Box 18

Einstein-Born Dispute

The 2,500-year-old fight between the method of the science of *Sphaerics* and the Aristotelean fraud represented by Euclidean geometry, is reflected during the Twentieth Century in the fight between Albert Einstein, Max Planck et al., and the culturally pessimistic irrationalism typified by Niels Bohr's so-called Copenhagen interpretation of quantum phenomena.

This fight has its immediate origin at the end of the Nineteenth Century, when scientists were confronting a growing body of experimental evidence, such as the photoelectric effect and Planck's discovery of the quantization of light and heat, which indicated that the characteristics of physical action in the microscopic domain are fundamentally different from the macroscopic domain of everyday experience. These experimental discoveries were consistent with the earlier work of Carl Gauss, Augustin Fresnel, Bernhard Riemann, Wilhelm Weber, et al., who, having extended G.W. Leibniz's method of the infinitesimal calculus, had begun the investigation of the characteristics of microscopic principles from their experimentally observed macroscopic effects. These Leibnizians understood that the characteristics of the very small, reflected *universal* principles, and thus, can only be considered with respect to the universe as a whole.

These investigations of Gauss, et al. had led Riemann, in his habilitation dissertation of 1854, to insist that it was scientifically unsound to assume that the characteristics of physical action observed in the macroscopic domain could be linearly extended into the very large and very small. Instead, Riemann insisted, science must develop a dynamic notion of physical geometry that reflected the potential for non-linear change between these domains of action.

As Riemann stated: "Knowledge of the causal connection of phenomena is based essentially upon the precision with which we follow them down into the infinitely small. . . . In the natural sciences, however, where simple fundamental concepts are still lacking for such syntheses, one pursues phenomenon into the spatially small, in order to perceive causal connections, just as far as the microscope permits. Questions concerning spatial relations of measure in the indefinitely small are therefore not useless."

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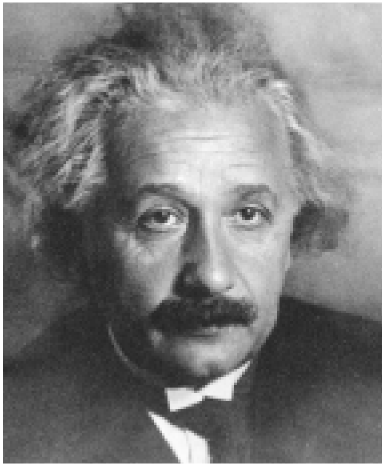
Carl F. Gauss (1777-1855). His 1799 attack on reductionism reflected the ancient quarrel between the followers of Plato and of Aristotle.

In reaction to Riemann, the British-centered empiricists desperately tried to revive the Aristotelean methods of Kant and Euclid, typified by the work of James Clerk Maxwell, who famously rejected Riemann's approach to physics, in favor of the neo-Euclidean doctrine which excluded "any geometries other than our own." Thus, when the relationship between the observed macroscopic effects of electromagnetism were considered in light of the growing body of experimental evidence indicating a



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Albert Einstein (1879-1955). His notion of a "finite but unbounded universe," approximated a Riemannian conception of a finitely self-bounded universe.

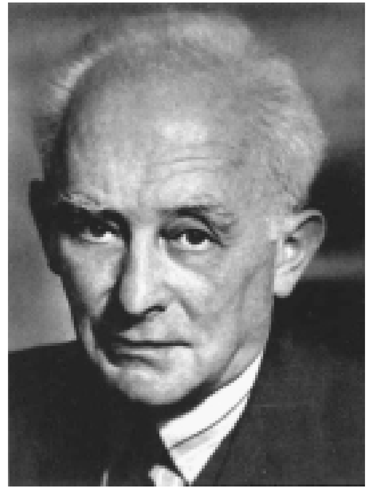
change in physical characteristic in the microscopic domain, Riemann's guidance proved to be essential.

Statistical Methods Creep In

In confronting the paradoxes presented by the experimental evidence of quantum phenomena, Einstein, Planck, and their collaborators, relied on Riemann's guidance. However, among Einstein's contemporaries, it became increasingly popular to avoid a confrontation with the assumptions of Euclideanism, by "explaining" these quantum phenomena by statistical methods, similar to those used by Ptolemy, Copernicus, and Brahe. These efforts were led by Niels Bohr, his protégé Werner Heisenberg, and Heisenberg's first teacher, Max Born.

Born had been an early collaborator of Einstein, developing some of the earliest elaborations of Einstein's special theory of relativity. In 1912, he joined Einstein and Planck at the University of Berlin, where he developed a close friendship with both. But, in 1921, Born returned to Göttingen University, where he began work on statistical mechanics. In 1926, in collaboration with his students Werner Heisenberg and Wolfgang Pauli, Born formulated a statistical approach to physics using matrix algebra, which he called "quantum mechanics."

Born's quantum mechanics was a mathematical formulation of Bohr's interpretation of quantum phenomena, which depended on considering quantum phenomena as isolated from the universe as a whole. So isolated, the quantum effects appeared to be erratic, and were not susceptible to being described by a simple mathematical expression. As such, Born, Bohr, Heisenberg, et al., relied on statistical probability matrices to describe quantum phenomena as the most probable result of a fundamentally random interaction, occurring in an empty,



Max Born (1882-1970) was an early collaborator of Einstein, but sank into the swamp of "qunatum mechanics."

Euclidean-type space. Born went still further, declaring that his matrix algebra was not merely a compromise attempt to describe the observed effects, but that it was an accurate reflection of the nature of the physical universe itself.

However, this so-called Copenhagen interpretation of quantum phenomena was not a serious scientific concept. Like Ptolemy's earlier sophistical attack on the Greek science of *Sphaerics,* the Copenhagen interpretation was an oligarchical-led attack on the method of

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Leibniz, Gauss, Riemann, et al., driven by the cultural pessimism that had come to prevail at the turn of the century. Like their predecessor Ptolemy, Bohr, Heisenberg, Born, et al., argued that since no mathematical formulas other than statistical methods had been found to describe physical phenomena, no physical principles existed other than their statistical formalism. Because no principles existed, none could be discovered.

Einstein stubbornly resisted this descent into irrationality, and along with Planck, vociferously defended causality in science throughout his life. However, Born, although initially an ally of Einstein and Planck, succumbed to the cultural pessimism that spread throughout Europe in the wake of World War I, and his earlier collaborative relationship with Einstein turned into an intellectually adversarial one. Nevertheless, the two men continued to exchange letters until Einstein's death in 1955. That exchange of letters provides a clear insight into these two opposing views of science.

Born summarized his view of the dispute in the published collection of his correspondence with Einstein:

"The basic reason for the dispute between us on the validity of statistical laws was as follows. Einstein was firmly convinced that physics can supply us with knowledge of the objectively existing world. Together with many other physicists I have been gradually converted, as a result of experiences in the field of atomic quantum phenomena, to the point of view that this is not so. At any given moment, our knowledge of the objective world is only a crude approximation from which, by applying certain rules such as the probability laws of quantum mechanics, we can predict unknown (e.g. future) conditions."

In September 1926, after reviewing Born's statistical work on quantum mechanics, Einstein stated his view clearly in a letter to Born:

"Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the 'old one.' I, at any rate, am convinced that *He* is not playing at dice. Waves in 3-dimensional space, whose velocity is regulated by potential energy (for example, rubber bands) . . . I am working very hard at deducing the equations of motion of material points regarded as singularities, given the differential equation of general relativity."

God Doesn't Play Dice

Writing to Born years later, in September 1944, Einstein summed up the view he had continued to express:

"We have become Antipodean in our scientific expectations. You believe in the God who plays dice, and I in complete law and order in a world which objectively exists, and which I, in a wildly speculative way am trying to capture. I firmly *believe*, but I hope that someone will discover a more realistic way, or rather a more tangible basis than it has been my lot to find. Even the great initial success of the quantum theory does not make me believe in the fundamental dice-game, although I am well aware that our younger colleagues interpret this as a consequence of senility. No doubt the day will come when we will see whose instinctive attitude was the correct one."

In September 1950, after his association with Kurt Gödel had improved his historical and epistemological knowledge, Einstein wrote Born, saying:

"I see from the last paragraph of your letter that you, too, take the quantum theoretical description as incomplete (referring to an ensemble). But you are after all convinced that no (complete) laws exist for a complete description, according to the positivistic maxim *esse est percipi*. Well, this is a programmatic attitude, not knowledge. This is where our attitudes really differ. For the time being, I am alone in my views as Leibniz was with respect to the absolute space of Newton's theory. There now, I've paraded my old hobby-horse once again. But it is your own fault, because you provoked me."

—*Bruce Director*