Lecture for "Structure and Semantics of Theories": Stein, "Some Reflections on the Structure of Our Knowledge in Physics"

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èsprit de technique

As at an earlier time philosophy was affected by a disease of system-building—the èsprit de systéme *against which a revulsion set in toward the end of the last century—so it has (I believe) in our own time been affected by an excess of what might be called the* èsprit de technique*. I see this as having two chief kinds of manifestation. One has to do with details: a tendency both to concentrate on such matters of detail as allow of highly formal systematic treatment (which can lead to the neglect of important matters on which sensible even if vague things can be said),*[1] *and (on the other hand), in treating matters of the latter sort, to subject them to quasi-technical elaboration beyond what, in the present state of knowledge, they can profitably bear. [p. 1]*

[1] *Wittgenstein's famous aphorism, "Was sich überhaupt sagen läßt, läßt sich klar sagen," although inspiring is unfortunately false; for the maxim he bases on it I would propose a more modest one: not "Wovon man nicht reden kann, darüber muß man schweigen," but "Wovon man nichts beleuchtendes zu sagen findet, darber schweige man lieber!"*

criticism of the Logical Empiricist view (axioms)
and of the semantic view (model theory)

The second principal manifestation lies in the way we treat the efforts of our forebears and contemporaries: namely, we often discuss their work less in the hope of drawing instructive insight from it than as a source of doctrines to analyze, contrast, elaborate, or destroy—in any case, to serve as material for the further exercise of technique. [p. 1]

“drawing instructive insight from”: *learning*

In the first place, what I have described can be characterized rather precisely as a species of scholasticism—which is about as far as may be imagined from what the advocates of a new spirit of philosophy intended to stimulate. In so far as the word "scholasticism," in its application to medieval thought, has a pejorative connotation, it refers to a tendency to develop sterile technicalities—characterized by ingenuity out of relation to fruitfulness; and to a tradition burdened by a large set of standard counterposed doctrines, with stores of arguments and counterarguments. In such a tradition, philosophical discussion becomes something like a series of games of chess, in which moves are largely drawn from a familiar repertoire, with occasional strokes of originality—whose effect is to increase the repertoire of known plays. [p. 2]

Stein's response

I want to use this occasion to make some remarks of a rather general kind about the character of our knowledge in physics. I do this with some diffidence: I run the risk that what I shall say may seem—may indeed be—largely platitudinous. But there are some points that seem to me important, even if obvious; and also seem, even if obvious, to be not widely recognized, or not held firmly in view, in current philosophical discussion. . . . [L]et me . . . hazard a rough diagnosis of the reason why some things that are (in my view) true, important, and obvious tend to get lost sight of in our discussions. I think "lost sight of" is the right phrase: it is a matter of perspective, of directions of looking and lines of sight. [p .1]

The first serious platitude I want to present is this: If Wittgenstein's early standard of clarity is impossible to meet; if the hopes of the logical empiricists for a philosophy built up with the rigor and exactness of mathematics upon a basis that is—if not entirely secure epistemologically—at least entirely precise in both structure and content, have failed; and if nonetheless we do not wish to abandon the attempt to achieve such clarity as is possible, or wish to abstain from the use of rigorous techniques where they are fruitful, then there is an obvious rough distinction that we ought never to lose sight of in philosophical work: namely, what I shall just call the distinction between presystematic *and* systematic *considerations. [pp. 2–3, emphases his]*

presystematic and *systematic*, as we will see, pertain not only to philosophy as traditionally conceived, but also to the structure of scientific knowledge itself

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. . . (a) our knowledge in physics as an achieved result: knowledge as the knowledge we have of X; (b) our knowledge as susceptible of justification or defense—that is, as involving a structure of "evidence" for its asserted contents; and (c) knowledge—science—as (to appropriate a word of Isaac Levi's) an enterprise: an activity aimed at increasing our knowledge in sense (a), by means appropriate to the constraints of (b). [p. 3]

relation of kind of knowledge to structure and semantics of theories: semantics purports to encapsulate as well as to ground our expression and use of knowledge, and should do so for *all* senses of the term:

no current view of semantics
can handle all of them

focus on *learning*: if one wants to understand the structure and character of our knowledge, in all its forms, one of the deepest and most powerful clues we have is what we do and can learn, and how we do and can learn it, and what the distinction between a subject matter's being *teachable* and its being *learnable* can tell us about it (shades of the *Protagoras*)

instruct by example:

> *As a subject for philosophical commentary, this issue continues to present virtually limitless opportunities; and I have felt the temptation to expatiate on the matter here to some degree. But I ask myself, how much profit is now to be gained from such discussion? The matter has been very widely treated. One may hope to put a point more trenchantly than has been done before, perhaps even to find a new turn of argument; but hardly, by subtle technical analysis, to effect a real transformation of the subject. ¶ Instead of something subtle, I want to suggest something crude. [pp. 3–4]*

walk away from the chess tournament!
(some things can be learned only by watching and then trying to do)

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theoretical knowledge

In Carnap's Platonic myth of the three volumes of physics, consider what the first and second volumes might look like. I submit that there is no difficulty at all in envisaging the first. Carnap says that it is to contain "the basic physical laws, represented as a formal axiom system." I should not wish to insist on the notion of logical formality, which seems to me to have been overemphasized by the logical empiricists; so let me just substitute the phrase, "a mathematical system." . . . . The first volume is conceived simply as having the form of a treatise on theoretical physics. There are many such treatises in existence, some of them very good indeed; and it is even possible to learn branches of theoretical physics by reading them.

The book [Weyl's Raum-Zeit-Materie*] was a triple revelation for me: it put the physical principles of the special and general theories of relativity—and also, as a preliminary, those of Maxwellian electrodynamics—in what seemed to me an astonishingly clear light; it opened my eyes to a new perspective on mathematics; and, in the process. . . , it altered my conception of what the philosophy of physics could be. . . . a book that reasonably resembles Carnap's ideal first volume (of course restricted to a more modest scope), and that succeeds not only as a systematic formulation but even as a pedagogical instrument. [p. 4]*

the many inextricable aspects of understanding knowledge as achieved state:

1. grasping the principles of the theory
2. seeing the possible roles of mathematics
3. understanding fruitful ways one can investigate the foundations of the theory

the structure of the theory in this aspect:

1. the principles of the theory
2. the way the mathematics represents them
3. the foundations of the theory (compare Friedman's ideas on the role of philosophical meta-frameworks)

Carnap says the "phenomenal-physical dictionary" [his second Platonic volume] contains is to make it possible to derive, from the data in the third and the laws in the first, "the qualities . . . which are observable at any position in space and time." But nothing remotely like this exists, for however restricted a domain of physics. . . . [F]or now I should like to consider a less demanding alternative to that dictionary: granted that it is possible to learn the principles of parts of theoretical physics from books in which those principles are presented in a systematic mathematical framework, is it analogously possible to learn corresponding parts of experimental physics? My own experience has been that it is at the least very much harder. My belief is that it is, in practice today (that is, with the help of the existing literature), very nearly impossible: I have never found a single book on experimental physics comparably instructive with those I have found on physical theory. My suspicion is that it may be impossible even in principle. [p. 4]

It is hard, but possible, to learn theory by self-study from books; it is surely much harder to learn experimental techniques without a teacher to help one acquire skills; but what I suspect to be impossible is to learn the principles of experiment without actual *experience with the relevant* instruments. *[pp. 4–5, emphases his]*

. . . I think too that there was a fundamental bar to success along any of the routes Carnap essayed. For he always assumed that "the observation language" is more restricted than, and included in, a total *language that* includes an observational part and a theoretical part, connected by deductive logical relations*. And this, I think—I do not say by virtue of some basic principle I can identify, but simply, at the present time,* de facto*—is not the case: there is no department of fundamental physics in which it is possible, in the strict sense, to* deduce *observations, or observable facts, from data and theory. So I suggest that the principal difficulty is not that of how to leave the theory outside the laboratory door, but that of how to get the laboratory inside the theory. [p. 5, emphases his]*

Well, how do *we do it? For of course we do put theory and experiment in relation to one another; otherwise it would be impossible to test theories, and impossible to apply them. It would also, I should add, be impossible to* understand *a theory, as anything but a purely mathematical structure—impossible, that is, to understand a theory* as *a theory of physics—if we had no systematic way to put the theory into connection with observation (or experience). [p. 5, emphases his]*

This is why understanding the way theory and experiment make fruitful contact and even intermingle with each other is the fundamental problem of semantics: the kinds of knowledge the two respectively embody are of fundamentally different characters, as shown by the radically different ways in which we can, even in principle, come to learn them: theoretical physics one can learn by reading a book (a "formalized system"); experimental one can learn only by doing—thus the need for a pragmatic approach to semantics. And this is why overly formalized contemporary approaches that do not acknowledge, much less address, the issue cannot give a semantics of a theory as a theory of physics. One cannot articulate a theory in a formal system that will fit in a philosophy paper—one needs an entire book to do it!

So it might be asked of me—and I did in fact ask of myself—how I succeeded in learning any physics *from Weyl's book. The short and simple answer is that Weyl first of all connects his exposition of the new theories he expounds with older physical theories I already knew something of, and secondly describes—I shall say "schematically," and return to comment on this word later—a few experiments that bear critically upon the theories he is developing. But that reply is not very instructive, without some indication of (a) how this is done at all, in view of the difficulties I have claimed lie in the way of drawing logical inferences between theoretical statements and observational ones, and (b) how—or to what extent—it suffices to establish "physical understanding" (Kantian* Inhalt*) for a theory. [p. 6, emphases his]*

what a theory is

a mathematical structure discernible in the world of phenomena, of observations, of experience [p. 6, emphases his]

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centrality of method

Newton tells us in the preface to the Principia that he is proposing in it a certain "method of philosophy" (that is, of natural philosophy: of physics). This method consists in investigating the phenomena of nature—in particular, of motions—with a view to determining what Newton refers to both as "the forces of nature," and "the natural powers"; and it involves the working hypothesis that all natural phenomena result from the action of such forces. [p. 6]

theoretical part "the working hypothesis that all natural phenomena result from the action of [forces of nature]": articulated in the first two "mathematical" books

experimental part "investigating the phenomena of nature—in particular, of motions": exemplified and displayed in the third book

(again, a *book* as the exemplar of a theory)

thus, a fourth "part" of theory,
relevant to knowledge as enterprise:
method

arriving at method

As I see it (judging both from the actual sequence of propositions and arguments in the Principia, and from the evidence of the circumstances surrounding the development of the work), Newton asked himself two interrelated—perhaps not clearly distinguished—questions: [(a) causes of gravity? (b) which bodies participate?] ¶ It is at this point, I should argue, that the new method of philosophy was born. [p. 9]

method from:

1. requirements of the foundations (causes of gravity?)
2. constraints of the principles (which bodies participate?)

inextricability of different parts of theory—they emerge and function together, not necessarily cleanly separable (the questions were "perhaps not clearly distinguished" for Newton)

Cf. also:

> *To complete the account requires a new concept, which carries its own—"extra-systematic" if not presystematic—marginal gloss: namely, the concept of what Newton calls a "force of nature." . . . But the forces of nature are to be known through* general laws *of nature (as Newton says, an example of this is given in the third Book of the* Principia*—the first example of the kind ever discovered, the "invention" and "proof" of which, I am suggesting, is what motivated Newton to elaborate this conceptual framework itself). And these laws—the search for them is the proposed "method of philosophy"— are to take the form of* laws of interaction *between* pairs *of bodies, in which each body enters symmetrically in the sense of the third law. [p. 12]*

I have described the theoretical framework—corresponding, as I put it, to Carnap's "first volume"—and have provided an extra-systematic commentary on the development, the motivation, and thus in a certain sense the intended "meaning," of this abstract theoretical structure (which itself is constituted by certain spaces and certain mappings or functions). [p. 12]

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This is not to say that the gravitational principle is established by the argument I have outlined; only that it is found "invented," as the seventeenth century would say—by that argument. [p. 10]

still need to hook it up systematically to evidence *beyond* what was used in developing it

"Was Carnap Entirely Wrong, After All?" [p. 290]

> *. . . we have no language at all in which there are well-defined logical relations between a theoretical part that incorporates fundamental physics and any observational part at all—no framework for physics that includes observational terms, whether theory-laden or not. . . . I cannot think of any case in which one can honestly deduce what might honestly be called an observation. What can be done, rather, is to represent . . . "schematically," within the mathematical structure of a theoretically characterized situation, the position of a "schematic observer," and infer something about the observations such an observer would have.*

schematic representation of the observer

Let me underscore the point that there can be no thought of deducing observations *within that framework. To do so in the strict sense, one would need to have a physical theory of the actual observer, and to incorporate it into the Newtonian framework. I certainly do not want to say that there is a reason "in principle" why such a thing can* never *be done, for* any *possible (future) physical framework; but everyone knows that Newton could not do it, and that we—in the best versions of our own physics—cannot do it. . . . [p. 14, emphases his]*

[cont.]

> *In actual fact, the experimental physics is treated separately as a discipline in its own right, that is partly an art: an affair of both knowledge and manipulative and perceptual skill. But the possibility of connecting this art with the theory is closely connected with a certain possibility* within *the mathematical structure that is the theoretical framework: using a word I have introduced earlier, the possibility of representing experiments, and of representing the observer, "schematically." . . . I want to speak (as it were conversely) of "schematizing the observer within the theory"; but the intention is analogous: to secure empirical content—content within experience—for an abstract structure. ¶ . . . [S]o far as the fundamental theory is concerned—or rather, so far as* mathematically defined structures and rigorous arguments *are demanded—the "schematic" representation of observers, experiments, and observations, is, I believe, as far as we know how to go. [p. 14, emphases his]*

Schematic representation of the observer captures the aspect of knowledge as being susceptible to verification and confirmation, as being "involved in a 'structure' of evidence". Thus, it must be incorporated in the structure and the semantics of the theory (*contra*, *e.g.*, van Fraassen).

. . . a special bearing of the crude account I have given upon the "structure" of our knowledge in the sense of epistemology*: it is the simple remark that our understanding of our own relation to the world is mediated by our ability to place ourselves, however "schematically," within our conception of the course of nature. [p. 17. emphases his]*

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The roughly sketched semantical theory of Plato, in Stein's "How Does Physics Bear upon Metaphysics; And Why Did Plato Hold That Philosophy Cannot Be Written Down?" (pp. 2–3)

> *There are, one reads [in the seventh Platonic letter], of anything that is, three requisites for knowledge; five things in all, then, counting the knowledge itself and its object—what is truly known. First there is a* word, *or* name, *or* noun*—for instance, 'circle'; second a* formula *or* definition, *composed of nouns and verbs—in the case at hand, "that in which the distance from extremity to center is everywhere equal" would be the [definition] of that whose name is* rotund *and* round *and* circle*; third is the* image*—here what is drawn and erased and turned on the lathe and destroyed. But none of these [images] is the circle that is the object of knowledge (a point that hardly needs to be amplified, whether on Plato's behalf or on that of mathematics itself).*

[cont.]

> Between *these first three and the veritable object of knowledge the writer inserts the fourth, which he now describes as "knowledge and intellectual grasp and true opinion concerning these things—which have to be posited as one further thing, existing not in sounds or shapes of bodies but in minds [or* souls*]." Thus the view is expressed that the whole apparatus of what we might call "object-semantics," involving both linguistic signs and ordinary things (Plato's "images"), cannot suffice to determine meaning and truth, without some essential involvement of the* language users *and their* conceptions and beliefs*. . .*

ibid., p. 25

> *Aristotle tells us (*Posterior Analytics I *9) that* it is hard to know whether one knows, *and (*Metaphysics I *2, 982b12, 983a12-21) that* philosophy begins in wonder, but ends in the contrary state. *Plato never wrote the hinted-at sequel to the* Theaetetus, Sophist, *and* Statesman, *to have been called the* Philosopher. *I have long cherished the fantasy, anachronistic though it be, that in that work Socrates, questioning Aristotle, would have led him to admit that it is impossible to know whether one knows, and that if wisdom is the contrary state to wonder, then philosophy never ends.*