Out of Einstein's Earlier Years: The 'Swiss Years' Correspondence

The Collected Papers of Albert Einstein, Vol. 5: The Swiss Years Writings, 1902–1914

Anna Beck, English translation
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Reviewed by Mendel Sachs

This English-language version of *The Swiss Years Writings* is a translation of the original fifth volume of *The Collected Papers of Albert Einstein*, edited by Martin J. Klein, A. J. Kox and Robert Schulmann (Princeton, 1993). It is an important contribution to the literature on the history of 20th-century physics, for physicists and historians of science alike.

The "Swiss years," 1902 to 1914, were seminal to Einstein's contributions to the early quantum theory and the theory of relativity. In this body of correspondence we see an unfolding of much of Einstein's thought process, his wavering back and forth on ideas before taking a firm hold. Some of the most important physicist–recipients (most letters in the volume are from Einstein) were: Michele Besso, Paul Ehrenfest, Erwin Freundlich, Willem Julius, George Hale, Jakob Laub, Max von Laue, Hendrik Lorentz, Ernst Mach, Max Planck, Arnold Sommerfeld, Wilhelm Wien and Heinrich Zangger. The letters span the periods from Einstein's employment at the patent office in Bern to his academic appointment at the German University in Prague to his move to the Polytechnic Institute in Zurich. The last letters in this volume just precede Einstein's appointment at the Prussian Academy of Sciences in Berlin.

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In addition to the letters dealing primarily with problems of physics, there are others that reveal Einstein's human side—those about his own and others' new appointments and his opinions of fellow physicists, a few letters to and from his first wife, Mileva, and more to his friend, cousin and soon-to-become second wife, Elsa Löwenthal. Also on the personal level, religious attitudes and the impacts of anti-semitism on his career are revealed. For example, after an exchange of letters with Sommerfeld, whom he respected most highly, Sommerfeld says in a letter to Lorentz: "Einstein's work contains an unhealthy dogmatism and expressing the abstract-conceptual manner of the Semite." (This is to be found in a footnote in the original, untranslated version of the book—footnote 1, document 73, 26 December, 1907.) This did not affect Lorentz's respect for Einstein; a few years later he offered his chair at the University of Leiden to Einstein, who professed to feel, among other things, too humble to accept (see documents 359 and 360).

The primary technical discussions in these letters concern Einstein's work with the quantum theory of electromagnetic radiation and the theory of relativity (mainly having to do with general relativity). It is interesting to see that neither Einstein nor Planck accepted the photon concept—a localized particle of light—as a "thing in itself." Rather, they saw the emission and absorption of quantized radiation as a manifestation of interacting matter. In a letter to Einstein (document 47, 6 July 1907) Planck says: "For I do not seek the meaning of the quantum of action (light quantum) in the vacuum, but at its sites of absorption and emission." In a letter to Laub (document 231, 4 November 1910), Einstein says: "I am very hopeful that I will solve the radiation problem and that I will do so without light quanta. . . . I no longer believe (at the present) in spatial light quanta." In a letter to Lorentz (document 250, 27 January 1911), Einstein says: "I am not the orthodox light quantizer for whom you take me; that [mistaken belief] might come from my imprecise way of expressing myself in my papers." In a letter to Zangger (document 398, 20 May 1912), Einstein says: "The more successes the quantum theory enjoys the more stupid it looks. How the nonphysicists would ridicule it if they could follow its curious course of development."

On the theory of relativity, Einstein's correspondence has mainly to do with the experimental and theoretical aspects of general relativity and its relation to gravity. There are many letters to Freundlich, who was concerned with an experimental determination of the bending of starlight in the vicinity of the Sun. On the gravitational redshift, Einstein had an exchange with Julius (document 288, 22 September 1911), who believed the apparent effect to be due to dispersion of solar absorption lines and not to gravitation. (The gravitational redshift was not settled conclusively until four years after Einstein's death, in the work of Robert V. Pound and his collaborators.)

Regarding the theoretical aspects of general relativity, Einstein was continually plagued with having failed to develop a dynamical theory from his formalism. In a letter to Lorentz (document 467, 14 August 1913), Einstein says: "And now to gravitation . . . there are still such major snags in the thing that my confidence in the admissibility of the theory is still shaky. . . . The gravitational field ($g_{\mu\nu}$) seems to be the skeleton . . . on which everything hangs. But unfortunately, the gravitation equations themselves do not possess the property of general covariance." In a letter to Ehrenfest (document 484, November 1913), Einstein says: "An unambiguous determination of the $g_{\mu\nu}$ from the $T_{\mu\nu}$ is only possible if special coordinate systems are chosen." In my opinion, the stumbling block here is in Einstein's holding onto the classical—Newtonian—view of $T_{\mu\nu}$, as representing the energy–momentum tensor for a distribution of discrete masses, thereby establishing a preferred coordinate system—that of the configuration of all of these masses, each in its own space-time. However, in his later years Einstein saw the necessity of going fully to the field concept, wherein not only $g_{\mu\nu}$ but also $T_{\mu\nu}$

must be represented solely in terms of nonlocal fields that are nonsingular everywhere, with all mapped in the same space-time. In this way, both $g_{\mu\nu}$ and $T_{\mu\nu}$ are represented by "regular" fields, and the formalism of general relativity becomes fully covariant, characterized by nonlinear space-time transformations.

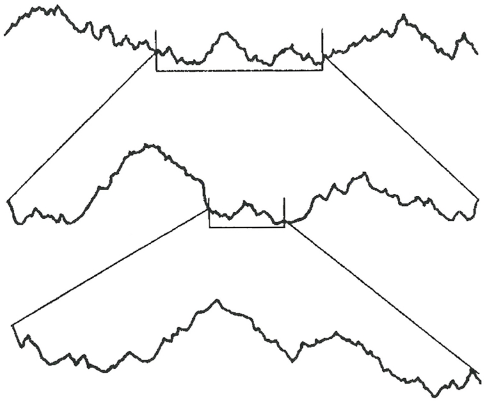
Summing up this book of correspondence, it is an excellent presentation of "Einstein the scientist" and "Einstein the man." I highly recommend it for all physicists and for historians and philosophers of physics. I have only two negative comments. First, there is a multitude of footnote references throughout the text but, as indicated above, the footnotes themselves were not included in this translated volume. These footnotes are given, in English, in the original version of the book. Second, there is no index for the book. These deficiencies are, nonetheless, far outweighed by the positive aspects of the book.

Fractal Physiology

J. B. Bassingthwaighte, L. S. Liebovitch and B. J. West
Oxford U. P., New York, 1994. 364 pp. $55.00 hc
ISBN 0-19-508013-0

Since the pioneering work of Hermann von Helmholtz, it has been the dream of many a physicist to make a significant contribution to physiology. Therefore, it is with some excitement that one opens *Fractal Physiology*—hoping that this relatively slim monograph might illuminate a path for statistical physicists to follow if they dream of uncovering some of the general physical principles that must certainly underlie even as complex a discipline as physiology.

But wait a minute! What have fractals to do with physiology? Quite a bit, one soon realizes, on reading *Fractal Physiology*. The book begins with an impressive list of biological systems that either are self-similar in space or time or are self-similar in a rather abstract sense that has nothing to do with the object itself, but rather has to do with some property of the object that is mapped onto a genuinely fractal object. An example of the latter category is shown in the accompanying figure. Here is shown the informational content of DNA—its sequence of base pairs—represented graphically, and it is the graphical representation, not the DNA itself, that is statistically self-similar.



A REPRESENTATION of the sequence of base pairs on noncoding DNA in which an "up" step corresponds to one type of base pair and a "down" step to another type. The statistical properties are the same at three different length scales, implying that this representation has useful scaling properties. (Courtesy of Sergey V. Buldyrev.)

After a short overview, which includes a brief section bearing the intriguing title "The Meaning of Fractals," the authors, J. B. Bassingthwaighte, L. S. Liebovitch and B. J. West, set out, in six well-organized chapters, the general principles of fractal science. This work nicely complements the somewhat more mathematical treatments found in the classic monographs by Jens Feder, *Fractals* (Plenum, 1988) and by Tamás Vicsek, *Fractal Growth Phenomena, second edition* (World Scientific, 1992), and it is more accessible than the widely quoted "essay" of Benoit Mandelbrot, *Fractal Geometry of Nature* (Freeman, 1982). Particularly welcome features are the careful distinction between fractals and chaos, two topics that are sometimes referred to as if they were synonymous, and the lovely description of fractal time concepts pioneered by Michael F. Shlesinger and his collaborators (PHYSICS TODAY, January 1991, page 26). Also well explained are practical procedures used to extract the various fractal parameters that characterize a given set of experimental data.

Fractal Physiology's final chapters deal with a potpourri of applications of fractal concepts to specific topics of interest in physiology. Some of these topics correspond to areas in which one or another of the authors has made major contributions. For example, there is an entire, self-contained chapter on the analysis of experimental data on the opening and closing of ion channels in membranes. Here fractal analysis is systematically compared to the more conventional Markovian models, and analogies are drawn to the dichotomy between Copernicus and Ptolomy.

Another quite readable chapter on fractals in nerves correctly notes that not one but rather many fractal dimensions will sometimes be required to distinguish among different physiological forms. And the concluding chapter concerns topics on which current research is just beginning, such as cardiovascular and neural networks and intraorgan flow heterogeneities.

By the end of this whirlwind tour, the reader may be left wondering, Are concepts of fractals no more than a way of quantifying complex data sets, be they spatial or temporal? Or could fractal concepts actually deepen our understanding of the physiological system itself? One cannot help but wonder if, perhaps, scale-free "fractal" features evolved in physiological structures because they confer some evolutionary advantage. Physiology is sometimes taught using metaphors akin to those of a Rube Goldberg machine: *A* changes *B* which changes *C* and so forth. Such a deterministic device is susceptible to errors at any stage. If building in redundancy by evolving scale-free structures can reduce the susceptibility to errors, could this account for the apparent ubiquity of scale-free phenomena in physiology?

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An Interpretive Introduction to Quantum Field Theory

Paul Teller
Princeton U. P., Princeton, N.J., 1995. 176 pp. $35.00 hc
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Physicists tend to view the philosophy of science with (healthy?) skepticism, if not outright disdain, and they regard the physics–philosophy connection as a bridge over which new ideas flow in one direction only (guess which), with little useful return. In earlier times, Niels Bohr and Werner Heisenberg eagerly acknowledged the influence of metaphysical learning on their theories, but few of us today think about our subject philosophically. Even in the resurgent discussions on the foundations of quantum mechanics, physicists have apparently found professional philosophy of limited help.

Although *An Interpretive Introduc-*