writing would probably annoy the more sophisticated reader. Yet it is the latter person who should read it, not the neophyte who could not appreciate the meaning of the book. There is also much that Gibson says with which I cannot agree. The brain does have processing functions. In this regard Gibson has overstated his case. Also, psychophysics may still be relevant, though its usefulness must hinge upon a set of assumptions different from those ascribed to it by Gibson. There are many conjectures in the book which need further support before they can be accepted. But it is this feature of the book that makes it most valuable. It is suggestive in a substantive sense, and it has novel insights into how one should view the problems of perception. This novelty is particularly valuable, for it succeeds in upsetting modes of thought which have become traditional over the past 150 years.

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The Development of Unified Field Theories

Einstein's Unified Field Theory. M. A. TONNELAT. Translated from the French edition (Paris, 1955) by Richard Akerib. Gordon and Breach, New York, 1966. 198 pp., illus. $10.

The special theory of relativity was developed by Einstein for the express purpose of bringing classical particle mechanics into conformity with Maxwell's theory of the electromagnetic field. Once this task was accomplished, it was natural for him to inquire whether the remaining known classical field, that of gravitation, could be expressed in a fashion consistent with the new relativistic mechanics. The well-known heuristic considerations based on the fundamental character of the principle of equivalence of gravitation and acceleration, or, equivalently, the equality of passive gravitational mass and inertial mass, led Einstein to revise both relativistic mechanics and Newtonian gravitation theory. The resulting General Theory of Relativity was able to incorporate the Maxwell theory with very minor and natural modifications. That stage of development having been obtained, there appeared to be no further logical necessity or even heuristic argument to require further revision or alteration of the truly imposing edifice which Einstein had constructed.

Nevertheless, Einstein felt an esthetic compulsion to unify in a much more intimate fashion the two known classical fields, much as Maxwell previously had unified the electric and the magnetic fields into a single geometric entity. Lacking any semblance of a heuristic guide, the attempts at unification of gravitation and electromagnetism necessarily became highly formal mathematical generalizations of the four-dimensional Riemannian geometry of General Relativity. A far from exhaustive enumeration of generalizations that have been considered by Einstein and others includes five-dimensional Riemannian geometries, conformal geometries, projective geometries, similarity geometries, spaces of distant parallelisms, Finsler spaces, nonsymmetric metrics, spaces with torsion, complex symmetric metrics, Hermitian metrics, and bitensor metrics. Because of the lack of any physical guiding principle, these formal generalizations rather typically suffered from an ambiguity in the interpretation of the symbols of the formalism. Not only did this multiplicity of possible generalizations, the ambiguity of interpretation, and the lack of any true necessity for a formal unification of gravitation and electromagnetism cause concern with unified field theories gradually to dwindle, but, much more significantly, two developments of contemporary physics ended virtually all interest in such theories. One of these developments was the discovery of nuclear forces, or, equivalently, meson fields, which made a mere unification of gravitation and electromagnetism of questionable interest. The other was the development of quantum theory, which undermined the role of a classical field theory as a fundamental building block of nature.

It is a testimony to the current lack of interest in unified field theories that despite the fact that the book under review is a translation of a text published more than a decade ago, no significant development in the intervening years has made the work the least bit dated. In this work Tonnelat has chosen to limit herself to spaces with nonsymmetric metrics and torsion, in view of the fact that it was precisely such theories that preoccupied Einstein in the last years of his life. Within this context, she has performed the very valuable service of organizing, as coherently and systematically as possible, a presentation of material by several authors which has been scattered throughout dozens of scientific journals. It is strikingly to the credit of this work that, contrary to the practice of most authors, no pretense is made of presenting anything approximating a completed theory or even an agreed-upon interpretation. In fact, where possible, ambiguities of interpretation are pointed out and discussed.

In view of the criticisms of unified field theories given above, the question naturally arises whether there is any value in pursuing the subject. Let us therefore enumerate several arguments in favor of such a pursuit: (i) the many generalizations enumerated above have proved to be an extraordinary fountainhead of ideas for purely mathematical investigations; (ii) the analysis of unfamiliar theories provides an excellent testing ground for new physical ideas; (iii) the methods developed for analyzing the generalized geometries of the unified theories can prove to be very useful and powerful when applied to General Relativity; and (iv) although they are at the moment out of fashion, one should surely tread with caution before discarding ideas which flowed from the intuition of one of the most extraordinary and fertile minds in the history of science. I am reminded of the uncanny intuition of Newton, who, despite his own discovery of "Newton's rings," continued to insist that light consisted of corpuscles. The anomaly of partial reflection of light by glass was effectively attributed to a breakdown of strict microscopic determinism—in Newton's words, the light corpuscles had fits!

In conclusion, I strongly recommend that every serious student familiar with Riemmanian geometry and General Relativity should have some exposure to various thoughts and works in unified field theories. Furthermore, I can think of no better, clearer, more comprehensive presentation of a particularly important version of unified field theory than that of Tonnelat. In providing a very clear and readable translation, Richard Akerib has performed a commendable service.

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