

Preface

This monograph presents a fresh look at the problems of the physics of the universe — the subject of cosmology — compared with other contemporary cosmological theories. Its main purpose is to fully exploit the most fundamental expression of Einstein’s theory of general relativity as the mathematical description (language) and the explanation of the physical behavior of the material universe. Contemporary quantum theory, the ‘standard model’ of elementary particle physics and thermodynamics, play no fundamental role in this analysis.

Physics is an empirical science. That is, its claims to understand the material behavior of the objects of the universe, with a logically consistent theory, must be backed by agreement between the theoretical predictions and the empirical facts. Newton’s theory of universal gravitation was believed to be true for the three centuries that preceded Einstein’s discovery of general relativity. But in the context of cosmology, Newton had no empirical backing for anything beyond our solar system — an infinitesimal portion of the universe! In the 20th century new experimental facts came to light on the problem of cosmology that did not fit Newton’s theory. Primary was Edwin Hubble’s discovery of the expansion of the universe. More recently, high-resolution instrumentation for observing the universe, such as the Hubble telescope, revealed observations unknown to Newton or his contemporaries, and his followers during the next three centuries. It has led to the revelation of a universe composed of an infinitude of galaxies, in addition to

our own galaxy, the Milky Way, the spiral structures and rotations of most of the galaxies, the clustering of the galaxies, the background radiation field of the universe, and to exotic stars, such as the quasars and pulsars.

In the early decades of the 20th century, Einstein's theory of general relativity reproduced all the successful results of Newton's theory of universal gravitation, as well as new empirical predictions of gravitational effects not at all predicted by the classical theory. Thus Einstein's general relativity superseded Newton's theory as an explanation of the phenomenon of gravity. Einstein's theory of gravitation was entirely different to that of Newton, conceptually and mathematically. That is to say, Newton's theory of universal gravitation *is not included* in Einstein's theory of general relativity. Rather, Newton's formalism is not more than a mathematical approximation for that of Einstein's theory of general relativity.

Newton's theory is based on a model of the universe as an open system, on atomism and on the concept of action-at-a-distance. Newton himself was dissatisfied with this as an *explanation* of gravitation, but he accepted it as a useful *description*, for his day. In his theory of gravitation, space and time are separate measures in the description of the gravitational force. In contrast, Einstein's theory entails the fusion of the space and time measures in the language of the laws of nature. In this generalization of the language, the space and time measures cannot be objectively separated. They form a fused spacetime, wherein a spatial (or temporal) measure in the language of a law of nature in one frame of reference is a mixture of a spatial and a temporal measure in a different reference frame where the same law is to be compared. Here is the idea of the universe as a closed system, where forces between matter components propagate at a finite speed. These matter components of the universe, in turn, are not separate, singular entities. Rather, they are the distinguishable correlated modes of the closed, continuous matter of the universe. Instead of atomism, this view is then based on the continuous, holistic field concept. (It is compatible with Mach's interpretation of the inertial mass of matter, named by Einstein, 'the Mach principle'.) *This is a genuine paradigm change from the atomistic*

view that has dominated physics for the many centuries since ancient Greece. An exception in the history of science was Michael Faraday's support of the continuous field concept, in the 19th century.

One of the important predictions of the Einstein theory was that in the description of the laws of nature, because the space and time measures are not separate, but are rather a fused spacetime measure, there is the implication that the objects of the universe are not in stationary orbits about other objects, as Newton's theory would hold. Instead, Einstein's theory is in agreement with the Hubble observation that the matter components of the universe are not in stationary orbits, rather they are moving away from all other material components of the universe, i.e. that *the universe is expanding*. Or in a different phase of an oscillating universe cosmology, they are moving toward all other matter components in a contraction phase of the universe.

Are there any deficiencies in Einstein's theory of general relativity, based on its own premises? Yes, there are. It was Einstein who said that to fully exploit the theory of general relativity, not only must one study its geometrical basis, but also its algebraic basis. The latter refers to the most general expression of the symmetry group that underlies this theory of matter. In my studies I have found that this is a *continuous group (indeed, it is a continuous group of analytic transformations — thus a 'Lie Group'. I have called it the 'Einstein Group')*. But the group of transformations that leave Einstein's tensor field equations covariant (i.e. frame-independent) are not only continuous, as they must be, but they are also reflection symmetric, which is not required. Thus Einstein's tensor equations are *not* the most general form for his theory of general relativity.

What I have shown in this monograph is that when the reflection symmetry elements of the underlying symmetry group are removed, Einstein's (reducible) tensor field equations factorize to an (irreducible) quaternion field equation. The 10-component, symmetric metric tensor $g^{\mu\nu}(x)$ of Einstein's original formulation of general relativity is then replaced with the 16-component quaternion metric field $q^{\mu}(x)$. This is covariant as a four-vector under the continuous transformations that characterize the Einstein group,

but it is not covariant under the discrete reflection elements that characterize the symmetry of Einstein's tensor field equations. The quaternion field $q^\mu(x)$ is a four-vector in which each of its four components is quaternion-valued. Thus this field has $4 \times 4 = 16$ independent components. The new quaternion metrical field equations are then 16 in number. I have shown in Chapter 3 (pp. 27–36) that this leads to a unified field theory — by iteration it is seen that ten of the components correspond exactly with Einstein's tensor formulation, thus explaining gravity. The remaining six equations give the Maxwell field equations in the three electric and three magnetic field variables, thus explaining electromagnetism. **This is the unified field theory that was sought by Einstein and Schrödinger.**

In Chapter 4 (pp. 37–50) it is shown that under the appropriate conditions, the new quaternion formulation of general relativity leads to: 1) The (empirically correct) Hubble law, as a non-covariant approximation for the dynamics of an expanding universe and 2) the spiral structure of an oscillating universe, alternating between expansion and contraction, in the never-ending cycles of the universe. Thus, with this view, there is no absolute (singular) 'beginning' of the universe. An absolute temporal beginning of the universe is indeed ruled out as incompatible with the relativity of the time measure in Einstein's theory of relativity. Further, the spacetime is necessarily curved, *everywhere*. The flat spacetime is only an ideal, unreachable limit that simply characterizes the universe as a vacuum *everywhere*.

In Chapter 5 (pp. 51–59) it is shown that a viable candidate for the dark matter of the universe is a dense sea of particle-antiparticle pairs (electron-positron and proton-antiproton) in a particular (*derived*) bound state of null energy, momentum and angular momentum — it is the true ground state of the pair; the sea of such pairs in this state is likened in other theories to the 'vacuum state'.

Many of these results are derived in more detail in previous publications of this author. The main purpose of this presentation is to focus discussion primarily on the problems of cosmology and to indicate their resolutions in a maximally explanatory way.

There are some brief, concluding remarks in the Chapters 6 and 7 on the subject of black holes and pulsars, as well as philosophical considerations.

Summing up, the language of the physics of the universe — the language of cosmology — is presented here in terms of Einstein's theory of general relativity, expressed in its *irreducible form* by removing the reflection symmetry elements from the underlying group (thus yielding the irreducible symmetry group — the 'Einstein group'). This leads to a unified field theory in terms of the generalization of the symmetric tensor representation (10 independent field equations) to the quaternion representation (16 independent field equations). This unification explains, in fundamental terms, gravitation and electromagnetism in a single formalism.

The (irreducible) quaternion formalism, as the language for cosmology, then leads to a new view of the universe. The dynamics of the universe is seen in terms of a cyclical, oscillating model, alternating between expansion and contraction. Further, this model is not in terms of an isotropic and homogeneous matter distribution of the universe, as the present-day cosmological theories contend. Rather, it is in terms of a spiral, rotating material universe, in a curved spacetime. The Hubble law is predicted here as an approximation for the dynamics of any expansion phase of the oscillating universe. With the view of 'dark matter' developed here, a prediction of this model is the empirically observed separation between matter and antimatter in the universe, occurring during the (non-singular!) 'big bang' that initiates any expansion phase. In contrast with present-day models that evoke concepts of particle physics — the quantum theory, the standard model, the string theories — these play no role in this dynamical representation of the physics of the universe. It is explained here strictly in terms of the theory of general relativity and its irreducible expression, based on the underlying *principle of covariance*.

Mendel Sachs
Buffalo, New York
July, 2009