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Axioms as Principles: The Case of Quantum Field Theory

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Physical principles separate the physical from the unphysical. They come in various forms and functions. The naturalness principle, for instance, is primarily a heuristic for model builders in present day elementary particle physics whose specific form and validity has been broadly debated recently. In some cases, such as Mach' s principle, debates last forever and extend into genuinely epistemological domains. Other principles, among them general covariance, the gauge principle, or quantum locality, are deeply ingrained into the formal structure of the respective theories. Debates about their meanings combine formal and philosophical arguments. This is especially the case if those theories can be given an axiomatic foundation, such that the traditional Carnapian methods of philosophy of science as logical analysis of conceptual frameworks can take hold. While doing so follows in the footsteps of the modern understanding of axiomatic developed by the Hilbert school, the concrete execution of Hilbert's Sixth Problem, the axiomatization of physics after the model of geometry, has often been less pure than present-day philosophers assume. In my talk, I discuss Hilbert's own axiomatization of relativity theory, von Neumann's larger program of the axiomatization of quantum theory, and the early phase of axiomatic approaches in the late 1950s and early 1960s. It will turn out that such axiomatizations are often guided by broader physical and philosophical intuitions, are sometimes more opportunistic than foundational, and strongly influenced by the availability of suitable mathematical theories.

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