them and qualify their relationship of similitude. The former philosopher drew from his academic studies on mathematics the relevance in order to interpret the foundations of science of the notion of infinity. His posthumously published book, the *Krisis,* through which he planned to start again his analysis on science (Husserl 1954), offered an authoritative interpretation on the birth of modern science according to this basic notion of infinity – just the subject of my first dichotomy in my interpretation of the foundations of science. According to the above table we can state that through this book Husserl gave a hint for a first structural interpretation of the foundations of modern science.

Koyré – who attended his lessons in Goettingen in 1911, having left Russia to reach Paris – was highly influenced by his teachings. The greatness of Koyré is to have applied Husserl's teachings on the case study of the birth of modern science. Moreover, he improved Husserl's structural appraisal of the foundations of science by adding a sharp distinction between actual infinity and potential infinity; this innovation constituted a first hint for grasping the foundations of science. As a first result he achieved a detailed interpretation of the original texts of the main scientists of the birth of modern science. Last but not least, through two short statements Koyré defined his

subjective categories – which are scientific-historical in nature – for interpreting science in the same period of time; they synthesise in an admirable way the subjective representation of Newtonian paradigm.

By passing, let us remark that instead Kuhn's categories have not contributed to a structural appraisal, since they are constituted by subjective notions only, and pertain rather to social sciences.

With respect to Husserl, his disciple Heidegger, owing to his lack of academic studies on science was unable to produce a structural analysis on science because lacking of a sufficient knowledge of the specific notions of mathematics and logic. One may correctly say that

"Husserl's approach is more logical, conceptual and abstract, while Heidegger's is more existential, historical and action oriented" (Heelan, Schulkin 1998: 280), "typically focused on how 'objects' (contents) of knowledge are 'constituted' (presented to communal knowers) within 'noetic' contexts of meaning (directed by communal vector of inquiry). Heidegger referred to such objects as 'ontic beings' disclosed prospectically to the 'circumspective care' of the human inquirer as *Da-sein*" (277).

However, Heidegger performed the best attempt for "calling the deep structure of pre-theoretical and pre-categorial understanding" (280) A footnote in the quoted text (299) adds that "By pre-categorised is meant: when language is used ostensively, that is before descriptive terms are reflexively given abstract definitions […]"; in my interpretation this equates the subjective representation.

Indeed, Heidegger followed Husserl in extensively exploring the subjective notions pertaining to his teacher's analysis and then in elaborating them. One may say that Heidegger was concerned mainly with the second part of *Krisis*, i.e. the part devoted to *Lebenswelt*[4].

[4] In his elaborated statement ("A god only….") one may see an infinite distance in power (between a humble person and a god), likely as there is an infinite distance

One may see the method of Heidegger – as well as the method of a variety of philosophers –, as an attempt at grasping an inner structure of formal science by the manipulation of subjective notions only. Since in past times the success of this kind of attempts was a partial one only, scientists charged philosophers with lacking the suitable tools for understanding science. In fact, who attempts to investigate scientific theories by means of only subjective notions, cannot appreciate how the mathematical language of science is capable of specifying which exact meaning corresponds to a subjective notion in a given theory as well as the accurate relationships among these notions. On the other hand, philosophers, and in particular, Heidegger, rightly distrusted scientific formalism. Indeed, previous table shows that this formalism merely constitutes only one representation of science, which in particular does not give reason of both subjective representation and effective representation, and moreover may obscure them.

Although merged inside a subjective representation only, Heidegger tried to recuperate by means of a new kind of reason – more linked to immediate life –, some hints for fighting what he saw as a monster, i.e. science as it was built by our civilisation. He tried to suggest even an "Echte Wissenschaft". Yet, this suggestion had no follow up; this fact agrees with the above appraisal on his method as a weak one. Indeed, Heidegger's by having missed Husserl's point of attack to science, i.e. the notion of infinity, sees theoretical science – whose nature is of a structural system –, as an indivisible whole and, worse, monopolised by the Newtonian MST. As a consequence, he saw the role played by science in society as a monolithic authority, enjoying the monopolistic capability to produce a so pervasive technology to freely change the human life. The two more celebrated

between Heidegger's subjective thinking and a structural choice – whose knowledge

Heidegger's statements about science, i.e. "Science does not think" and "A god only can save us", wisely stressed some characteristic features of modern science, yet both emphasise Heidegger's outside position from the structure of science and – as a consequence – his real position, that of a man defeated by science's successes.

He was successful rather in suggesting a new role to be played by contemporary philosophy. In my opinion, his main, positive contribution was the introduction of a new hermeneutics as the appropriate method for philosophy, in opposition to the "analytical method" – which is the dominating method also in Newtonian scientific theories. Yet Heidegger's effort to induce from a long hermeneutic praxis a new, commonly accepted characterisation of the synthetic method of reasoning was inconclusive. Previous analysis in Sect. 4 pointed out that he, lacking structural features of human understanding, was doomed to fail in recognising the very level of our arguing upon a whole theory.

7. Incommensurability phenomena between couples of scientific theories and hermeneutics

Heelan made a proposal for a new hermeneutics on science; it is a "Hermeneutical" Realism, which "[…] is neither that of *Conventionalism*, nor of *Cultural Relativism*. Like them however, it admits plural incompatible empirically descriptive frameworks among which […] some are complementary [...]" (Heelan 1982: 84)

Indeed, Poincaré's "conventionalist" position was interpreted as moving towards the same direction by the logician Adjukewicz and then the philosopher of science Giedymin. They gave an account of a scientific theory as a body of knowledge whose theoretical structures are underdetermined by experimental findings; hence, its theoretical

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only suggests how to change the nature of past dominating science.

part may assume a pluralism of formulations (Giedymin 1991: 15)[5]. The interpretation of science as illustrated by the above table supports the same view. Moreover, it offers a clear-cut definition of the kind of pluralism of structures occurring in science, i.e. the theoretical pluralism of four MTSs; that at the same time denies the radical viewpoint of Cultural Relativism.

Moreover, Heelan considered Kuhn's historiography as a source of a new image of science; yet, he does not remember that Kuhn introduced the notion of incommensurability between two subsequent paradigms. Actually, this notion generates serious problem in rationality, since it suggests that scientific reason is unable to perform an easy translation from a theory to another one. In intuitive terms, Kuhn illustrated this feature by means of a *Gestalt* phenomenon, i.e. the apperception through a same figure two different images, which our mind cannot see together at the same time; e.g. the profile of a cup which is perceived alternatively as the profiles of two opposite faces is a well-known example.

Actually, no more divergent phenomenon in science and philosophy may occur than that suggested by the two basic dichotomies – i.e. a difference either in the choice on the kind of logic or in the choice on the kind of mathematics –, since they shape the foundations of scientific theories. This difference cannot be overcome by means of a formal translation, since it inescapably results to be a partial one – as for example Kolmogoroff-Glivenko-Goedel's translation between classical logic and intuitionistic logic is (Troelstra, van Dalen, 1988: 56; Hintikka 1996: Ch. 11). This difference gives a formal qualification of what Kuhn often stressed, i.e. between two incommensurable theories there exists an only partial translatability.

[5] I discussed this philosophical attitude in Drago 1999b.

From all the above one can draw an applicable notion of incommensurability, as I have suggested since 1986: *Two theories are said incommensurable when 1) they are organised in a systematic way; 2) they are mathematized; 3) they mutually differ in at least one choice on the two basic dichotomies* (see Drago 1986, 1987 and 1988). Both conditions 1) and 2) circumscribe an exact field of application of this definition; this field is narrower than that addressed to by Kuhn's rough notion; yet, it allows to list of a great number of pairs of incommensurable theories (Drago 1999). These pairs often concern theories occurring at the same time; this agrees with Heelan's remarks in the end of Sect. 5; that is, in the hermeneutic method even two contemporary theories may result to be two incommensurable theories.

8. Incommensurability and historiography of science

As an application, let us come back to the subject from which present analysis started, i.e. historiography of science and let us apply to it the hermeneutic method, as it was defined in the above. Under the light of the two basic dichotomies, one may analyse all categories offered by historians of science – i.e. their *Vorsicht* – as instances of an indirect search for the foundational aspects of science and eventually as representing their respective *Vorgriff*.

It is easy to interpret Koyré's categories. They are expressed by few subjective words, according to which modern science is founded upon a pair of choices whereas the pair of choices concerning the foundations of ancient science is rejected. "Geometrization of space" alludes to the analytic geometry as an *a priori* mathematical structure from which to draw the physical phenomena, according to Descartes, that is the choice AO. This fact introduces to the mathematization of the world, through not only geometry, but also infinitesimal analysis; that manifests the choice AI. At the same time through the words

"dissolution of finite cosmos" modern science rejects the finitism of ancient cosmos, i.e. the choice PI; and moreover it rejects – through the word "dissolution" translating it into a historical process – its organisation relying upon a problem; that is, the choice PO. In sum, Koyré's viewpoint agree with the Newton's; in other words, Koyré was so successful since his analysis assumed the same fundamental viewpoint of Newton, which eventually won the long struggle among the many viewpoints suggested by the various scientists contributing to the birth of modern science.

The adequacy of this interpretation can be confirmed by the following improvement of his categories. In opposition to Koyré, one can accept the pair of choices previously rejected and *viceversa*. One obtains the categories for representing the birth of scientific theories, alternative to Newtonian ones, i.e. chemistry, L. Carnot's mechanics, S. Carnot's thermodynamics. Their basic choices may be surrogated in a parallel way to Koyré's categories, by the following subjective notions: "Evanescence of force-cause and discretisation of matter" (Drago 2001); some historians induced by ingenuousness these categories; at the best the two similar statements concluding the book of history of chemistry by Arnold Thackray (Thackray 1970).

Let us now interpret Kuhn's categories by means of the two dichotomies. Since the scientific community dictates the rule on scientific research of its time, it represents an AO. Since a *Gestalt* phenomenon transcends even the collective mind of scientific community, it represents AI. That means that Kuhn's *Vorgriff* is the same of Newton's mechanics, and hence it is also substantiated by Newtonian paradigm, but in a new way with respect to Koyré's *Vorgriff*. In fact, Kuhn's subjective notions, i.e. normal science, paradigm, anomaly, crisis and revolution, all translate directly the basic notions of Newtonian mechanics; they correspond to respectively uniform motion, ref-

erence system, acceleration, force, change of reference system (Cerreta and Drago).

This interpretation gives reason to

1) so many forerunners of Kuhn's analysis;

2) the extraordinarily great success of his book;

3) Kuhn's dismissing both history of mathematics and history of Newton's theory, otherwise his account would be self-referential;

4) his dismissing the history of thermodynamics, truly an incommensurable theory with respect to Newtonian mechanics;

5) his strange interpretation of the birth of chemistry as originating by an unlikely "supramechanical aspect"; in reality, he wanted to exclude that two incommensurable paradigms are present at the same time; in this way he cancelled any revolution inside the period of time in which Newtonian paradigm dominated scientific thinking; hence, against the common view recognising in chemistry a revolutionary science, he included the birth of chemistry in its incommensurable theory dominating this time.

6) the failure of his categories in explaining the birth of quantum mechanics; since were in agreement with Newton's mathematics they could not representing a new theory which includes quanta and whose mathematics is also discrete.

Let us remark that Koyré's categories grasp better the foundations of science than Kuhn's. The former ones surrogate all four choices, whereas among the plethora of subjective notions constituting the latter ones, two notions only surrogate the pair of positive choices. Moreover, the former ones manifest a basic conflict in science, whereas the latter ones – despite the "revolutionary" title of Kuhn's book – drove away any foundational conflict in science to the subsequent period of time of modern physics.

A similar analysis may be performed of the categories suggested by each historiography of science; they result to constitute an intui-

tive, approximate picture of some basic choices. In particular, those by Koyré represent Newtonian choices and rejections, in a so unambiguous way to suggest new categories for the alternative theories.

By having recognised by means of the phenomenon of incommensurability an essential conflict in the foundations of science, one can give reason to the basic divisions that all the authors of historiographies implicitly introduced. Two main classes of historiographies result, i.e. Newtonian ones – for instance, those by Koyré, Kuhn, etc., - and the alternative ones – those by Mach, Williams, Thackray. From such a variety of instances of interpretative categories a general method for generating them from basic choices may be induced (Drago 1995, 1999a).

9. Incommensurability and hermeneutic philosophy of science

The above definition of incommensurability suggests several implications for philosophy of science. Among those, I limited myself to those relating to hermeneutical concepts.

In a historical perspective of the entire development of science, my definition of incommensurability suggests a parallelism between ancient and modern science. Whereas the Greeks accepted incommensurability and *deliberately* bounded themselves in constructing science, modern scientists chose to develop an ever growing scientific production although they were *unaware* of the incommensurability phenomenon, which effectively bounded their activity. Surely, Western science included a sin of *hubris*, to claim the capability of a full explication of the reality by means of hard data, whereas it ignored at all the basic choices shaping these data in a specific theory. This scientists' ignorance justifies philosophers' unsatisfaction about a self-glorifying science; they rightly suspected that despite its enormous growth its basic attitude was ill-founded in philosophical terms.

On the other hand, incommensurability phenomenon influenced even past hermeneutic understanding. When applied to a scientific theory, hermeneutic work met different difficulties according to which choices pertain to the theory at issue; for ex. a clever hermeneutic work has to be very different in the two case-studies of a PO and PI theory, say chemistry, and an AO and AI theory, say Newtonian mechanics. Therefore, since the time of the birth of modern science hermeneutics method should have specialized according to at least the two main kinds of MTSs and hence the two main kinds of theoretical science. As a matter of fact, hermeneutic scholars rejected dominant science, which corresponds to the MTS choosing AO and AI. As an alternative to this scientific domination, they looked for what Heidegger called "Echte Wissenschaft"; that means that hermeneutics actually chose to be on the side of the alternative MTS. Nevertheless, according to my interpretation by means of four MTSs, Heidegger's new science actually represents a merely attempts of philosophical nature to the dominant tradition of alternative science. Indeed, Heidegger was unable – likely as all other philosophers – to accurately recognise in past theories some instances of this alternative; at last, his effort resulted to be unsuccessful.

Rather, the ideal disciple of Husserl, Koyré, offered the best study of this kind, maybe because he chose the easier case study of the birth of modern science. By analysing several authors – Galilei, Cavalieri, Torricelli, Huygens, Descartes and Newton – he was able to recognise an alternative; he discovered the two basic attitudes resulting from the two choices on the dichotomy on the kind of infinity; and in a skilful way he characterised it in the several authors of that time. In a retrospective view, one may join Heelan opinion that it is time that hermeneutic scholars recognise this great advancement in hermeneutic work on history of science. But the historians of the new historiography did not recognise as an alternative science the most

known theory playing such a role in the historical development of Western science, i.e. chemistry (which, being characterised through the basic choices PO and PI, belongs to the alternative MTS). Hence their support is decisive, but not conclusive.

When one recognises which are the alternative theories of the dominant paradigm, one may ask for their common characteristic features. The most striking common feature is the notion of cycle; i.e., S. Carnot's cycle in thermodynamics and Mendeleev's periodic table. One easily shows that these cycles in scientific theories actually represent tools for reasoning.

Moreover, in the case of L. Carnot's mechanics one may show that this tool of reasoning represents an algebraic technique giving the motion invariants. This technique has to be considered the first instance of the powerful mathematical technique of symmetry. In present research of theoretical physics this technique enjoys relevance at all comparable with that of infinitesimal analysis (it is remarkable that in Leibniz' philosophical thinking privileged this mathematical technique: "Our mind looks for invariants"). L. Carnot's applied such technique in the introduction of relative quantities, imaginary quantities and infinitesimal numbers (L. Carnot) By comparing this method with the hermeneutic cycle, one obtains a more general viewpoint, including symmetry technique (Drago, 1997).

Let us come back to Kuhn's example of a *Gestalt* phenomenon. In this figure, each particular element plays a different role according to which of the two images it pertains. By analogy, Kuhn stressed the radical meaning variations presented by the common notions of two incommensurable theories. For instance, in Newtonian mechanics the notion of mass radically differs from the notion of energy-mass in special relativity; in Newtonian mechanics the notion of space radically differs from the notion of quadridimensional space-time in special relativity.

Also in my interpretation the basic choices of a scientific theory, since they are of an effective and structural nature, fashion differently the basic notions of this theory. In previous papers I offered a table where I compared the main notions of Newton's mechanics with those of both L. Carnot's mechanics and S. Carnot's thermodynamics (Drago 1997, 1999: 150). The last two theories, although concerning two radically different fields of phenomena – mechanical ones and thermodynamical ones –, share several notions having common meanings; instead, the first two theories, although concerning the same field of phenomena, are completely at odd in the meanings of their basic notions. This table proves that in constructing a physical theory, the cultural and philosophical factors are more relevant than the different field of experimental data, which the theory refers to.

It is easy to remark that radical variations in the meaning of the notions pertaining to two incommensurable theories play a decisive role in hermeneutic understanding; indeed, the work of understand a specific theory through a hermeneutic work often meets an essential ambivalence in interpreting a basic notion pertaining to two incommensurable formulations of a same scientific theory; for instance, the notion of space in Euclid's formulation and in Lobachevskii's formulation of geometry. I do not know any account of this ambivalence within hermeneutic literature, except for the above-mentioned analysis by Koyré on the basic notions characterising the works by the beginners of modern science.

Moreover, by accepting that there exist some incommensurable theories with the dominant one, the relationship between science and technology is not only the relationship presented by the dominant science, i.e. a work of merely applying some completed, interpretative schemes on particular, complex situations of reality. Indeed both L. Carnot's mechanics and S. Carnot's thermodynamics have been obtained by reflecting upon machines, being they considered – as the

title of first L. Carnot's book proclaims it – "en général", i.e. by disregarding any specific detail. As a direct consequence, Heidegger's analysis on present technology as dominated by Newtonian science, results to be too pessimistic in nature because it is a partial analysis; mankind invented an alternative way to conceive technology with respect to dominant technology[6].

10. Conclusion

The present paper constitutes a meeting point between a philosopher launching a proposal for a new kind of hermeneutics such to exploit the experience accumulated by the "new historiography of science", and a historian of physics offering a philosophical interpretation of this historiography.

If my analysis is correct, we may then conclude that even if we agree with Heidegger that "Science does not think", however the new historiography of science has however been capable of addressing our minds in discovering in which way one may think about science and eventually led us to discover an effective structure underlying science. As a consequence, it is true that dominant science did not think, yet only inasmuch as science is erroneously equated to the Newtonian MST solely. Instead, by taking into account in some way the pluralism of MSTs, one can show that science is capable of a vari-

[6] In the history of philosophy a phenomenon very similar to scientific incommensurability was experienced – In the relationships between the two opposite currents of modern philosophy, i.e. rationalism and empiricism. When one looks for an anticipation in philosophical terms of the notion of incommensurability given by the two dichotomies, one discovers Leibniz' philosophy as suggesting the best approximation to it. In particular, the two basic principle of human reason, the contradiction principle and the principle of sufficient reason, may be recognised as the basic logico-philosophical sources of the two kinds of organisation of a theory. Furthermore, Leibniz stressed the "two labyrinths of the reason", the infinity – either *in actu* or potential - and the conflict between the free will and the law – i.e. a subjective view on the conflict between the two kinds of organisation of a theory, respectively PO and AO. Although these issues essentially pertain to his philosophy, Leibniz' reconciliative spirit unfortunately did not give so much relevance to these alternatives (Drago 1994).

ety of answers to the search of a theorisation on the world and these answers mutually differ for philosophical reasons.

Several results obtained in the above by means of the scientific structure of the four MST's encourage me to advance a suggestion for a new definition of hermeneutics. By paraphrasing an old hermeneutic *dictum*, I suggest that 'The understanding of science is a science of the understanding'.

References

Birkhoff, D., Von Neumann, J. (1936). The Logic of Quantum Mechanics. *Annals of Math. 37*(4): 823–843.

Bishop, E. (1967). *Foundations of Constructive Mathematics*: New York: Mc Graw-Hill.

Cerreta, P., Drago A. (1987). La "Weltbild" di Planck reinterpretata col paradigma di Kuhn e col modello di teoria scientifica. In F. Bevilacqua (ed.), *Atti VIII Congr. Naz. St. Fisica*. Pavia: La Goliardica, 63–80.

Carnot, L. (1813). *Réflexions sur la metaphysique du calcul infinitesimal*. Paris: Courcier, 217–253.

Drago A. (1986). Una definizione precisa di incommensurabilità delle teorie scientifiche. In F. Bevilacqua (ed.), *Atti VII Congr. Naz. Storia Fisica*. Pavia: La Goliardica, 124–129.

Drago, A. (1987). An effective definition of incommensurability. Comm. to *VIII Congress on Logic, Methodology and Phil. Sci.,* Moscow*, 4*, pt. 1: 159–162.

Drago, A. (1988). An effective definition of incommensurability. In C. Cellucci *et alii* (eds.). Temi e prospettive della logica e della filosofia della scienza contemporanea*. CLUEB*, *2*: 117–120.

Drago, A. (1993a). Is Goedel's incompleteness theorem a consequence of the two kinds of organization of a scientific theory? In Z.W.K. Wolkowsky (ed.), *First International Symposium on Goedel's Theorems*. London: World Scientific, 107–135.

Drago, A. (1993b) 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.* Bologna: SIF, 69–80.

Drago, A. (1994). The modern fulfilment of Leibniz' program for a *Scientia generalis*. In H. Breger (ed.), *VI Int. Kongress: Leibniz und Europa,* Hannover, 185–195.

Drago, A. (1995). Koyré, Kuhn and beyond. 10th Logic, Meth. Phil. Sci., Florence, p. 320 (abstract).

Drago, A. (1996). Poincaré vs. Peano and Hilbert about the mathematical principle of induction. In J.-L. Greffe, G. Heinzmann, K. Lorenz (eds.), *Henri Poincaré. Science et Philosophie*. Paris: Blanchard / Berlin: Springer, 513–527.

Drago, A. (1997). Cycle and Symmetry in the Hermeneutical Interpretation of Science. *Metalogicon*, *10*(1) : 13–25.

Drago, A. (1999a). Incommensurability as a Bound of Hermeneutics in Science. In M. Féher, L. Ropolyi, O. Kiss (eds.), *Hermeneutics and Science.* Kluwer Acad. P., 135–155.

Drago, A. (1999b). La geometria adeguata alla teoria astronomica: il "convenzionalismo" di Poincaré. In G. Proverbio (ed.), *Atti del Conv. Naz di Storia dell'Astronomia,* Napoli, 1997.

Drago, A. (2001). The several categories suggested for the new historiography of science: An interpretative analysis from a foundational viewpoint. *Epistemologia 24*: 48–82.

Drago, A. (2013). The emergence of two options from Einstein's first paper on Quanta. In R. Pisano, D. Capecchi, A. Lukesova (eds.), *Physics, Astronomy and Engineering. Critical Problems in the History of Science and Society*. Siauliai: Scientia Socialis P., 227–234.

Drago, A., Manno, S.D. (1989). Le ipotesi fondamentali della meccanica secondo Lazare Carnot. *Epistemologia, 12*: 305–330

Dummett, M. (1975). *Elements of Intuitionism*. Oxfrod: Claredon, 1977.

Giedymin, J. (1991). Geometrical and physical conventionalism of Poincaré in epistemological formulation. *Stud. Hist. Phil. Sci. 22*(1): 1–22.

Heelan, P.A. (1982). Hermeneutical Realism and scientific observation. In P.D. Asquith and T. Nickles (eds.), *Philosophy of Science Association 1982*. Michigan U.P.: PSA; vol. 1, 77–87.

Heelan, P.A. (1998). The Scope of Hermeneutics in Natural Science. *Hist. St. Hist. Sci. 29*(2): 273–298.

Heelan, P.A., Schulkin J. (1998) Hermeneutical philosophy and pragmatism: A philosophy of science. *Synthèse*, 115: 269–302.

Heidegger, M. (1953). *Sein und Zeit*. Tuebingen: Niemeyer, VII ed.

Hintikka, J. (1996). *Principles of Mathematics Revisited*. Oxford: Oxford U.P.

Husserl, E. (1954). *Die Krisis*. L'Aia: Nijhoff.

Klein, M.J. (1967). Thermodynamics in Einstein's Thought. *Science*, *57*: 505–516

Koyré, A. (1939). *Études Galiléennes*. Paris: Hermann, 1966.

Koyré, A. (1957). *From the Closed World to the Infinite Universe.* Baltimore: Johns Hopkins Press.

Kuhn, T.S. (1969). *The Structure of Scientific Revolutions*. Chicago: Chicago U. P.

Kuhn, T.S. (1970). Reply to my critics. In I. Lakatos, A. Musgrave (eds.), *Criticism and the Growth of Knowledge* (1970), 313–364.

Kuhn, T.S. (1977). *The Essential Tension*. Chicago: Chicago U.P.

Lakatos, I. (1976). *Philosophical Papers*. Oxford: Oxford U.P., vol. 1.

Lakatos, I., Musgrave, A. (eds.) (1970). Criticism and the Growth of Knowledge. Cambridge: Cambridge U.P.

Mastermann, M. (1970). The nature of paradigm. In I. Lakatos, A. Musgrave (1970), *Criticism and the Growth of Knowledge*, op. cit., 58–89.

Miller, A.I. (1981). *Albert Einstein's Special Theory of Relativity*. Addison-Wesley, 123–142.

Naughton, R. (1982). Revolution in Science. *The New Scientist*, *95*: 3702–3705.

Poincaré, H. (1905). *La valeur de la Science*. Paris: Flammarion.

Prawitz, D. (1977). Meaning and Proof. *Theoria 43*(1): 6–39.

Thackray, A. (1970). *Atoms and Powers*. Harvard: Cambridge.

Troelstra, A., van Dalen, D. (1988). *Constructivism in Mathematics. An Introduction*. North-Holland, Amsterdam.