

## PREFACE TO THE SECOND EDITION

Einstein, with Kaluza and Klein, realized that extra dimensions can be used to unify the fields of physics, as well as unifying the fields with their material sources. In fact, it was Einstein's dream to transpose the "base wood" of the matter term in his field equations to the "marble" of the geometrical term. During his lifetime, this kind of unified theory achieved only partial success. But the modern approach, outlined in this book, is elegant and agrees with all of the classical tests.

Space, time and matter are physical concepts, with a long but somewhat subjective history. Tensor calculus and differential geometry are highly developed mathematical formalisms. Any theory which joins physics and algebra is perforce open to discussions about interpretation, and the one presented in this book leads to new issues concerning the nature of matter. The theory can be couched in any number of dimensions, and so can be related to 10D supersymmetry, 11D supergravity and higher-dimensional versions of string theory. However, 5D is the basic extension of Einstein's theory of gravity, and is believed to be the low-energy limit of higher-dimensional theories which pertain to particle physics. But the modern version of 5D relativity should not really be called Kaluza-Klein. It drops the hobbling "cylinder" condition introduced by Kaluza in 1921 in his attempt to unify gravity with electromagnetism. It also abandons the questionable condition of "compactification" introduced by Klein in 1926 in his extension of the theory to quantum mechanics. (Likewise, there is no

singular hypersurface as in membrane theory.) The result is a rich, fully covariant 5D algebra. The field equations in apparent 5D vacuum then split naturally into two parts. One part gives back the traditional field equations for 4D spacetime. The other part gives back a description of what we conventionally call matter. In this way, Einstein's dream of unifying the fields with their sources is realized.

This modern approach to 5D relativity dates essentially from 1992, when it was outlined by the author and rapidly taken up by a large number of workers. The contributions of some of these are included in this book. Acknowledgements are due (alphabetically) to A.P. Billyard, S. Chatterjee, A.A. Coley, T. Fukui, D. Kalligas, T. Liko, P. Lim, H. Liu, B. Mashhoon, J.M. Overduin, W.N. Sajko, J. Ponce de Leon, S.S. Seahra and R. Tavakol. Thanks are also due to C.W.F. Everitt, for an invitation to Stanford University where much of this book was written. The theory developed by these and other workers should not be confused with 4D general relativity, though its basis lies there. In the modern theory, there is no explicit energy-momentum tensor, and it is the geometrical terms which come from 5D which give back the matter terms. For this reason, it has frequently been called induced-matter theory. Alternatively, it has been referred to as space-time-matter theory.

The first edition of this book, using the above appellation, came out in 1999. It enjoyed a positive reception in the physics community, necessitating a second edition. This differs only modestly from the first, though typographical errors have been corrected and the text has been

completely reset. It should be mentioned in this regard that the author published another volume in 2006 called *Five-Dimensional Physics* (also with World Scientific). However, there is minimal overlap between the two books and their goals are somewhat different. The first covers all of modern theoretical physics, with an emphasis on concepts. The second deals with 5D, and its focus is embedding theorems. (Campbell's theorem ensures the validity of our approach from algebra, though the theory was originally developed from physics.) Thus, the volume in the reader's hands covers a diverse range of topics, with the aim of understanding what we mean by "matter".

Einstein's insights provide the basis for this book, insofar as it shows how to realize his vision of welding together the geometry of fields with their sources in matter. But the reader will discern another influence. Eddington's views on the nature of the physical world echo those of his contemporary, and it is therefore apt to dedicate this book to the memory of Sir Arthur Eddington.

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