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# Hermeneutics of Experimental Science in the Context of the Life-World

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# *Interdisciplinary Phenomenology*

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## HERMENEUTICS OF EXPERIMENTAL SCIENCE IN THE CONTEXT OF THE LIFE-WORLD

Natural science, familiarly called "science," has a pervading presence and influence in our culture because it, more than any other form of knowledge, seems effectively to lay claim to the rigor, objectivity, permanence and universality that the Greeks sought as their emancipatory goal **1** and the search for which, Husserl claims,[2] is the special teleology of the Western community. Natural science, then, developed within the total cultural and philosophical perspective of the West, which gave it impetus and which in turn derived sustenance from its achievements. As an element of our total culture, I shall call this "historical science." The critique of historical science, then, is a critique of a total cultural milieu. Many authors have addressed themselves to this critique—in fact, almost everybody who has written in the phenomenological style in America or Europe has at one time or another taken part in this critique of historical science, for historical science with its claims to unsurpassable rigor, its methodological abstraction from the life-world, its seeming independence of subjective human interests and the non-historical

1. Jurgen Habermas, *Knowledge and Interest*, trans. by Jeremy Shapiro (Boston: Beacon Press, 1971), pp. 306-7.
2. Edmund Husserl, *The Crisis of European Sciences and Transcendental Phenonlenology*, trans. by David Carr (Evanston, Ill.: Northwestern Univ. Press, 1970), p. 15.

character of its laws and explanations, is a rival of phenomenological rigor, a living antithesis of its principles and a challenge to its primary concerns.

The features of historical science that make it the current antithesis to phenomenology may be summed up in three characteristics, objectivism, scientism and technicism, which are shared by the two most influential philosophical systems that are most strongly influenced by natural science, Cartesianism and Positivism.

Objectivism is the dogmatic assumption that objectivated knowledge whether scientific or non-scientific, represents the world, its object, without any connotation of the human knowing subject, or more accurately, that human objectivations represent things as they exist in themselves independently of human intentionality-structures.[3] Principal among these objectivations of knowledge is the scientific image of the world, based on objective processes of measurement that substitute the objective restrictions of causal interaction for the subjective discovery of meaning within the life-world of man. The world, in the objectivist view, comes to be an objective WorldPicture, already-out-there-now-real,[4] to which the human spirit

3. Habermas, *op. cit.*, p. 304, where he summarizes Husserl's critique of "historical science" in the *Crisis* as "It is directed in the first place against the objectivism of the sciences, for which the world appears objectively as a universe of facts whose lawlike connection can be grasped descriptively. In truth, however, knowledge of the apparently objective world of fact has its transcendental basis in the prescientific world. The possible objects of scientific analysis are constituted *a priori* in the self-evidence of our primary life-world. In this layer, phenomenology discloses the products of a meaning-generative subjectivity." Objectivism is introduced by Husserl on pp. 69-70 of the *Crisis*. See also, Joseph J. Kockelmans, "L'objectivité des sciences positives d'après Ic point de vue de Ia phenomenologie," *Arch. de Philosophie*, 27 (1963), pp. *339-355*. An excellent critique of objectivistic thinking is found in Marjorie Grene's outstanding work *The Knower and the Known* (New York: Basic Books, 1966).

4. This term is used very effectively in Bernard F. Lonergan, *Insight: A Study of Human Understanding* (London: Longmans Green, 1957); see also his *Method in Theology* (London: Darton, Longmans, and Todd, 1972).

merely adds the cultural superstructure of a *Weltanschauung* or World-PersPective.[5] In criticism of this view, it is said that the onto-logical dimension of ontic beings is systematically concealed, the historicity of the World and of the human subject are both lost, and knowledge is conceived erroneously as a mental copy of what is antecedently out there. The opposite of objectivism is what Husserl in the *Crisis of European Sciences* calls "transcendentalism." This is the view that "ontic meaning of the pre-given life-world and all objectivated knowledge is a subjective structure, it is the achievement of experiencing pre-scientific life."[6]

The second criticism of historical science is its cultural imperialism, that is, the dogmatic belief called "scientism" that the methodology of the positive sciences is in principle capable of answering all meaningful questions and that philosophy is a pre-scientific stage in the thrust towards positive science and will wither away in a scientific culture. Scientism, then, comprises claims both about the comprehensiveness of the methodology of the positive sciences and about the superior rigor of that methodology vis-à-vis knowledge. Because of these claims, Boehm concludes, science is a threat to the very existence of philosophy considered as phenomenology.[7]

The third criticism of historical science is technicism, that is, the view that science is no more than a *technë*, albeit a very successful one for manipulating and exploiting nature. Habermas, for instance, expresses this position: "the cognitive interest of the empirical-analytic sciences" he writes, "is technical control over objectified processes."[8] The manipulatory character of science, it is claimed,

5. Martin Heidegger, *Being and Time*, trans. by John Macquarrie and Edward Robinson (New York: Harper and Row, 1962), pp. 413-14.
6. Husserl, *Crisis,* p. 69.
7. Rudolf Boehm, "Les sciences exactes et l'idéal husserlien d'un savoir rigoureux," *Arch. de Philo.* 27 (1964), p. 425.
8. Habermas, *op. cit.,* p. 309.

is shown by its use of functional concepts, which are ways of relating mere entities, the extrinsic terms of implicitly defined relations and, like Lockean substances, unknowable in themselves.[9]

In summary, historical science is non-historical, since it lacks an intrinsic historical dimension. It is non-hermeneutical, since it is founded on a copy theory of knowledge, whether of sensations or forms. It is non-ontological, since it has no horizon of Being, but constructs abstract models to serve man's interest in technical control. It is non-dialectical, since progress is not through the conflict of opposing objectivations of the knowing subject, but exclusively by the gradual accretion of objective facts, the painful elimination of error and the exercise of logic. On the level of cultural critique, therefore, phenomenology has the task of confronting and opposing historical science.

That the philosophical positions of objectivism, scientism and technicism are deeply ingrained in our culture and that they are historically linked with the development of science can hardly be denied. Historical science, however, is science viewed from a great altitude,'[10] from such a distance that distinctions are lost between the practice and self-understanding of individual scientists, of the scientific community and of society as a whole. Historical science does not necessarily represent the viewpoint of practising scientists, although I am sure it represented the view of many in the past and continues to represent the view of some.[11]Historical science as such,

9.Heidegger, *Being and Tune,* p. 122, *Discourse on Thinking,* trans. by J. Anderson, E. H. Freund (New York: Harper and Row, 1966), p. 50 and passim.

10.The useful notion of the "altitude" from which an inquiry is made is borrowed from Gerard Radnitzky, *Contemporary Schools of Metascience,* vol. 2, IV F 1 and passim. However, investigation has to be made into the kind of logical ordering that gives levels of "altitude."

11.The principle supporters of "historical science" today come from the social and behavioral sciences, as, for example, B. F. C. Skinner in his *Beyond Freedom and Dignity* (New York: Knopf, 1971).

however, is an element of our total culture in which scientists and others participate. A sophisticated scientist today might well make his contribution to philosophy by opposing the influence of historical science as a deformation of the true creative scientific spirit, and stress the fact that in his experience there are historical, hermeneutical and dialectical dimensions which are overlooked and negated by historical science.[12]

Historical science considers natural science from a great altitude and sees itself merely as one element in a total culture. I wish on the contrary to consider natural science from a low altitude as the occupation of individual scientists. I want to consider a scientist's activity of doing natural science, taking up in its regard a set of characteristically phenomenological themes. My purpose is to show that natural science as it is practised is not essentially and necessarily vitiated by the defects of historical science, and that certain kinds of scientific activity cannot be well or properly understood without having recourse to phenomenological categories. Moreover, I wish to show how the life-world both of the scientific community and of our general culture, is enriched by science and technology and attempt to give a genetic analysis of this enrichment.'[13]

But first, I should like to clarify what I mean by certain key philosophical terms. I shall call "hermeneutical" any activity that results in displacing the cut between the subject and the object.'[14] As an

12. For example, among physicists, Werner Heisenberg, Karl Friedrich von Weizshcker, Eugene Wigner, Erwin Schrodinger among others.
13. The point of view I take is that of the late Husserl of *Formal and Transcendental Logic*, trans. by Dorian Cairns (The Hague: Nijhoff, 1969), *Cartesian Meditations*, trans. by Dorian Cairns (The Hague: Nijhoff, 1960) and *Crisis* and I am deeply indebted to Robert Sokolowski's book *The Formation of Husserl's Concept of Constitution* (The Hague: Nijhoff, 1964) for my understanding of those works.
14. For a brief and excellent account of the history and contemporary state of hermeneutical science see Radnitzky, *op. cit.*, vol. 2, IV F 3. Its key notions, he says, are *meaning*, *language* and *history*. I have redefined the term in the interests of the specific material I am concerned with.

example, let us suppose that marks are discovered on clay tablets known to belong to an ancient but as yet undeciphered language. These marks are at first studied and compared as objects: the subject-object cut places them on the object side of the cut. Later, when fully deciphered, they are recognized as signs belonging to a natural or artificial language. When students of this language are sufficiently familiar with it, they can begin to read the signs for their meaning. Now when signs are read for their meaning, they are no longer objects vis-à-vis the activity of reading, since the object is now the meaning meant by the signs. Moreover, the signs themselves are not part of the object, since it is immaterial to the reader what signs are used (whether they belong to the newly discovered language or, say, to English, French or German translations) provided they convey the meaning meant. The meaning meant is the invariant object under possible transpositions of signs; the signs themselves do not enter into the meaning. The signs, then, have come to be displaced to the subject side of the cut. This displacement of the subject-object cut, I take to be a characteristic of a hermeneutical activity. An important consequence of this analysis is the illustration it affords of the variability of the subject qua subject. Before deciphering the language, the signs are outside the subject: after deciphering the language, and to the extent that the language is being used as a text to be read or spoken, the signs are a part of the being of the subject. The subject when he reads a text or speaks a language embodies himself in the language-signs and his noetic intention operates intentionally through them in order to objectivate a horizon of meaning.

Secondly, I wish to clarify what I mean by the notions of *dialectic* and *dialectical development'*. These notions are notoriously ambiguous, getting their sense from a wide variety of different contexts. The following account is one suggested by an analysis of the structure of quantum mechanics, and aims at being logically precise and controllable in use. Moreover, though it originates in the heart of contemporary physics, where its value and applicability can be checked, the logical structure it exhibits is common to virtually every domain that at one time or another has been said to display a dialectical structure.[15]

A dialectical development takes place when in a historical setting antithetical traditions which have existed and developed more or less in logical isolation from one another, become synthesized in a more comprehensive tradition that subsumes each of the older traditions and shows them to have been but partial perspectives of a more comprehensive horizon. From the point of view of the (later) synthesis, the earlier traditions were partial or complementary; from a point of view prior to the synthesis they are said to be dialectically opposed. A dialectic then supposes the kind of relation that the thesis and antithesis have to one another in the light of the subsequent synthesis. A dialectical development then involves a manifold of conceptual frameworks, ordered both logically and temporally in a certain way.'[16]

Let me consider first of all, what kind of logical ordering is plausible. Let LA,, LA,, LA3,... be a sequence of explicit languages representing the stages in the development of tradition A. A (descriptive) language I am taking to be the set of (descriptive) statements that affirm (whether with truth or falsity is immaterial) the possible objects *(themes, realities)* that fall within the *horizon* or *context* of the intention constituting the tradition.[17] Instead of the term "tradition", I might

15. Patrick Heelan, "The Logic of Framework Transpositions," Internat. Philos. Qrtly, 11(1971), pp. 314-334.
16. An *ordering* of elements of a set is a reflexive, non-symmetric, transitive relation between elements of the set. An ordering is *linear* if every element (except first and last, if the set is finite) has a unique antecedent and a unique consequent:otherwise the ordering is *partial.*
17. The phenomenological notions of *theme* and *horizon* are elucidated by Alfred Schutz in his *Collected Papers,* vol. 1, pp. 99-117; vol. 3, pp. 98f. (The Hague: Nijhoff, vol. i, 1962; vol. 3 1966); cf. also the classic *loci,* Husserl, Ideen 1 *(Ideas,* trans. by W. R. Boyce Gibson, New York: MacMillan, 1931), secs. 82, 113, 114; *Erfahrang und Urteil,* ed. by Ludwig Landgrebe (Hamburg: Claasen, *1954),* sees. 8-10; Aron Gurwitsch, *The Field of Consciousness* (Pittsburgh: Duquesne Univ. Press, 1964), pp. 224-46; L. Landgrebe, "The World as a

have said "research program", a term used by Lakatos of the Popperian school in his studies in the history and philosophy of science.[18] The symbol A then represents the general context of the tradition, that is, the invariant elements that comprise a fixed noetic intention. A fixed noetic intention, also called "a heuristic structure"[19] or "internal steering field" [20] is that which, when shared by the members of a research community, makes possible an identifiable tradition of research. It is a composite of implicit, tacit or sedimented elements rooted in bodily or instrumental expertise, in subjective habitualities or in that limit-mode of sedimented consciousness which Husserl calls "the unconscious", [21] and of explicit elements, like the terms of a common descriptive language, a rudimentary mathematical model and standard operating procedures. A noetic intention has methodological aspects which can be analyzed into

Phenomenological Problem," trans. by Dorian Cairns, *Philosophy and Phenomenological Research* 1 (1940), pp. 38-58; Helmut Kuhn, "The Phenomenological Concept of Horizon," in M. Farber (ed.), *Philosophical Essays in Memory of Edmund Husserl* (Cambridge: Harvard Univ. Press, 1940), pp. 106-24. For the connection between *language*, *intentionaliry-structure*, *horizon* and *tradition*, see the author's "Horizon, Objectivity and Reality in the Physical Sciences," Internat. Philos. Qrtly, 7 (1967), pp. 375-412 and "The Logic of Framework Transpositions."

18. Imre Lakatos, "Falsification and the Methodology of Scientific Research Programmes," in I. Lakatos and A. Musgrave (eds.), *Criticism and the Growth of Knowledge* (Cambridge Univ. Press, 1970), pp. 91-196.
19. For example, by Lonergan in *Insight.*
20. G. Radnitzky, "Toward a Theory of Research which is neither Logical Reconstruction nor Psychology or Sociology of Science," to be included in the revised ed. of *Contemporary Schools of Metascience* (Chicago, Regnery, 1972).
21. Husserl, *Formal and Transcendental Logic,* p. 319. For the notion of *sedimentation,* cf. A. Schutz, *Reflections on the Problem of Relevance,* ed. by R. Zaner (New Haven: Yale Univ. Press, 1970).

what Lakatos calls a "negative heuristic", which are methodological rules for protecting the "hard core" of the research program or tradition, and a "positive heuristic" which are clues or hints for the development, mostly, of the explicit theoretical structure of the program or tradition,[22] in order to extend the theory to cover eventually all the experimental or experiential anomalies not already accounted for by the tradition, and to enlarge the theory's contact with the experiential world. All of the explicit languages $L_{A1}$, $L_{A2}$, $L_{A3}$,… being stages in the development of a common tradition A, possess the same *horizon* of research.

Let an arrow ("→") represent the ordering (that is, a reflexive, transitive, non-symmetric relation) of the explicit languages representing the development of a tradition or research program. This will, of course give a linear ordering:

$$L_{A}, \rightarrow L_{A2} \rightarrow L_{A3} \ldots \rightarrow L_{A}$$

where $L_A$, the last of the sequence is the ideal limit of complete disclosure of the horizon A. Prescinding as we do from the temporal aspect of the series, what possible logical relationship, we ask, could the ordering represent? It might be suggested that $L_{Ai} \rightarrow L_{Aj}$ ($i \leq j$), whenever $L_{Ai}$ is a sufficient, though perhaps not a necessary, condition for $L_{Aj}$. That would suppose, however, that the tradition developed entirely from resources within the subject, which is an idealist position. That position I do not want to hold for the same reasons Husserl turned away from it.[23] Perhaps, it is suggested that $L_{Ai}$ is a necessary, though perhaps not a sufficient, condition for $L_{Aj}$, as for example, in the case of elementary mathematics, where one first learns to count, then to add, subtract and multiply. But who is to say that every tradition develops along a unique and necessary trajectory?

22. Lakatos, *op. cit.*, pp. 132-8.
23. See Robert Sokolowski, *op. cit.*, pp. 137-8.

It is at least conceivable that the present stage of, say, nuclear science, could have been reached by a path other than the actual historical one. For this reason, then, I reject the notion that the ordering in question is one of necessary conditions. I propose instead the following interpretation for the ordering relationship "→", namely, that

$$L_{Ai} \rightarrow L_{Aj} \ (i \leq j)$$

if and only if(l) both explicit languages have the same noetic intention and the same ultimate horizon LA (that is, they belong to the same tradition or research program), and (2) that whatever can be said, truly and appropriately in $L_{Ai}$ in *retrospect from* $L_{Aj}$ can be said truly and appropriately in $L_{Aj}$ but not necessarily vice versa.'[24] This relation is a reflexive, transitive, non-symmetric relation like material implication between statements, and we call it "implication between explicit languages." It is a logical not a temporal relation, but whenever a series so ordered is also time-ordered, then we have the historical development of a tradition.[25]

24. This is a relation between statements; the notion of *appropriateness* takes account of the context of the statement; the notion of *truth* applies to the statement itself (roughly, a *true* statement asserts what is the case).

25. The development of a tradition corresponds more or less to what Thomas S. Kuhn calls "normal science" in his *Structure of Scientific Revolutions,* 2nd. ed. enlarged (Chicago: Chicago Univ. Press, 1970). With regard to the formal conditions I have postulated, these agree precisely with the normative conditions laid down by Imre Lakatos for the development of a genuine "research program"; cf. his paper, *op. cit.*, pp. 118-20, 132-8. Taking Lakatos' $T^1$, $T^2$, $T^3$, ... to be the same as my LA1. LA2, LA3, ... he says that a series of theories belong to a genuine research program only if "each subsequent theory results from adding auxiliary clauses to (or from semantical reinterpretations of) the previous theory in order to accommodate some anomaly, each theory having at least as much empirical content as the unrefuted content of its predecessor," moreover, "each new theory leads to the actual discovery of some new fact" (p. 118). Because of the last clause, Lakatos' ordering of theories is *non-reflexive.* For reasons of formal elegance, I have chosen to use the *reflexive* counterpart of this ordering. The identity of the research program is interpreted by me to imply the identity of the horizon of the developing tradition.

Consider now the dialectical case: two traditions, A and B, develop more or less in logical isolation from one another and then become synthesized in a more comprehensive tradition, A + B, that subsumes each of the older traditions and shows them to have been but partial perspectives of a more comprehensive horizon. The logical structure of this development is that of a set of traditions partially-ordered as in figure 1, where a greatest lower bound (g.l.b.), $L_0$, has been added to convert the structure into a lattice. The g.l.b. comprises all the traditions presupposed by both A and B. The lattice, for reasons to be discussed below, is a non-uniquely complemented non-distributive lattice (a Q-lattice[26]) under a partial ordering of implication between traditions. Provisionally, let us assume that implication between traditions can be interpreted in much the same way as implication between explicit language discussed above, that is, if X and Y are two traditions, then $L_x \rightarrow L_y$ ($L_x$ implies $L_y$) if and only if whatever can be said truly and appropriately in $L_x$ in retrospect from $L_y$ can be said truly and appropriately in L~, though not necessarily vice versa. However, unlike the preceding case where we considered explicit stages in the development of one tradition, $L_x$ and $L_y$ are not explicit languages but in some sense ideal languages or limit languages ordered to the disclosure of the full potentialities of the two traditions, X and Y respectively.[27] In figure 1, $L_{A*}$ and $L_{B*}$ represent traditions intermediate between $L_A$ and $L_B$ respectively

26. *Q-lattice* stands for *Quantum-lattice;* the reason for this name will appear below. For information about lattices, see, for example, Garrett Birckhoff, *Lattice Theory* (Providence, RI., Amer. Math. Soc., 1940) or some recent textbook in modern algebra like S. MacLane and Garrett Birckhoff, *Algebra* (New York:
MacMillan, 1967).

27. Lx and Ly might also be interpreted (with appropriate changes in the definition of " **—*.")** as distinct research programs, or distinct noetic intentions, or distinct horizons for research. For example, if Lx and L~ are taken as research programs, then the partial ordering, Lx—*~ L~, would be interpreted as "whatever problem in retrospect from L~ can be solved in Lx, can be solved in L~, but not necessarily vice versa."

and $L_1$. $L_1$ is the synthesis, that is, the least upper bound (l.u.b.) or sum of $L_A$ and $L_B$.

The logical structure represented by figure 1 can be taken to define the notion of *complementarity* between the A and the B traditions. Complementarity is a notion introduced by Niels Bohr to describe the relation between conjugate variables, like position and momentum, in quantum mechanics. I have shown that the Q-lattice of quantum mechanics can best be interpreted as a relationship between two context-dependent descriptive languages, of position and of momentum, and this seems to have been the sense that Bohr himself had in mind.[28] We shall return to the quantum mechanical interpretation of figure 1 below. When one adds the time dimension to the logical structure (represented by the vertical line marked on figure 1) one has a form appropriate, as we shall see, for the elucidation of dialectical development.

An important property of the Q-lattice represented in figure 1, is its character of non-distributivity vis-à-vis sums and products. If $L_x$ and $L_y$ are any two languages of the set, then the sum $L_x + L_y$ (also called the "least upper bound" or "l.u.b.") of two languages is the "least" which both imply; that is, if $L_x + L_y = L_z$, then $L_x \rightarrow L_z$ and $L_y \rightarrow L_z$ and $L_z$ is the "least" language with this property, that is, there is no $L_w$ (distinct from $L_x$, $L_y$ and $L_z$) such that $L_x \rightarrow L_w$, $L_y \rightarrow L_w$ and $L_w \rightarrow L_z$. The product $L_x$ X $L_y$ (also called "greatest lower bound" or "g.l.b.") of two languages is the "greatest" of the partially ordered set which implies both:
that is, if $L_x$ X $L_y = L_p$, then $L_p \rightarrow L_x$, $L_p \rightarrow L_y$, and $L_p$ is the "greatest" language with this property, that is, there is no $L_o$

28. P. Heelan, "Quantum Logic or Classical Logic: Their Respective Roles," *Synthese* 21 (1970), pp. 2-33, and "Complementarity, Context-dependence and Quantum Logic," *Foundations of Physics* 1 (1970), pp. 95-110. Bohr, as **I** point out in the latter paper, might have had reservations about the full implications of the position I am attributing to him because of conflicts with his epistemology.

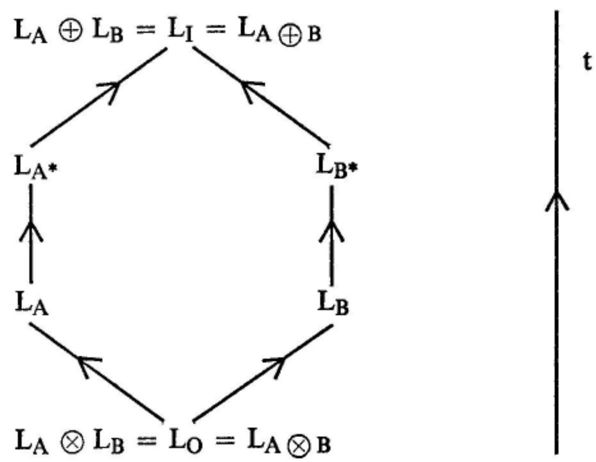


FIGURE 1. — Q-LATTICE

(distinct from $L_x$, $L_y$ and $L_p$) such that, $L_q \rightarrow L_x$, $L_q \rightarrow L_y$ and $L_p \rightarrow L_q$. Now if the lattice were distributive under sums and products, the following equality would hold:

$$L_A + (L_B \text{ X } L_{A^*}) = (L_A + L_B) \text{ X } (L_A + L_{A^*})$$

But, referring to figure 1, we find that the left hand side of the equation is $L_A$ while the right hand side is $L_{A^*}$. Hence, the lattice is distributive only if $L_A = L_{A^*}$ and $L_B = L_{B^*}$. The significance of this can be exhibited in a kind of Venn diagram (figure 2). If the horizon of each language is represented by a rectangle, then the partial ordering relation ("→") can be interpreted as a relation of inclusion, thus $L_0$ is included in $L_A$, $L_{A^*}$, $L_B$, $L_{B^*}$ and $L_1$ $L_A$ is included in $L_{A^*}$ and $L_1$, but not in $L_B$ or $L_{B^*}$, and so on. Then, the condition that $L_A \neq L_{A^*}$ (or $L_B \neq L_{B^*}$) entails that $L_1$ *must* be more comprehensive than $L_A$ and $L_B$ taken separately. Thus, the non-distributivity condition, signifies that when traditions A and B are synthesized, their union has a more comprehensive horizon than that which would be obtained from A and B separately.

But what are $L_{A*}$ and $L_{B*}$? And how do they relate to $L_A$ and $L_B$? $L_A$ and $L_B$ are evidently contained in $L_{A*}$ and $L_{B*}$, respectively, although the latter are not simply developments of the former. In quantum mechanics, which suggested the lattice, $L_{A*}$ is the orthocomplement of $L_B$, that is, it contains all those sentences of the theory that are orthogonal to (that is, independent of) every sentence of LB. Thus, $L_{A*}$ and $L_{B*}$ refer to the largest sub-horizons (of $L_1$) that are independent respectively of the sub-horizons of $L_B$ and $L_A$. [29]

In the more general case outside of quantum mechanics $L_{A*}$ might, for example, be the amplification of $L_A$ by what Kuhn calls the "translation" in the A-tradition of that part of the B-tradition that can be translated.'[30] For example, if $L_A$ is physical language (language about physical bodies) and $L_B$ is mental language (language about mental phenomena), then $L_{A*}$ might be the attempted reductionist language of psychophysics, and $L_{B*}$ the attempted reductionist language of phenomenalism. Or, for example, in the case of classical electromagnetic theory ($L_A$) and Bohr's Old Quantum Theory ($L_B$) (which set out to explain the stability of atomic systems and the phenomena of line spectra); the latter, $L_B$, proceeded on premises that were inconsistent with the former, $L_A$; in this case $L_{A*}$ would

29. In quantum mechanics, the constitution of a horizon (really, of the context for measurement of a certain type) involves preparing a physical system to interact appropriately with a measuring environment (instrument under standard conditions). The subscripts A, A*, B, B* then represent different kinds of measuring environments not all of which, in quantum mechanics—and this is the novelty of quantum mechanics—are simultaneously compatible : A is compatible with A*, B with $B^9$, but A is not compatible with B or B*, nor is B compatible with A or A*. Cf. Heelan, "Quantum Logic ..." and "Complementarity…"

30. Kuhn, *op. cit.,* p. 202; see also Kuhn, in *Criticism and the Growth of Knowledge,* pp. 267-70.

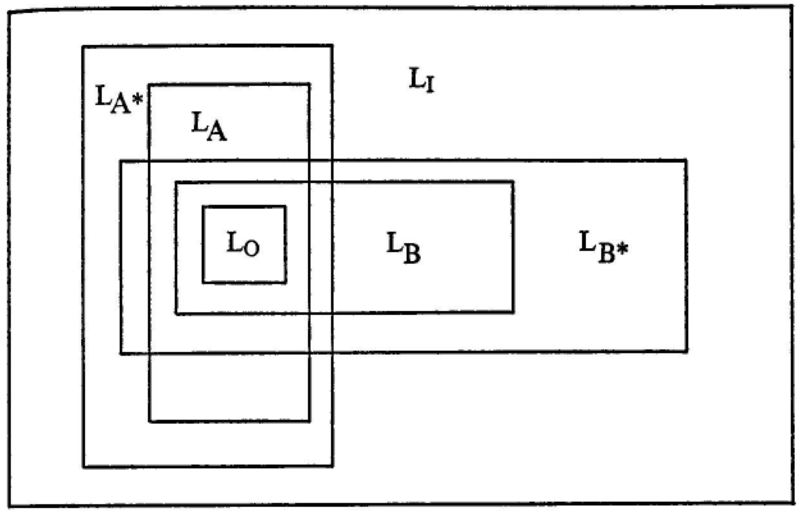


FIGURE 2

be the attempt to account for classical electromagnetic phenomena in a manner consistent with $L_A$, $L_{B*}$ would be the attempt to bring the anomalies of atomic spectra, etc., into line with classical electromagnetic theory.

While the interplay between those subjective anticipations that are a stage in the sedimentation of a particular tradition and experiential encounter with reality is often described as dialectical (so that even the development of a single tradition is in this sense dialectical) still a dialectic is better conceived as a clash between opposing intentionalities in the subject; for a prepredicative encounter can have no purchase on the subject except by appealing to some form of subjectivity or habitual intentionality that can give it sense, even though perhaps the sense that is given turns out to be not the sense anticipated by the tradition that is being assumed, but one that shocks the subject out of his taken-for-granted horizon. Dialectical opposition is rather in the clash of traditions or intentionalities that give conflicting interpretations of experience. Some such conflicts are in principle unresolvable, and the battle between them ends with the definitive victory of one of the traditions. Others are resolvable by a transforming synthesis which is the essence of a dialectical move. I am proposing then to call “a dialectical development” only such resolutions of opposing traditions as have the structure of a Q-lattice. (For convenience, and because of the Hegelian model, I have considered only the simplest of such lattices, the one represented in figure 1; in principle, however, Q-lattices can involve three or more dialectically opposed traditions or intentionality-structures.) By stipulation, then, intentions or traditions are *complementary* if and only if they are complementary in a Q-lattice under the partial ordering that we have called “implication between traditions,” and *dialectically opposed*, if there is a temporal movement together with the logical ordering.

The history of science gives abundant examples of dialectical development in the sense stipulated above; for example, the union of mechanics and electromagnetics in special relativity, of classical electromagnetics and the Old Bohr Quantum Theory in quantum mechanics,[31] of Prout’s theory (that the atomic weights of all pure chemical elements are whole numbers) and chemistry in the physical chemistry of isotopes,[32] and so on. Even post-Newtonian science can be shown to be in some sense a progressive dialectical synthesis of

31. This example is worked out by Lakatos, *op. cit.*, pp. 140-154 as illustrating the tenacity with which two mutually inconsistent research programs can be pursued by the scientific community.
32. This example is also worked out by Lakatos, *op. cit.*, pp. 138-40 but as an illustration of the victory of one research program (Prout’s) over another (19th century chemistry). The case, however, illustrates a dialectical development.

Aristotelian and Cartesian science.[33] In fact, most cases of what Kuhn calls "scientific revolutions" or what Lakatos speaks of as the victory of one research program over a competing one, are really dialectical developments in the sense stipulated above.'[34]

One important aspect of a dialectical development is a transformation of meaning of the basic terms of a theory requiring something like a *theory of analogy between languages*. For example, Newtonian mechanics (as $L_A$) and Maxwellian electromagnetics (as $L_B$**)** come to a dialectical synthesis in special relativity (as $L_{A+B}$**)** provided that whatever *in retrospect from special relativity* can be said truly and appropriately in mechanics or electromagnetics, can be said truly and appropriately in special relativity, though not necessarily vice versa. Though all the basic mechanical and electromagnetic terms are preserved in special relativity, each undergoes a notable modification of meaning brought about by the addition of the phrase *"in retrospect from special relativity."*[35]

It addition to its use as a heuristic tool in historical studies,'[36]

33. Cartesian science at first admitted only *extensive* qualities as scientific, but soon it became necessary to reintroduce *intensive* (or Aristotelian) qualities, as, for example, gravitational mass, electric charge, etc.

34. Lakatos asks the question: what is important in the study of the history of science *(op. cit.*, p. 138). His answer is research programs and how they develop and compete under the rules of what he calls "sophisticated methodological falsificationism." However, he fails to note that his methodological rules can move research programs to develop in a variety of ways: (1) linearly (as in an episode of "normal science"), (2) by replacing (without substantive change) a competing program, (3) by being replaced by a competing program (which is not substantively changed), and (4) by dialectical synthesis (in which both programs are in some sense victorious). Most of the examples he gives belong, in fact, to class (4); although he writes as if he were discussing only examples of classes 1, 2 and 3.

35. This is the "semantical reinterpretation" mentioned by Lakatos, *op. cit.*, p. 118.

36. Such, for example, is the use Lakatos makes of his theory of sophisticated methodological falsificationism, see note 34.

the Q-lattice suggests a method for the resolution of many philosophical dualisms, where the Q-lattice represents a certain norm of rationality. For example, psychological and physical languages (as the A and B traditions) should be dialectically synthesizable in transcendental language, that is, in the language of transcendental philosophy;[37] materialism and idealism in phenomenology; physical determinism and free will in an adequate theory of ethics; historicity and permanence in an adequate theory of history; body and mind in an adequate theory of human action, and so on. In all of these cases, the test for dialectical synthesis is the existence of the enlarged intention and its ability to handle questions that cannot be settled by either of the restrictive and opposed intentions. The thrust for dialectical synthesis in this view becomes normative.

lt may be asked whether in the case of implication between traditions, particularly in cases involving a Q-lattice, the partial ordering might not also be interpreted as an ordering according to necessary conditions. It is a common view among historians of science, art and culture generally, that complex traditions have their necessary antecedents in simpler ones, for example, Heisenberg's opinion that classical physics is an ***a*** *priori* condition for quantum mechanics, or Wölfflin's view that the painterly style in art must presuppose the linear style. A similar view is expressed in Piaget's genetic epistemology, Schutz's theory of the life-world and underlies Husserl's later notion of genetic constitution. There may be in this suggestion no more than what is already implicit in the Q-lattice. The Q-lattice structure read downwards analyzes component traditions present in a complex tradition: one can plausibly assume that the analysis is unique. This uniqueness is logical, not historical, and concerns the ideal type of the traditions in question, not their progressive historical realizations. Implications between traditions then, does

37. See below.

plausibly involve a form of logical necessity. Whether logically prior traditions are also and necessarily historically prior is another question, and to answer it one needs a theory of history. If the intrinsic meaning of history is cultural, then the answer may be Yes! But if historical time is taken cosmologically or astronomically, the answer may well be, No! I raise the question here merely to show the relevance of the Q-lattice to a broad range of problems about which phenomenology is concerned.

After these programmatic and methodological considerations, I want to consider some aspects of experimental science and technology from a phenomenological point of view. Let me describe what I mean by this. The phenomenological point of view starts from an originary mode of givenness in the subject's developed life-world and proceeds thence to search for the ***a** priori* subjective structure that makes such a mode of givenness possible and for the type of prepredicative encounter that evoked the subjective structure as its response. Although this description of the phenomenological enterprise represents a position closer to Husserl, than, say, to Heidegger or Merleau-Ponty, I shall readily avail myself of the insights, criticisms and refinements of a large number of writers belonging to the phenomenological tradition. My intention is to reflect on experimental science from within the phenomenological tradition without attempting to adjudicate which authors or texts constitute the purest exemplars of that tradition.'[38]

38. For an excellent introduction to phenomenological method, see Richard Zaner**,** *The Way of Phenomenology* (New York: Pegasus, 1970). Contributions to the topic of phenomenology and the natural sciences have been made by Ilusserl, *Crisis;* M. Heidegger, *Discourse on Thinking;* K.-O. Apel, "Szientismus oder Transzentale Hermeneutik?" in *Hermeneutik and Dialektik. Festschrift f. H. G. Gadamer* (Tubingen, Mohr, 1970); M. Merleau-Ponty, *The Structure of Behavior,* trans. by Alden L. Fisher (Boston: Beacon Press, 1963), pp. 137-45; Theodore Kisiel, "Zu einer Hermeneutik naturwissenschaftlisher Entdeckung," *Zeit. f. Allgem. Wissenschaftstheorie* 2 (1971), pp. 195-221; Gerard Radnitzky, "Theorienpluralismus_Theorieflmonismus," in *Der Methoden- and Theorienpluralismas in den Wissenschaften* (Meisenheim, A. Hem, 1971); Herbert Marcuse, "On Science and Phenomenology," in *Boston Studies in the Philosophy of Science,* vol. 2 (New York:

(I) *Scientific states of affairs are given in an originary way to an experiencing scientist during the course of scientific observations.*

Observation is a mode of direct, non-inferential, originary apprehension of an object using the senses, with or without the aid of instruments, in which the reality of the observed object is endorsed as observed.'[39] Observation is judgmental, that is, what one observes is expressed in a statement like, "Such and such is the case," and involves the use of a descriptive language. It aims at positing a public reality—public, that is, relative to some reference community. Observation, then, delivers ontic being, with the immediateness and directness of an element in the life-world. Whatever is or can be observed is an element of the life-world.[40] What I want to establish,

Humanities Press, *1965),* pp. 279-290; John J. Compton, "Natural Science and the Experience of Nature," in *Phenomenology in America,* ed. by James Edie (Chicago: Quadrangle Press, 1969), pp. 80-95; Aron Gurwitsch, "The Last Work of Edmund Husserl," in *Studies in Phenomenology and Psychology* (Evanston, Ill.: Northwestern Univ. Press, 1966), pp. 397-445; P. Heelan, "Towards a Hermeneutic of Natural Science," and "Reply to Wolfe Ways," in *Brit. Jour, for Phenomenology,* Sept., 1972—to mention just a few of the authors contributing to this area. My present paper can be read as taking off from where Compton in his excellent essay referred to above, left off.

39. For a brilliant analysis of the notion of observation in physics, see N. R. Hanson, *Patterns of Discovery* (Cambridge Univ. Press, 1961), pp. 4-30. See also Lakatos important statement that "no factual proposition can ever be proved from an experiment," Lakatos, *op. cit.*, p. 99.

40. The notion of Lebenswelt or life-world was introduced by Husserl in the *Crisis,* p. 48 and passim. There the life-world is identified with "the only real world, the one that is actually given through perception, that is ever experienced and experienceable," p. 48. In the same passage, he opposes it to the ideal world of Galilean science where there is a "surreptitious substitution of the mathematically substructed world of idealities for the only real world." There is, then, a tension in Husserl's notion of the life-world: on the one hand, whatever can be perceived or experienced belongs to it, and on the other, the idealities of "historical science" do not belong to it. I will argue that the observable scientific entities of experimental science do belong to the life-world. For a similar position, see Compton, op. *cit.*

first of all, is that acts of observation of scientific states of affairs do take place within the life-world of the scientific community, and that these scientific states of affairs with properly scientific predicates are given with a critical absoluteness in no way different from the way common and familiar objects are given perceptually in the life-world.

A physicist will say, pointing to the dial of an ammeter, that there is a current of *5* microamperes in the circuit, and this he will call a scientific observation. His observation has been preceded by many complex inferences and a specialized training, but when he comes to observe, he does not calculate or infer; he performs a simple act in which there is no trace of inference. He brings to bear for this purpose, of course, his antecedent knowledge and expectations about the scientific object, but these are not used as part of an argument; they are presupposed; they belong to the subjective intention of the observing scientist. If, however, anticipations about the behavior of the object are not borne out, the scientist will return to calculating and checking, in much the same way that if you were to see a pink elephant sitting in your favorite chair, you would hesitate to declare this as a matter of observed fact, until you had checked whether or not your senses were working properly. Scientific observation with an instrument, though logically a form of immediate knowing, and simple, therefore, to the initiated, is not a naive form of knowing, and certainly is not to be conceived as simply opening one's eyes and passively receiving an impression. It has to be learned, and is learned often only with great difficulty.[41] An untrained person

41. See Don Ihde's "A Phenomenology of Man-machine Relations," in *Work, Technology and Education,* eds. Walter Feinberg and Henry Rosemont (Urbana: Univ. of Illinois Press, 1973).

cannot use a microscope to make observations of mitochondria and Golgi bodies, because the facets or perspectives of these entities under the microscope have to be learned, just as, for example, a person has to learn to recognize the calls and flight patterns of different species of birds. A horizon of expectations has to be created before observations can be made. Neither the difficulty of the art of observing, nor the fact that it is learned, nor the fact that an instrument may be needed for observing, nor the dependence of the act on a theory to account for what is observed—none of these is incompatible with the performance of an act in which an object is given in a direct originary way. If everyday states of affairs can be objects of acts of observation, then so also can scientific states of affairs.

What I have said about the observability of scientific states of affairs contradicts one of the basic principles of much philosophy written both in the style of phenomenology and of logical empiricism, that there is a hard distinction to be made between observational and theoretical entities. Some entities, the principle says, can be observed;[42] these are observational entities and comprise, roughly, familiar common sense macroscopic objects (sometimes, the sense data of which these are allegedly composed): other entities cannot be observed; these are theoretical entities, like the explanatory variables and constructs of a scientific theory. Theoretical entities are linked with observational states of affairs through correspondence or bridge rules, the function of which is to state explicitly the observational circumstances in which it is warranted to use a theoretical term. The covering law model of explanation is based on the observational-theoretical distinction and assumes that scientific states of affairs characterized by the predicates of a scientific theory are not observed: but can only be inferred from observed macroscopic

42. Properly speaking, not *entities but facts* are observed; namely that such and such (a named entity) is so and so (has a named property).

instrumental states. The observational-theoretical distinction as an epistemological keystone of logical empiricist philosophy of science has been attacked vigorously by Norwood Russell Hanson,[43] Paul Feyerabend [44] and a group that favors a pragmatic theory of observation[45] and it has now been largely abandoned. Even among those who try to maintain this distinction in some form, like Wilfred Sellars,[46] it has become fashionable to accept the genuine ontic status of scientific states of affairs. Let me state where I stand: all descriptive terms—that is, terms capable of being used with realistic intent—whether they be scientific or non-scientific, can be used observationally or theoretically, although in practice, common familiar non-scientific terms are usually used observationally, while scientific terms are often used theoretically. The difference between the observational and the theoretical is not a difference in ontology, but one in logical usage or mode of predication. For example, a scientific instrument can be treated as a macroscopic piece of matter that interacts according to known causal laws with the object to be investigated: information about the object obtained in this way is indirect, mediate and inferential, and the scientific terms used to express this information are used theoretically. However, with training, a scientist acquires progressively a sedimented stock of expertise with instruments that transforms his relationship to them as I shall show, in such a way that with their help, scientific objects can manifest themselves to him as givens in an originary way. Scientific terms under such circumstances come to be used observationally to make observational statements. Theory and observation, then,

43. Hanson, *Patterns of Discovery*.
44. P. Feyerahend, “Problems of Empiricism,” in *Beyond the Edge of Certainty*, ed. by R. G. Coldny (Englewood Cliffs, N.J.: Prentice-Hall, 1965), pp. 145-260.
45. For example, Karl Popper, Marx Wartofsky, Imre Lakatos and others.
46. Wilfred Sellars, *Science, Perception and Reality* (London: Routledge and Kegan Paul, 1963), and *Science and Metaphysics* (London: Routledge and Kegan Paul, 1968).

are linked: theory says what observation can see,[47] and observation is always "theory-laden,"[48] but the presence of a theoretical component does not preclude the possibility of observation.

It has been objected that scientific states of affairs are inferred, abstract, theoretical interpretations or explanations of situations in the life-world and as such lack the absoluteness of the life-world.[49] To this I would respond that, while science certainly engages in abstract theoretical activity like the making of mathematical models, its goal in so doing is to reveal something about the real world, that is, to make *observable* those states of affairs that science speaks about. Whatever is given to observation, is given only because certain conditions are fulfilled: that there is an ability to observe which is the product of learning; that there is a descriptive language in which the objective possibilities of observation are sedimented; that certain pragmatic conditions, such as standardized situations, can be reproduced or recognized which depends on our (often unsophisticated) knowledge of the fixed causal relations in nature. None of these conditions discriminates between scientific and nonscientific entities; the only difference is in the last respect, where, in order to observe scientific entities, we use more sophisticated knowledge about the fixed causal relations between things, a fact which supposes a special background knowledge and a special training. The givenness of scientific objects, I conclude, is no less absolute than that of other elements of the life-world.

47. Albert Einstein held this to be the proper relationship between theory and observation, cf. his autobiography in *Albert Einstein: Philosopher-Scientist*, ed. by P. Schilpp (Evanston, Ill., Library of Living Philosophers, 1949), pp. 20-21, 48-49, and Heisenberg's report of a conversation he had with Einstein, in W. Heisenberg, *Physics and Beyond* (New York: Harper and Row, 1971), p. 63.
48. Hanson, *op. cit.*, p. 19.
49. An important distinction has to be made between the *abstract model* and the *use made of the model* to make particular statements of realistic intent about the world. See below.

(2) *Scientific observation involves a special non-objective use of the instrument; one in which the noetic intention is embodied in the instrument joined, physically and intentionally, with the scientist; this non-objective use is characterized by a hermeneutical shift in the subject-object cut so as to place the instrument on the subject side of the cut, and the instrumental signals in a position of a "text" to be "read" in a "context."*

Science comprises a variety of activities. Besides the making of scientific observations, there are mathematical models to be developed, calculations to be made, experiments to be performed and instruments to be tested. For cultural reasons, the principal spokesmen of physics have been mathematical physicists who tend to consider exclusively the construction and manipulation of mathematical models and the literature about physics by physicists and many philosophers of science reflect this bias.'[50] The terminal object of physics, however, is not a model of the world, but concrete particulars reached through the mediation of a measurement in which models are used for the purposes of observation, but are not thelnselves objectivated.[51] A measurement is a contrived act designed for the purpose of gaining publicly, verifiable information about the state of a physical system through the use of an instrument. The instrument serves to withdraw the data gathering process from the biasses of individual human judgments, by mapping the intensity of the physical quantity on the number field in such a way as to provide a record open to public scrutiny. A measurement is always an experiment involving the coupling of an instrument and an object through an interaction in a controlled environment. A physical variable, like every property

50. A. Eddington, **J.** Jeans, A Einstein, W. Heisenberg, E. Schrodinger, N. Bohr, were all mathematical physicists: the only well-known writers on physics who were experimental physicists are P. K. Bridgman and Arthur Compton.
51. See note 49.

we know of, is a relation to a standard context, and in this case, to a standard context involving physical interaction.[52] To be a measurement, there must be a coupling interaction, but also one that produces a macroscopic effect perceptible to a community of trained scientists. This macroscopic effect must be in one-to-one correspondence with the physical states of the object, and this correlation is guaranteed by the correct use of a scientific theory or model in the design of the instrument. In this respect, the instrument is subject to the laws of physics like any other piece of macroscopic matter. From the effects on the instrument, a scientist can infer the state of the object. In this inference, the instrumental effect is used as a premise in an argument; it is a special class of auxiliary objects, outside of the subject.

Instead of using the instrument objectively as described above, a trained scientist with an acquired stock of expertise can use it non-objectively, the way a communications medium is used. The macroscopic modification of the instrument can be treated as a modulation of a signal medium. Such instrumental signals are not natural signs, for they are not unique of their kind, like smoke of fire, and the medium of the signal can be changed at the will of the experimenter in an infinite variety of ways, from moving pointers, to flashlights, to beeps, to a computer print-out. Each signal space once chosen, has its own syntax, but all signify one and the same message space, the horizon of the scientific object. When used as a sign, the modification of the instrument is no longer used as a premise in an argument but more like a text to be read in its context. A word or a sentence does not function by reason of any relation of similarity

52. I am taking the view that (1) all properties are relational and (2) that quantification is based on measurement and not vice versa. See my *Quantum Mechanics and Objectivity* (The Hague: Nijhoff, 1965). For the opposite viewpoint, see Mario Bunge, *Scientific Research II* (New York: Springer-Verlag, 1967), p. 202.

or causality between its shape (or other physical qualities) and that of the thing signified. A picture represents because to some extent, it is physically like what it represents, and some signs signify because they are causally related to the things they signify, but a sentence represents its object, not by being like its object, nor by being caused by its object, but by signifying a meaning within a context of possible meanings conventionally established. An instrumental sign can function for the trained scientist in the way a sentence does. The position of the pointer on the ammeter, for example, can be read as "There is a current of *5* microamperes in the circuit." In the nonobjective use of the instrument the scientist simply "reads" this "sentence" in the presupposed context of the measuring process and uses it to state what he has observed. The instrumental sign as a physical thing, is not, in this case, objectivated either for its own sake or for use as a premise in an argument; it has passed from the objective side of the subject-object cut to the subjective side. In this transition, the instrument becomes a part of the subject, physically and intentionally, that is, a part of the body-as-subject. What, we ask, is the character of embodiment that permits the instrument to become part of the body-as-subject?

Man is present to others and in his world through his body. A description of man's body as a physical object localizes it within a definite contour delineated by the membrane of his skin; but the body as subject of intentional activities is, as I have shown, of variable dimensions. This phenomenon was noted by Maurice MerleauPonty, by Michael Polanyi and others. A blind man, as MerleauPonty points out in the *Phenomenology of Perception* is present up to the tip of the cane that taps the sidewalk,[53] and Polanyi treats

53. Maurice Merleau-Ponty, *The Phenomenology of Perception,* trans. by Cohn Smith (New York: Humanities Press, 1962), p. 143.

the same phenomenon under the title “the tacit dimension.”[54] What establishes the fact and character of intentional bodily indwelling in an artifact is its non-objective use.[55] As in the example just given, the instrument or other artifact is located on the subjective side of the subject-object cut and is to be accounted part of the body-as-subject.

The importance and necessity of apprenticeship to an experimental tradition by becoming familiar with a set of exemplary experiments, is stressed by Kuhn and others. The disciplinary matrix, then, does not consist solely in the ability to construct or manipulate mathematical models, but comprises also the ability to attach these models to nature.’[56] This ability to “empiricize” mathematical models is learned, not linguistically through a system of bridge rules, but “by some non-linguistic process like ostension[57] in which mastering exemplary experiments plays a large role. An experiment is not a piece of Nature, pure and simple; but a humanly contrived phenomenon in which Nature is made to “write a text” in conventional symbols for the scientist “to read.”

(3) *Scientific experimentation in the fullest sense involves the possibility of a human subject embodying himself in instrumentation not only for the purposes of observation, but also to create that context, physical and noetic, which is the condition of possibility for the scientific object to manifest itself in observation.*

Scientific observation is only a part of experimentation. The other part is what is called “preparing the object for observation,” that is,

54. Michael Polanyi, *Personal Knowledge* (Chicago: Chicago Univ. Press, *1958)* and *Tacit Dimension* (New York: Harper Torchbooks).
55. For an excellent and critical treatment of this topic in Marcel, Sartre and Merleau-Ponty, see Richard Zaner, *The Problem of Embodiment* (The Hague:
Nijhoff, 1964), especially Part III on Merleau-Ponty.
56. Thomas S. Kuhn, *The Structure of Scientific Revolutions,* 2nd ed., especially “Postscript- 1969,” pp. 174-210.
57. Lakatos and Musgrave, *op. cit.,* p. 270.

finding or producing specimens for observation and bringing them within the range of instrumental observation. For example, to make an observation of electron spin, one has to have at hand a source of electrons of appropriate momentum. Scientific experimentation, then, in its fullest sense, involves two kinds of activity, a manipulation of the environment to bring the object within reach (setting up the active context or horizon of the experiment) and acts of observation which record the contingent events that occur within the context of the inquiry. The active context of the experiment is not that which is observed, but that which because of its directive activity, makes acts of observation possible. The active context of the experiment is both physical, including all the apparatus necessary to prepare the object for observation, and noetic, that is, the intention which animates the inquiry. The active context, then, is another name for the embodied intention of the subject—the *conscience engagée et incarnée—;* it is what remains structurally invariant on the subjective side of the cut throughout various acts of observation; in this case, it is the scientific experimenter conjoined physically and intentionally with his instrumentation. The active context, then, is the body-as-subject.'[58]

(4) *The historical fact of scientific revolutions confirms the hermeneutical aspect of experimental science and adds a dialectical movement to its history.*

According to a view first proposed by Thomas S. Kuhn, the history of science manifests two kinds of episodes: that which he calls "normal science," which is the linear development of a tradition of

58. The total context can be divided into an active and passive context. The active context is the noetic intention embodied in (sedimented) habits and instrumental procedures; the passive context comprises all those conditions that are necessary but are not active in the search for, or recognition of an object.

research, called by him "a disciplinary matrix" and another which he calls "revolutionary science," which begins when a formerly entrenched tradition is called into question by the discovery of persistent anomalies and new and rival traditions, discontinuous with the old, thrust themselves forward.[59]

Anomalies are systematic encounters with the world that fail to make sense within the tradition or research program within which they ought to make sense. The effect on the scientific community of persistent experienced anomalies to a theory is, according to Kuhn, to encourage work on rival theories or research programs which then compete for the attention and allegiance of the scientific community until such time as one of them comes to replace the old as the basis of a new "normal science." The Popperians, on the other hand, defend the view that science is (normatively) an effort to supplant old theories by new ones of greater explanatory power, and that the search for systematic anomalies is crucial to this effort.

Much discussion has centered recently on the existence of scientific revolutions, on how they should be described and on the role they play in the scientific enterprise, whether considered normatively (as by the Popperians) or descriptively and historically (as by Kuhn). That science is not simply the accumulation of and systematization of factual information about the world is generally agreed, but that it involves essentially the construction of theories that transform the content of one's vision of the real world. Theories change and are replaced: is this a rational process? Is it consistent with a belief that scientific theories articulate reality? Is the scientific reality so articulated a historical one—like social reality—or is it already out there, independent of history and fixed?

The rationality of theory change is bound up with the models of development laid out in this paper. All of the historical examples

59. Kuhn, *op. cit.;* see also Lakatos and Musgrave, *op. cit.*

from the history of science cited by Kuhn, Lakatos, Feyerabend and others as illustrations of discontinuity through theory shifts, can be shown either to exemplify the dialectical case, or to be in search of a dialectical synthesis as the normative goal towards which ongoing research is moving. I have already treated this point briefly, earlier in my paper. I want to add, however, a note on an important, often overlooked distinction, relevant to the question of continuity in theory shifts. A distinction has to be made between an *abstract model*, like a system of Newtonian point-masses, and the *use of the model* to make particular statements with realistic intent about the world. A mass-point is a constructed, abstract, unreal entity; but the Sun-Earth system (to which this model for certain purposes can be correctly applied to yield true statements) is not a system of mass-points, but a *representation* of a mass-point model. The notion of *representation* (or of the *use* made of a model) is an essential epistemological refinement and serves to distinguish between, say, the *Earth-represented-as-mass-point* and *mass-point as an element of an abstract model*. Husserl in the *Crisis* took the view that the use science makes of abstract models is to *substitute* them for reality. This is a very prevalent misunderstanding of the use to which mathematical models are put. The point of my emphasis on experimental or observational acts in science is to insist that science is not about models (as substitutes for reality) but about reality *as understood through the appropriate—not substitutive—use of models*. Models are merely instruments to enable us to understand factual experience. Hence, radical differences in model constructions are no more evidence for radical differences in our understanding of factual experience (where the models are used), than is the difference between a washing board and a washing machine evidence that washing clothes is no longer washing clothes. The continuity that is sought in the development of scientific theories is not to be judged by the syntactical congruences or noncongruences between the theories-as-models, but by the greater or less inclusivity of their empirical horizons (represented by the ability to order them under the arrow relation "→" introduced above [60]) A *theory* in the latter sense, is a pre-linguistic entity, logically antecedent to models (though necessarily using models in its explicit articulations) and coincides with what I have called a "noetic intention."

Revolutionary science, whether merely in historical episodes as Kuhn claims, or as a permanent state of science as the Popperians would have it, is dialectical, as I have shown. It is also hermeneutical, since any anomaly that persistently frustrates the noetic act of scientific observation brings up for reflective questioning the cut that separates the subject from the object of science.

It is historical, since the persistent and significant failure of a tradition forces the scientific community to reflect on the historical roots and path of development of the tradition in an effort to find the negativity systematically overlooked. This is usually contained in an existing but minor tradition, incompatible with the former, and therefore considered of less significance. The purpose of this return to historical roots is to recover the intentions that were operative prior to the entrenchment of the major tradition and that continues to underlie it. This can be illustrated in various historical cases, for example, in Einstein's reflections prior to the formulation of relativity,[61] and in Heisenberg's prior to the formulation of quantum mechanics. [62]

60. Thus, the mathematical equations of, say, Newtonian mechanics and relativistic mechanics are two (syntactically) incompatible theories-as-models; but in *use,* the two theories (as noetic intentions) are ordered by the arrow **("→")** relation.

61. See, for example, Gary Gutting, "Einstein's Discovery of the Special Theory of Relativity," *Philos. Sci.* 39 (1972), pp. 51-68, where he evaluates the relative weights of *a priori* considerations to experimental data.

62. Heelan, *Quantum Mechanics and Objectivity.*

If scientific theories articulate physical reality, and scientific theories are historical, is not physical reality then also historical— having a history like the theories that are used to describe what is real? But surely such a conclusion is paradoxical: physical reality is what is independent of human knowers; how then can physical reality have a human history? Reality can be considered as the ultimate horizon of Being towards which all knowledge turns but is never fully thematic, or as the thelnatic beings which are here and now at hand to particular knowers. The former is a transcendental invariant, independent of all particular knowers. The latter is subject to historical change, not arbitrarily however, but as the product of the encounter between pre-predicative experience and the structures of transcendental subjectivity. Even in the latter case, there is a certain independence of particular knowers, relative that is, to the historical community that shares common horizons. This relative independence is, however, sufficient for the truth of observational statements, and for the kind of reality possessed by the life-world.

*(5) In consequence of what has been said, we can now outline the moments in the genetic constitution of scientjflc objects as elements of the life-world of the scientist: the scientist .first learns the objective use of instrumentation, then, through acquired expertise, he passes to a non-objective use of instruments characterized by the following: intentional or subjective embodiment in instrumental artifacts, a bermeneutical shift in the subject-object cut, and the assimilation of instrumental signals to a "text" to be "read" in its "context."*

The process of genetic constitution outlined above is not simply cumulative, that is, adding sense on sense, but involves a revolutionary move in which instrumental signals lose their objective quality as premises and pass over to the subject side of the cut where they begin to function as a "text" to be "read" in its "context." The rationale for this transition was explained above.

(6) *Technological artifacts make possible modes of observational givenness which, unlike experimental science, are constituted by human technical interests; within this context scientific terms are used with analogical meanings.*

However, the ability to observe entities bearing scientific names is, in an important way, not restricted to experimental scientists. Scientists design instruments and can give a theoretical account of why they function as they do. But once constructed and standardized, they can be multiplied by mass production technology and put in the hands of persons untrained in science, for the pursuit of technical interests. For example, a Geiger counter (an instrument which responds to radiation given off by radioactive atoms) can enable an ordinary person to discriminate between radioactive and non-radioactive materials. The distinction usually does not have for him a properly scientific significance, since he does not have a univocal understanding of nuclear physics,[63] nor is it necessary for him to have such a knowledge. But it is necessary for him to have some subjective intention to enable him to give meaning to his use of scientific terms. These terms come to have for him significance within the context of health hazards in the environment, or the location of valuable natural resources, or other technical purposes to which a Geiger counter can be put. A new mode of observational givenness can then be created for the ordinary man through the instrumentality of the Geiger counter, one which yields new objects bearing the same scientific names one finds in experimental sciences, but with altered meanings. The meanings are analogical relative to their primary

63. "Univocal understanding," that is, understanding physics as physicists understand it.

sense in experimental science, and are constituted by man's technical interest. It is these analogical meanings that make science significant to our total culture; this is the science about which Habermas, Heidegger and others are concerned: it is one aspect of historical science. Through instrumentation (for the scientist) and technology (for the general public) man comes to surround himself with useful artifacts that extend not only his powers of seeing, reaching, hearing and sensing old and familiar objects, but create new powers of sensing such things as are called "magnetic fields," "cosmic rays," "atomic vibrations," "electronic beams" and a host of unfamiliar, otherwise non-sensible aspects of our environment. If, on the one hand, the definition of these entities in the scientific model seems to leave them mere functional entities, on the other, use of the model through instrumentation and technology to make these observable, enables man to assimilate them to the more familiar entities of his life-world.

(7) *Quantum mechanics as a physical science gives a logical model, the Q-lattice, for the relation bet it'een context-dependent and dialectically related languages, that is, languages supposing relatively non-compossible modes of subjectivity.*

If measurement and experiment are at the center of science, and if the scientific object is given to or observed by a subject embodied in the scientific instrument, then it is clear that although Mind or Spirit is not a parameter of the scientific object, it nevertheless has a place in the scientific scheme of things. Mind resides in the knowing subject, which is embodied in the instrument conjoined, physically and intentionally, with the scientist. Hence the kind of Mind presupposed by science, though not an object of (physical) science, is nevertheless operative in the physical scheme of things but always on the side of the subject. Mind or Spirit, as far as science goes, however, is not pure disembodied soul, but the embodied subjectivity of the observer and experimenter joined to his instruments.

These conclusions are seen to constitute the essence of that revolution from classical to quantum mechanics which took place in the first decades of this century. This involved a conversion from the classical model of a subjectless scientific objectivity to the subject-dependent objectivity of quantum mechanics. Quantum mechanics arose as the outcome of Werner Heisenberg's reflection that, if the elements of a classical space-time model of physical reality cannot be observed or measured, then the model must yield to some theory whose elements are observable and measurable, even though these are not objectifiable in the classical spatio-temporal sense.[64] His intuition rejected the objectivist presuppositions of classical physics, and in a profoundly significant epistemological move, he consciously placed the measuring subject or observer at the heart of quantum mechanics. "Natural science," wrote Heisenberg, "does not simply describe and explain nature: it describes nature as exposed to our method of questioning."[65] The classical physics of his time presupposed that observers were outside of physics or at least outside of history. The quantum mechanical observer, on the other hand, is part of physics, for quantum physics is a theory of what observers get when they interact with a quantum mechanical system. "The aim of research," wrote Heisenberg elsewhere, "is no longer an understanding of atoms and their movements 'in themselves,' i.e., independently of the formulation of experimental problems."[66] He then continues in a very difficult passage which my paper, I hope, has clarified to some extent, "From the start, we are involved in the argument between nature and man in which science plays only a part, so that the common division of the world into subject and object,

64. Heelan, *Quantum Mechanics and Objectivity*.
65. Werner Heisenberg, *Physics and Philosophy* (New York: Harper and Row, *1958),* p. 81.
66. Heisenberg, *The Physicist's Conception of Nature* (London: Hutchinson, 1958), p. 24.

inner world and outer world, body and soul, is no longer adequate and leads us into difficulties."

How a particular object manifests itself, that is, with what significant variables, depends on the choice of instrumentation or measuring process. Moreover—and this is a surprising result peculiar to quantum mechanics—no panel of measuring instruments can be constructed which yield precise values for all possible observables (descriptive variables) of the system. Consequently, the only observations of concrete particulars possible in quantum mechanics are observations contextualized by the choice of instruments of measurement. Since observations, however, are made by knowing subjects, what we have just said means that the knowing subject or observer has first to choose the limits of his embodiment, that is, the kind of measurement or observational context he wishes to use, and only then are the appropriate categories specified for observation. The most famous expression of this observer-or instrument-dependent character of quantum mechanical variables is Heisenberg's Uncertainty Principle,[67] which relates the measure of statistical inaccuracy ($\Delta x$) of a position measurement (x) with the associated measure of statistical inaccuracy ($\Delta p$) of the momentum measurement (p) according to the inequality

$$\Delta x.\ \Delta p \geq h/2\pi$$

where h is Planck's constant.

The context-dependent character of observations or descriptions in quantum mechanics was given the name "complementarity" by Niels Bohr.[68] Returning to figure 1, let $L_A$ be the language and context of precise position, and $L_B$ the language and context of Precise momentum. They are complementary in the sense that if

67.Heisenberg, "Uber den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik," *Zeit.f. Physik,* 43 (1927), pp. 172-198.
68. See Heelan, "Complementarity, Context-dependence and Quantum Logic," last section,

one is appropriate in a particular observational case, then the other is inappropriate. They are opposing non-compossible contexts of observation, incompatible embodiments for an observing subject. However, although complementary contexts are polar opposites, they are not absolutely incompatible, since complementary contexts of observation can mix though not without each affecting the precision attainable in the other. For example, in a mixed position and momentum context, precise position and precise momentum cannot, in principle, be observed, but imprecise position (x) and imprecise momentum (p) can be observed, and the systematic variabilities (or "uncertainties") $\Delta x$ and $\Delta p$ of x and p respectively will obey Heisenberg's Uncertainty Principle. The enlarged descriptive language which contains resources for the description of events in all possible contexts, precise and imprecise, is $L_1$ (= $L_{A+B}$) and clearly is richer than $L_A$ and $L_B$ taken together but in isolation. The mathematical theory of quantum mechanics interposes $L_{A*}$ and $L_{B*}$_orthocomplements of $L_B$ and $L_A$ respectively—and so guarantees the non-distributivity of the lattice. $L_{A+B}$ in this case comprises a set of new and enlarged kinematical concepts, the introduction of which constituted for Heisenberg the quantum physical revolution, as witnessed by the title of his first paper on quantum mechanics: "On the quantum theoretical re-interpretation of kinematical and mechanical variables." [69] This enlarged quantum mechanical language is not the non-contextual language of classical physics, nor is it made up of disjoint elements of this language, but it is a new context-dependent synthesis of complementary languages of position and momentum.

69. Heisenberg, "*Uber quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen*," *Zeit. f. Physik* 30 (1925), pp. 879-93. An English translation will be found in *The Sources of Quantum Mechanics*, ed. by B. L. van der Waerden (Amsterdam: North Holland, 1967).

(8) *Quantum mechanics cannot be understood without recourse to a transcendental language that is the dialectical synthesis in a Q-lattice of physics and psychology.*

Heisenberg has written much about the subject-object (observer-observed) cut in quantum mechanics: "The traditional requirement of science... a division of the world into subject and object (observer and observed) is not permissible in quantum physics," he wrote in 1929,[70] implying that there is no *fixed* division between subject and object, observer and observed. Many philosophers of science especially of the logical empiricist school find statements of this kind repugnant to the scientific tradition and contributing to a confusion between physics and psychology. Mario Bunge, for instance, writes:[71] "theoretical physics must be kept thoroughly physical, strictly ghost-free or else its name must be changed to 'psychology'." The ghost in question is, of course, the observer. Bunge would not deny the existence and legitimate role of subjects, observers and consciousness in creating, interpreting and using physics, but he wants to remove what he believes to be mental and psychological terms from among the conceptual apparatus of physics.

The term, "observer," like "subject," can be taken objectively or subjectively. Objectively, it connotes both a physical spatiotemporal entity and a psychological entity (a knower).'[72] Subjectively, it connotes both a division of being, the being of subjectivity, and a division within consciousness, the noetic pole of a noetic-noematic intentionality structure. The objective senses are empirical and belong respectively to physics and psychology. The subjective senses

70. Heisenberg, *Physical Principles of the Quantum Theory* (Chicago: Chicago Univ. Press, 1970), p. 2.
71. M. Bunge, *Quantum Theory and Reality* (New York: Springer-Verlag, 1967), p. 7.
72. See Heelan, *The Observable: Observation, Description and Reality in Quantum Mechanics* (in manuscript).

are transcendental and belong to metaphysics and phenomenology respectively. The observer qua observer has the being appropriate to an embodied or “worldly” subject, and hence falls under all those categories of description that a body falls under, although those categories do not exhaust its being. The body as subject, therefore, is a spatio-temporal entity with all the physical predicates of a physical object. The instrument which is a part of it and the biological organism of the scientist which is also a part of it and with which it is in physical contact, are in this respect no different from any other physical objects: they have well-defined physical descriptions. But qua observer, the instrument, embodies the noetic intention of the scientist, and this embodied intention has its proper ontic reality. As such it cannot be described either with the resources of empirical psychology or with those of physics: what is needed is a language of transcendental philosophy. These two empirical languages of physics and psychology are complementary and dialectically opposed:their synthesis is the language of transcendental philosophy, which is the comprehensive language of Being. From what has been said it is clear that this is the least upper bound in a non-distributive Q-lattice of complementary physical and psychological languages.

In quantum mechanics, then, which is the heart of modern physics, objectivism has broken down. This is especially significant since physics has always been considered the paradigm case of scientific objectivity and classical physics with its claim to an absolute objectivity set the stage for such demands outside of physics in the other sciences and in our own experience. With the collapse of this kind of objectivity in physics, it will be hard to sustain these claims in the other sciences.

*(9) The hernieneutic aspects of natural science and technology have momentous consequences for the evolution of human subjectivity and the ljf~-world.*

One final point, about the ethical, social and political consequences of the notion of embodiment in human artifacts used in this paper.[73] Man as a cognitive and moral agent has a body that may vary as to what it physically encompasses, permitting it to include at times instruments and other artifacts present in the environment. The mass availability today of technical artifacts made possible by science provides a range of bodily extensions that result in new forms of human subjectivity that open up, in turn, horizons of the life-world that did not exist a generation ago. When one realizes that man's willing or forced adoption of any bodily extension, as, for example, of the automobile, telephone or television, changes the quality of human subjectivity at least transiently and could affect it permanently if the artifact becomes institutionalized in our culture, one sees that the power to take technological initiatives is not morally or socially neutral. A permanent change in the quality of human subjectivity is equivalent to a change in human nature. By *human nature,* I mean the pattern of taken-for-granted embodied anticipations and powers with which the normal adult is equipped to act cognitively and morally who has learned to embody the cultural environment of his time. Man, as we have discovered, has the power to modify his environment by technology so as effectively to alter the range of his habitual embodiments. Such, as I have said, is a power to change man's nature and it is the continuation on the human level of those forces for change manifested in the evolution of biological species. However, the decision as to what instruments and techniques are made available

73. See Heelan, "Nature and its Transformations," contributed to the Sept. 1972 issue of *Theological Studies* devoted to moral and religious aspects of genetical engineering.

to the general public is generally made in our society without formal consultation with the general public, or with representatives as such of the scientific community, and certainly without philosophical reflection on their implications. The decision is made usually by State or Federal agencies like the Department of Defense, and private entrepreneurs in search of business profits, neither of whom know anything about the overriding evolutionary significance of their choices and whose sense of public responsibility in this regard is often in direct conflict with their more selfish interests. Is it not foolish to think that human progress and social development can be served by continuing to allow scientific results to be exploited solely and principally in the interests of human destruction or private speculative profit? Human nature will continue to change, mostly through the mass effect of applied science in transforming human subjectivity, but how can our society avoid those cultural *cul-de-sacs* that frustrate progress? This is the most serious cosmological, moral and social question of our times, and if I am correct, only a phenomenologically oriented philosophy of science and technology can usefully contribute to its resolution.

Finally let me summarize what has been said in this paper. I distinguished science as an element of our total contemporary culture, "historical science," from science as the professional business of natural scientists, "experimental science." Phenomenology has always taken a very critical stance against certain defects or biasses—objectivism, scientism, technicism—it has found in historical science. It is my purpose to show that these defects and biasses, associated historically with physical science, are not necessary parts of physical science, and consequently, that physics, especially experimental physics, has all of those hermeneutical, ontological, historical and dialectical dimensions negated by historical science. The notion of *dialectic* is given a formal logical construction as a time-dependent

Q-lattice (Quantum-lattice or Quantum-logic), the form of which is suggested by quantum mechanics. The following positions are then proposed and defended: (1) Scientific states of affairs are given in an originary way to the experiencing scientist during the course of scientific observation. (2) Scientific observation involves a special non-objective use of the instrument; one in which the noetic intention is embodied in the instrument joined, physically and intentionally, with the scientist; this non-objective use is characterized by a hermeneutical shift in the subject-object cut so as to place the instrument on the subject side of the cut, and the instrumental signals in a position of a “text” to be “read” in a “context.” (3) Scientific experimentation in the fullest sense involves the possibility of a human subject embodying himself in instrumentation not only for the purposes of observation, but also to create that context, physical and noetic, which is the condition of possibility for the scientific object to manifest itself in observation. (4) The historical fact of scientific revolutions confirms the hermeneutical aspect of experimental science and adds a dialectical movement to its history. (5) In consequence of what has been said, we can outline the moments in the genetic constitution of scientific objects as elements of the life-world of the scientist; the scientist first learns the objective use of instrumentation, then, through acquired expertise, he passes to a non-objective use of instrumentation characterized by the following: intentional or subjective embodiment in instrumental artifacts, a hermeneutical shift in the subject-object cut, and the assimilation of instrumental signals to a text. (6) Technological artifacts make possible modes of observational givenness which, unlike experimental science, are constituted by human technical interests; within this context scientific terms are used with analogical meanings. (7) Quantum mechanics as a physical science gives a logical model, the Q-lattice, for the relation between context-dependent and dialectically related languages, that is, languages supposing relatively non-compossible modes of subjectivity. (8) Quantum mechanics cannot be understood without recourse to a transcendental language that is the dialectical synthesis, in a Q-lattice, of physics and psychology. (9) The hermeneutic aspects of natural science and technology have momentous consequences for the evolution of human subjectivity and the life-world.