Preface

The broad acceptance of the expansion of the universe as a physically real phenomenon has been rooted in part in the apparent lack of an alternative explanation of the redshift. Since its discovery more than a half-century ago, many new observational phenomena have been uncovered, of which quasars and microwave background radiation appear to be particularly fundamental and striking. Nevertheless, there seem to have been few attempts to rework the foundations of cosmology in a way that might tie these phenomena together in a scientifically more economical way. This is probably due more to the momentum of the theoretical studies based on the expansion theory than to its agreement with observation, which has been quite limited and increasingly equivocal.

In this book I present a new theory that is very different from the expansion theory, though equally rooted in the ideas of relativity going back to Einstein, Minkowski, Robb, Veblen, and others. The specific germinal point of the theory was the observation I made 25 years ago that a more natural operator to represent the physical energy than the conventional generator of temporal translation in Minkowski space was a certain generator of the conformal group that physically closely approximates the conventional energy. It has taken a long time to realize that the redness of the observed shift follows from a law of conservation of the new, essentially curved, energy, which necessarily involves a depletion in the old, essentially flat, energy, which is all that can locally be measured and directly observed.

This book is however not merely, or even basically, the presentation of a new model. It is in large part an attempt to lay rational foundations for cosmology on the basis of the most elementary types of causality and related symmetry considerations. It is extraordinary how incisive these qualitative desiderata turn out to be, when integrated with the modern theory of transformation groups. On the purely physical side, the key concepts of time and of its dual energy are given a new precision of definition and treatment that removes much apparent mystery and, in particular, partially mechanizes the murky but important matter of the correlation of mathematical with observational quantities. The title of my original abstract, *Covariant chronogeometry and extreme distances*, summarizes this natural philosophic standpoint, but a corresponding treatment of very small distances (i.e., elementary particles) will require much further exploration.

The new "chronometric" theory emerges in a unique way from this standpoint. It has been interesting to test it against virtually all available relevant astronomical data and to find that, despite its lack of adjustable parameters (other than the unit of distance), it is accepted, in the sense of the theory of statistical hypotheses, by all large or objectively defined samples of galaxies or quasars, indeed at notably high probability levels. In the cases of samples less amenable to rigorous statistical treatment, it typically provides a disdinctly better fit to the data than does the expansion theory, with its free parameter q_0, with one equivocal exception. From an overall scientific point of view, it has been reassuring to find that a fully rational approach to cosmology can lead to physical predictions that conform to observation, and that modern statistical theory is a vital aid in comparing theory with observation, rather than, as appears to be the outlook of some astronomers, an annoying hindrance.

One reason for the delay in promulgating the new theory was that initially one of its predictions appeared in flat contradiction with observation. It implied a square-law redshift–distance dependence for sufficiently small distances, whereas it was "well known" that the relation was observed to be linear. But the mathematical unicity and simplicity of the model, together with its immediate success in dealing with quasars, gave grounds for further exploration of the theory. It has been quite reassuring to find confirmation for the square law in a number of observational studies at moderate redshifts, and overwhelming evidence for a phenomenological square law in the case of low-redshift galaxies. (Of course, actual distances are not directly observable, but the implications of the respective laws for the relations between the redshift, number, apparent luminosity, and angular diameter of luminous objects may be compared with actual observations.) Hubble's original (1929) derivation of the linear law was based on 22 of the more than 700 galaxies included in the low-redshift analysis, and it now appears that the linear law was of a much more tentative character than has been generally realized. The later observations by his associates and successors must be seen in the context of a natural tendency to seek the validation and development of a previously indicated hypothesis, rather than to explore possible alternatives.

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