

# **What is quantum field theory, technologically, mathematically, and philosophically?**

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In the wake of the introduction of quantum mechanics in 1925, Niels Bohr spoke of the “mathematical instruments” of higher algebra as playing an essential part in the new theory. The expression “mathematical instruments” was not merely a convenient metaphor. Bohr saw quantum mechanics as a mathematical technique or technology for predicting, in probabilistic terms, the outcomes of quantum experiments, rather than for describing quantum objects and processes, in the way classical mechanics would. Accordingly, Bohr also spoke of a new type of relationships between mathematics and mechanics, and mathematics and nature, established by Heisenberg’s theory. By the same token, a new philosophy of physics was also at stake.

Taking Bohr’s argument as point of departure, this paper argues that the situation takes an even more radical form in quantum field theory and the experimental physics in the corresponding energy regimes. Just as in the case of low-energy regimes, treated by quantum mechanics, the practice of experimental physics in (high-energy) regimes treated by quantum field theory, no longer consists in tracking what already happened in nature, but in creating new configurations of experimental technology in which new phenomena are observed. The practice of theoretical physics no longer consists of offering a mathematical description of the ultimate constitution and workings of nature. It consists of establishing the relationships, necessarily probabilistic in character, between two “technologies:” the “mathematical instruments,” comprising the formalism, and measuring instruments involved. Quantum field theory, however, is characterized by a much greater complexity than quantum mechanics. This complexity arises in view of the following three, correlative, circumstances: (1) a more complex nature and handling of the mathematical formalism of the theory (reflected in part in the necessity of renormalization); (2) more complex configurations of phenomena observed and hence measuring apparatuses involved; and (3) a more complex character of the quantum-field-theoretical predictions and, hence, of the relationships between mathematical and measuring instruments involved in high-energy physics. The aim of present paper is to explore this greater complexity of quantum field theory, under the epistemological conditions that it shares with quantum mechanics. As all technologies, the technologies, mathematical and properly technological, of quantum field theory can, and even one day must, become obsolete. This, however, is a good thing, because, since nature is never obsolete, we will be compelled to invent new mathematical and experimental technologies, new configurations of measuring instruments. In quantum physics, from quantum mechanics to quantum field theory and beyond, we experiment both with nature and (by inventing new mathematics of quantum theory) with mind.