# Critical Studies, Reviews, Notes

*[Editor's note: The first three reviews included here have direct relevance to the special focus section on Process Thought and Natural Science. Special thanks to Focus Editor Tim Eastman, to Review Editor Leemon McHenry, and to the reviewers]*

**SUNNY AUYANG, *How Is Quantum Field Theory Possible?* New York: Oxford University Press, 1995: 280 pages. [Reviewed by William Kallfelz, Department of Physics, Georgia Institute of Technology, Atlanta GA 30332]**

In this carefully presented work, Sunny Auyang provides a philosophical analysis of quantum field theory (QFT) that is explicitly Kantian, in method and scope. The title, for example, indicates to the reader that Auyang adopts Kant's method of transcendental deduction. Formally, transcendental deduction exhibits the following structure:

i. Given X.
ii. For X to be possible, the conditions p must be satisfied.
iii. Therefore p.

Therefore, for QFT to be possible, Auyang argues, a certain conceptual framework and structure must be posited and analyzed, namely, common sense. Auyang advocates an interpretation of QFT that both refines common sense and delimits its epistemic horizons. I briefly summarize the work, prior to commenting on her philosophy.

Auyang introduces her argument by specifying a logical distinction between the substantive *content* and the general, *categorical framework* of a theory. Thus, while quantum theory may alter our conceptions of "charge" and "mass," generally common concepts such as "object" and "relation," remain unchanged (12). As opposed to expressing the innate structure of "things," quantum theory describes things with their associated empirical characterizations. "Modern physical theories bring to relief our finitude and offer an understanding of the world in which we are appropriately integrated" (11).

Concise synopses of non-relativistic quantum mechanics, relativity, and symmetry are presented in the second and third chapters. The material is generally accessible for both the physically-minded philosopher and the philosophically-minded physicist. Fairly descriptive endnotes are also provided, and important subtleties are not overlooked. Paraphrasing Weyl, for instance, Auyang points out that for the physicist in the late nineteenth century, what proved to be of far greater significance was the geometric development of infinitesimal versus finite structures, rather than the discovery of non-Euclidean spaces (28).

The fourth chapter provides an equally lucid and concise summary of the salient theoretical principles undergirding contemporary QFT, in which the notions of matter and interaction fields are carefully elucidated. Most notably, Auyang presents a remarkably clear and elegant description of the Aharanov–Bohm effect, illustrating potentials and phase couplings (54–60).

Auyang's conceptual analysis of the parallels drawn between common sense and QFT is found in the fifth through the seventh chapters. The project comprises three major stages: deriving transcendental conditions for the *existence of objects, plurality of objects*, and *causal interaction*.



In the fifth chapter, a semantic correspondence between an object and a *field-event* $\varphi(x)$ is first established. Field-events $\varphi(x)$ represent an interactive structure, reminiscent of a more complex version of Whitehead's concept of *extensive connection*, wherein actual entities relate to one another. Thus objects, like actual entities, are by nature complex, relational, and innately autonomous. The field reference point x residing in a non-metric differentiable manifold M corresponds to the object's *identity (ding-an-sich)*, while the range values of $\varphi$ in a local frame correspond with the object's empirical conventions.

Our intuitions of a *plurality* of events are likewise seen to correspond with the "many-body" approach adopted in QFT's formalism. The reader is once again tempted to draw parallels with QFT and PR, as virtual particles are represented as *processes* in which fields couple (160), as proper time "aims" the system's evolution (155), etc. "Processual" themes seem especially prominent in the seventh chapter, since descriptions of groups of events represented in a parameterized curve (172) resemble the notion of *causal efficacy* (PR 168-170). The presuppositions of "enduring objects" implied in notions of time (180) relate to Whitehead's "eternal objects."

In short, there are enough concepts latent within QFT *alone* to suggest voluminous associations with process thought. But such a reading ignores the philosophical import of Auyang's work altogether. Nowhere is Whitehead mentioned. Hence, a more fruitful analysis entails examining some of the potentially serious hermeneutical shortcomings within Auyang's program, in the hopes that aspects of *Process and Reality* may provide the necessary elixirs. This suggests a dialogue between Kantian critical realism and Whiteheadian organic realism.

I begin with the most glaring issue: Kant's subjective sensationalism (PR 161). "The ultimate evidence of empirical knowledge is what we directly perceive at an instant" (90). The entire methodology of transcendental deduction arises from presentational immediacy, thus lending credence to the virtual cliché that applications or misapplications of Kant downgrade the necessary roles played by development and evolution within any context of justification. The cliché unfortunately displays some truth in Auyang's case, as the entire work may present itself to the reader as somewhat of an unnecessarily rigid conceptual structure.

The work begins, for example, by stating that QFT "is our most fundamental physical theory" (3). Certainly QFT's quantitative predictions are astoundingly accurate. But a theory's predictive accuracy alone obviously does not necessitate any *fundamental* quality. For example, Ptolemy's epicycles can be treated as a Fourier series, expandable to arbitrary accuracy. Aside from positing a continuum as a basic structure, with all its associated singularities and non-physical divergences, Wigner and Inonu showed that all field theories cannot be fundamental: after contraction, their group elements contain non-semi-simple matrix representations [3]. This is a mathematical way of stating that all variables defined as physical objects do not mutually and symmetrically transform into one another. Hence, among other reasons, a significant number of researchers view QFT and the Standard Model as valuable in a *provisional* sense, suggesting *heuristic* guidelines for the development of more fundamental theories ([1], [2]).

Auyang's conclusions seem fraught with excessive conceptual reification, "misplaced concreteness." For example, in the final chapter she states that renormalization delimits conceptual boundaries to the common sense engagement with the world. Yet "renormalization"

is a method most researchers would agree is at best somewhat of an ad-hoc mathematical trick, hardly qualifying it as any kind of "limitation theorem" on the powers of common sense [2]. Such "misplaced concreteness" likewise seems to appear as well in her remarks on non-relativistic quantum theory. "[T]here is yet no evidence that [quantum mechanics] applies to classical systems" (17). "It appears that the world requires two general classes of predicates, quantum and classical, for description. Why it is so no mortal can answer" (80). Classical descriptions, however, are *statistical condensations* of underlying quantum mechanical processes, as revealed in Ehrenfest's Theorems. This does not suggest any clash of ontologies.

Auyang reifies a particular categorical framework that causes her to conflate all phenomenal interpretations of quantum theory with positivism, "anti-realism," conventionalism (12, 73, 108, 236). This proves especially unfortunate, since she overlooks the *epistemological* similarities shared by object theories and certain phenomenal approaches. Much of Neils Bohr's philosophy, for example, involves descriptions comprising the external system of the observer's representations and conventions, in addition to the system, or "thing." It remains unclear, and perhaps unrepresentative, to typecast immediately Bohr and Heisenberg as denying the objective reality of the microscopic world (229, note 3). Bohr and Heisenberg's operational and modal characterizations of observations likewise imply Auyang's "objective" approach. However, their interpretations certainly harbor a less restrictive *ontology* than Auyang's Kantian approach.

Auyang, furthermore, misconstrues Bohr's "claim to *finality* of quantum mechanics" (244, note 127) by overlooking the obvious issue of conceptual evolution and theory-change. From an evolutionary perspective as advocated in *Process and Reality*, Bohr's position could also be understood as provisionally accepting quantum theory in an epistemically monist sense, certainly a necessary stage in the evolution of any body of knowledge. Thus, an evolutionary ontology implied for instance in organic realism would accommodate a larger gene pool of interpretations of quantum theory without sacrificing any of the intellectual rigor inherent in transcendental deduction.

***References:*** [1] David Finkelstein, *Quantum Relativity* (Springer: NY, 1996); [2] Lewis Ryder, *Quantum Field Theory* (Cambridge: Cambridge University Press, 1985); [3] E. Inonu and E.P. Wigner, "On the Contraction of Groups and their Representations," *Proceedings of the National Academy of Sciences* 39 (1952), 510–525.

**LAWRENCE W. FAGG, *The Becoming of Time*. Atlanta, GA: Scholars Press, 1995: 281 pages. [Reviewed by Robert J. Valenza, Department of Mathematics, Claremont McKenna College, Claremont CA 91711]**

The goal of this book, as explained more precisely below, is a dual explication of time, and the means, whatever the ultimate success, are remarkable. Fagg conscientiously tries to draw together the more mutually repellent elements of both physics and religion. The discussions drawn from the former discipline are replete with pedagogic savvy and thus entirely comprehensible. While the religious discussions are perhaps somewhat less synthetic and more programmatic—but Fagg is by profession a physicist—they are nonetheless of panoramic scope and earnestly informative. For reasons that will soon begin to emerge, this book should be of great interest to almost all Whitehead scholars. But first allow me one reluctant observation.



To make a metaphor of its structure, *The Becoming of Time* resembles a barbell of the low-tech gymnasiums of days past: technically the *center* of gravity lies in the middle of the connecting rod, but this is hardly where the weight is. Similarly, in *The Becoming of Time* the dominant masses of physics and religion to either side are connected by a slender rod of philosophy, and the philosophy, while it stands in the midst of things, is not where the action is. For instance, Fagg says: "Via an intricate system of interactions the brain presents the mind with a total picture, an integrated evaluation. While the brain exists in three-dimensional space as well as in time, the mind results from an exquisitely complex interaction of various parts of the brain and is not localized in any one of them" (150). Whether one interprets these sentences as classical Cartesianism or twentieth-century identity theory, this is a big claim that goes undefended in light of, say, eliminative materialism. My point here is neither to refute nor to reproach, but simply to remark that this book is not seen in best light as a philosophical treatise.

*The Becoming of Time* proceeds in five parts, each one of which encompasses from two to six chapters. The first part introduces the basic subjective-objective duality as it relates to time and sketches a few philosophical developments, organized historically. Here, too, Fagg sets forth the goal of the whole book, which must be understood with some precision. Fagg does *not* seek to give some sort of essentialist definition or characterization of time, although he certainly entertains many conjectural characterizations, but rather to identify and to juxtapose key features of science and religion "in seeking ultimately a unified view of time" (12). His methodology, then, is a kind of forced rapprochement of *Naturwissenschaften* and *Geisteswissenschaften*, which has a clear affinity with the spirit of Whiteheadian metaphysics. This affinity is not lost on the author, and thus already in Chapter 2 we get an explicit summary of process metaphysics and its relevance to the reconciliation of the objective and subjective notions of time (23–25). While this does include some mention of Whitehead's hypothesis of the atomicity of time, Fagg, in keeping with his overall plan, does not seize and expound upon this technical aspect as he might were his goal to define rather than to unify.

Part II is largely a technical exposition of what Fagg aptly calls "our cosmic cocoon." Here we learn in Chapters 3–5 how the theory of relativity fundamentally limits what is physically observable in our universe (hence the term cocoon) and the basic principles of quantum and electromagnetic theory. Chapter 6 balances this science diet with a serving of religion, necessary because "mathematically based physical theories ... furnish only a 'map' of the universe's 'terrain.' Although the map is continuously being made more accurate, it cannot fully describe the 'terrain,' the underlying reality, which the religions address intuitively and spiritually, thus serving to complement the scientific picture" (90). Accordingly we learn something of the Hindu, Buddhist, Taoist, and Judeo-Christian traditions, about the cyclic and linear elements of these traditions, and, most particularly, about the relationship between time and salvation.

The longest unit of the book is Part III (Chapters 7–12), an examination of the nature of time—but again without any essentialist presumptions or conclusions. The component issues include the relation of time and motion, the gauges of time, the nature of the moment, eternity, and the beginning and the end of time. Each of these subtopics is like a separate landscape illuminated by the twin suns of science and religion. Viewed from afar, the