

The Expanding Spacetime Theory

To Anne-Marie, Malin, and Jonas
and to all who will see.

The Expanding Spacetime Theory

A coherent worldview from quantum theory to cosmology

by C. Johan Masreliez

Nu Inc.
Corvallis Oregon

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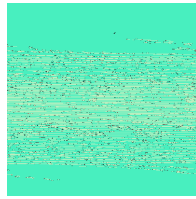
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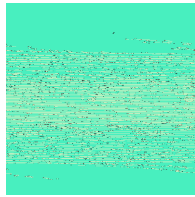
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Preface: The Insight

Ø Several years have now passed since I first realized how many were the false opinions that my youth took to be true, and thus how doubtful were all the things I subsequently built upon these opinions.Ø

Ø RenØ Descartes, *Meditations on First Philosophy*

In the fall of 1993, while on a long plane trip, I read the little book *Ancient Light* by Alan Lightman. This well-written paperback outlines the currently popular cosmological ideas and highlights several unresolved cosmological puzzles. Later that night, when lying in bed in my hotel room, a most beautiful thought suddenly entered my mind in a flash of insight. This is its essence:

The universe expands in both space and time rather than just in space.

Since then, I have tried to find out as much as I can about the universe. Everything I have learned supports my original flash of insight. This insight has become the basis of the Expanding Spacetime (EST) theory. The theory is based on a few simple fundamental principles, which are outlined in the first chapter.

Currently two teams of scientists, one in the US and one in Russia are reworking calculations and combing over historical data relating to various cosmological observations to verify this new model. Some data that has been enigmatic in the past is now making sense. Particularly, some puzzling data relating to the planetary orbits and the orbit of our own Moon are matching up well in the new model where it has been

mysterious in past models. Observations from distant galaxies also fit well into the EST model.

A Question of Scale

Perhaps as a child you wondered why objects have the size they have; wondered if perhaps there could be different worlds where everything were bigger or smaller than in our world. We know that most material objects consist of molecules made up of atoms and that the atoms in turn are made up of elementary particles. We also know that an elementary particle is sometimes thought of as a mass point and sometimes as bundle of energy waves occupying a tiny region in space.

But, how can such a particle know its size in a perfect vacuum? We have to assume that a vacuum without the particle must have some properties that define the scale of things, i.e. that even in a perfect vacuum there exist guidelines for the creation of things like particles. I believe that these guidelines are the metrics of spacetime. The metrics of spacetime define the length of a centimeter (or inch) and the duration of a second. Thus, I suggest that the scale of material objects is defined by the metrics of space and time (spacetime).

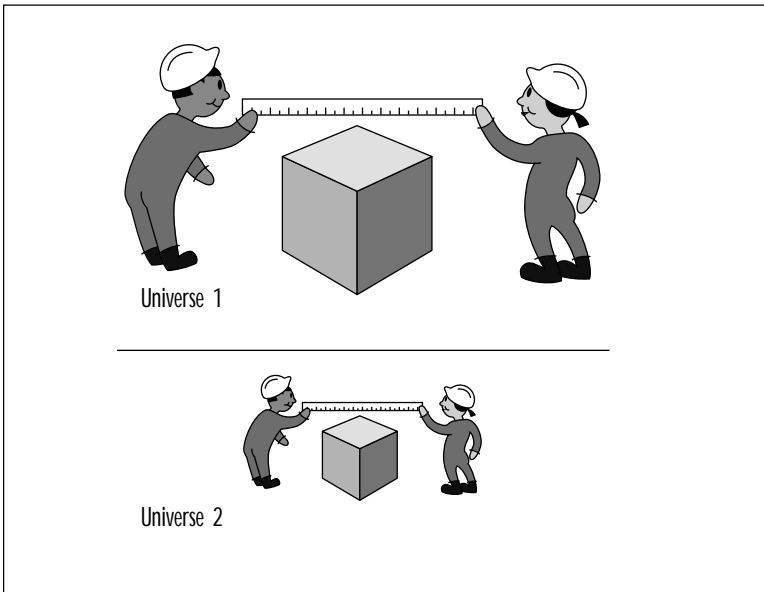


Figure 1: Objects measure the same regardless of scale.

Einstein's General Relativity equations do not show a preference for any particular scale or metrics; all scales are equivalent. A universe in which everything including elementary particles is twice as large (or small) as in our universe and in which the duration of a second is twice (or half) as long would be completely equivalent to our universe—the laws of physics would be the same. If you lived in such a universe, there would be no way for you to notice any difference. Thus the concept of scale is relative. This makes sense. How could there be a preferred scale of things in a perfect vacuum where there are no references whatsoever?

Yet, for things to exist there must obviously be a scale. This makes it natural to ask why the scale of the world happens to be what it is, i.e. why things are as big as they are. In asking this question, we implicitly assume that the scale of things has always been (and will always be) the same. But there are no physical or philosophical reasons why the scale should always be the same. The scale could change with time.

In fact, I propose that this is the way in which the universe expands—*by continually changing the scale of spacetime*. This continually changing scale of everything—including material objects—causes the expansion that has been mistakenly interpreted as originating from a Big Bang. This expansion of spacetime also causes what we experience as the progression of time. Since such an in-scale spacetime expansion can continue forever, this model suggests the universe could paradoxically expand eternally without changing.

In this book, and in published papers on this subject, I show that an observer living in such a scale expanding spacetime would experience the universe exactly as we see our universe. Scientists who looked deep into the universe at distant galaxies from an Earth in such a cosmos would make exactly the same observations that we see in our universe. In fact, I will show that the Expanding Spacetime theory agrees much better with observations than does the Big Bang theory. I will show conclusively that the EST theory is an alternative to the Big Bang theory that seems to have considerable merit, an alternative that solves several cosmological puzzles without the event we call the Big Bang.



Chapter 1: Introduction

This book describes the Expanding SpaceTime (EST) theory and explores ways that this model of the universe can simplify and clarify our understanding of both the cosmos and the subatomic world. The primary goal of this book is to describe the EST theory at an introductory level and to present some evidence and arguments supporting the theory. In doing this, the book also looks at some of the general concepts of the Big Bang theory to compare and contrast them with the EST theory.

In order to present this theory to a popular audience, we have avoided reliance on mathematical arguments. These arguments have been presented in the *Journal of Astrophysics and Space Science* article listed in the bibliography (The Scale Expanding Cosmos Theory) and in other papers that are in the process of submission to scientific journals.

This book has the following ten chapters:

Chapter 1: Introduction provides a foundation to help you grasp most of the concepts presented in the EST theory. This is a review for some, new material for others.

Chapter 2: Building a New Theory describes the historical development of various mathematical models used to describe the universe and how new models are developed.

Chapter 3: Implications of Expanding Spacetime discusses the far-reaching implications of describing the universe using the EST model, in which it is assumed that all four dimensions of spacetime expand simultaneously.

Chapter 4: Enigmas and Discrepancies in the Big Bang Theory describes some of the difficulties that scientists encounter when they try to explain some events and observations in the cosmos using the assumptions of the Big Bang theory. It compares and contrasts how observations fit into each of the models and shows how the EST model simplifies many explanations.

Chapter 5: Evidence for the EST Theory Close to Home describes the motion of the planets and the Moon, and how measurements made with a consistent time base and an improved stellar reference frame tend to support the EST model.

Chapter 6: Other Evidence in the Cosmos examines other cosmological puzzles in light of the EST theory, such as spiral galaxy formation, the spin-down of pulsars, and binary star system orbits.

Chapter 7: The Quasar Puzzle interprets the phenomenon of quasars using the EST model and suggests that they might be failed Black Holes.

Chapter 8: The EST and the Second Law of Thermodynamics explains how the EST (as a steady state theory) can accommodate the observation that entropy always increases.

Chapter 9: But Can the Expanding Spacetime Theory Really be Right? summarizes the book's comparison between the Big Bang theory and the EST theory in a simulated debate between proponents of the two theories.

Chapter 10: Concluding Comments gives the personal perspective of the author.

A New Idea in a Tradition of New Ideas

The Expanding Spacetime theory is a new idea. It has yet to be widely studied, challenged, and debated. But, as we show in this book, it is an idea that fits our observations so neatly and solves cosmological enigmas so elegantly that it cannot be ignored.

New ideas take time to become accepted. At one time we thought that the world was flat. As new observations and theories improved our understanding, we conceived of the world as round and at the center of the universe. Eventually we realized that the Earth is just one of several planets circling the Sun against a background of stationary stars. In the beginning of the 20th century, we found that the Sun is but one of billions of stars in our galaxy, the Milky Way. Now we know that there are billions of galaxies that appear to recede from each other in a uniform cosmological expansion that is believed to have originated at

a singular point in space and time—the Big Bang.

Each of these leaps in our view of the universe required the acceptance of new ideas that were almost inconceivable at the time they were introduced. But as the new ideas matched more closely with our observations of the universe and solved many mysteries, they were gradually accepted as being correct.

The Expanding Spacetime (EST) theory is controversial since it suggests that much of what we believe to be true may be false. As you will see, the EST theory suggests that there never was a Big Bang creation; that Black Holes do not exist; that there is no Dark Matter consisting of exotic particles; that there is no Inflationary Expansion; and that the Cosmic Microwave Background is not remnant radiation from the Big Bang. Also, the EST theory has other implications that challenge current views. It suggests that a light beam loses energy with the length of time it travels through space (the Tired Light effect); it implies the existence of a cosmic reference frame; it suggests that a vacuum may contain energy; and it forces us to re-conceptualize the nature of time. All of these radical notions are the result of modeling the universe using General Relativity and expanding spacetime instead of expanding only space.

How could an idea as radical as a continually changing scale of spacetime be correct? Scientists have learned that they cannot always trust common sense interpretations of reality. For example, they have discovered that particles can vanish at one point and reappear elsewhere, and that time can progress at different rates in different locations. They have come to accept these counterintuitive explanations simply because these explanations better fit observations.

Again it appears that our common sense interpretations may be deceiving us. There may never have been a Big Bang. The Big Bang theory is the result of applying a common sense interpretation to the observation that distant galaxies appear to be receding. The EST theory provides an alternative explanation that perhaps initially defies common sense and yet better fits our observations.

The Copernican revolution completely changed our worldview by placing us on a planet orbiting the Sun instead of at the center of the universe. This was very counterintuitive to many people when they first learned about it, but it is well accepted today. In the same way, the EST theory will seem very natural when you get used to the idea, since it elegantly resolves several cosmological puzzles and logical contradictions with current models of the universe.

Nicolaus Copernicus

The Polish astronomer Nicolaus Copernicus (1473-1543) is usually credited with the heliocentric model in which the Earth and the planets move in circles around the Sun. However, this idea was not new; it had been proposed much earlier by Aristarchus of Samos (who lived around 280 B.C.). Aristarchus also explained night and day by the rotation of the Earth around its axis. The reason his correct worldview was not accepted and was eventually forgotten is unknown, but can perhaps be attributed to an old desire of humanity to be at the center of creation. Copernicus was careful to avoid conflict with the church by delaying publishing his ideas until 1543, just before his death the same year! Also, he proposed his model merely as a construction that simplified the prediction of the motions of the heavenly bodies, thereby avoiding the heretic suggestion that the Earth actually moved around the Sun. In spite of the elegance of his theory, it took some fifty years after his death before the heliocentric worldview gained general acceptance.

Models of the Universe

If you gain only one concept from this book, it should be the realization that as humans we construct models, or \emptyset mental pictures \emptyset related to what is already known, in an attempt to explain what we observe. The models become tools, or maps, that we test against our observations of our world and the universe. If the models match our observations, we use them to predict events and undiscovered phenomena, and hopefully we gain a better understanding of the world we live in. The more refined the model, the more accurately it describes reality. Unfortunately, it is very easy to start mistaking a model for reality and therefore become close-minded, assuming that the model *is* the reality.

As time goes on, our technology and thus our observations get more and more refined. Periodically, we need to adjust the model we use to explain our observations. Occasionally, like with the flat-earth model, we have to throw out the model entirely and start over. The universe and nature do not change. But our model, the map that we use in order to explain what we see, does change as our understanding advances.

In basic physics, we learn that Isaac Newton developed a physical model to describe the universe. Newtonian mechanics is a model of the universe that is spatial and three-dimensional. The coordinate system is fixed, secure, and events occur within this coordinate system with time applied as an external variable. Newtonian mechanics very accurately model the universe we experience. This mathematical model

fits our daily lives very well, and outside of the more advanced applications, for example in space, nuclear, and electronics industries, the majority of the calculations we need to predict daily events on our planet are handled using the Newtonian model.

When Einstein introduced the concepts of relativity, he presented a model of the universe that was completely new and unique, but its utility is not apparent in our daily lives. Few people finish school with an understanding of relativity or how it completely changes our ingrained concepts of space and time.

Einstein showed that in his more refined model of the universe, space and time are inseparable. In Einstein's model, the relative pace of time slows down for a reference frame in motion or in a gravitational field, and energy is, in essence, equivalent with matter ($E = mc^2$). Einstein's relativistic model predicted the bending of light in gravitational fields and the huge energies present in nuclear reactions, both things that we have observed or used. It is widely accepted as a better description of our universe than the Newtonian model.

The EST theory presents a simple new model that builds upon Einstein's relativity model to describe the universe. It is most probably not final, but it might be closer to the truth than previous models. It might help us to look at the universe through this model. It may even predict phenomena in the universe that as yet have gone undiscovered.

Four-dimensional Spacetime

Einstein's relativity theories rely mathematically on a model of spacetime introduced by Hermann Minkowski. In Minkowski spacetime, time is one of four dimensions of the universe (t, x, y, z). This four-dimensional model can be used to describe any event in the universe, showing exactly when (t) it occurred and where (x, y, z). The goal of any model of the universe is to describe and predict events, where an event can be anything from an interaction of subatomic particles to the formation of a galaxy.

The four-dimensional spacetime model of the universe helps us think beyond the three-dimensional space with an external time that was used by Newtonian mechanics. Minkowski's model forces us to remember that time and space are both part of the same continuum (spacetime). The more we understand Einstein's relativistic thinking, the more we realize that space cannot be affected by some phenomena without time also being affected.

The Expansion of Spacetime

The EST theory starts with the four-dimensional spacetime model and develops it just a little bit further. Space in the EST model cannot expand without time also expanding. This is called a scale expansion. The expansion of spacetime occurs in scale, and thus preserves our perception of the relative scale of the universe and everything in it. Einstein gained acceptance for the four-dimensional model of the universe. The EST theory uses a mathematical model where all four dimensions expand at the same rate.

If you can accept the idea of the spacetime continuum, which is fundamental to relativity, then the notion of space and time expanding together makes intuitive sense.

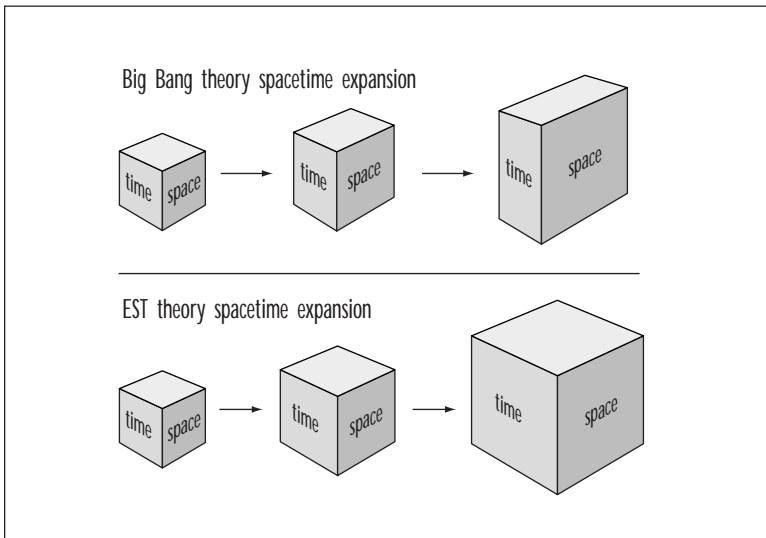


Figure 1.1: This illustration shows a cube of spacetime expanding with time held constant (top) and with time expanding at the same rate (bottom). In order to show time as one dimension here, one of the three spatial dimensions is not shown.



Chapter 2: Building a New Theory

This chapter presents the Expanding Spacetime theory in the context of other models. It describes the historical development of cosmology, particularly the Big Bang theory, and how modern cosmological models are based on Einstein's General Theory of Relativity. It also describes the assumptions underlying the EST and the mathematical results of applying these assumptions to General Relativity.

Chapter 3 describes the physical implications of these mathematical results and observational evidence for the EST.

A Recipe for Cosmological Models

Modern cosmological theories are scientific models that rely on Einstein's General Relativity theory to predict the geometry of spacetime and related phenomena. These models are like maps that show how the universe evolves with time.

What Is a Scientific Model?

A scientific model is a mathematical description of a certain aspect of nature. As building blocks, we use what we know about the process to be modeled. What we do not know, we guess. A scientific model is therefore a combination of known facts and speculation. We design a picture of how we think things might work so that we can predict what would happen if the model were right. This allows us to design tests that either confirm or refute the model's predictions. If the model works, then we are on the right track. If it does not work, we modify the model or try something else.

What Is a Cosmological Model?

A cosmological model is also a scientific model. Cosmological models employ Einstein's General Relativity and other known physics, for example quantum mechanics, to construct a picture of how we think the universe might work. Models are evaluated by comparing the model's predictions to observations. There are special cosmological observational programs, so called cosmological tests, specifically designed to test cosmological models.

In order to understand the implications of the Expanding Spacetime theory, it is best first to review the current thinking and the origins of the Big Bang theory, the cosmological model that is currently in vogue. We will see that the Big Bang model is under severe strain due to unexplainable disagreements with observations.

A Brief History of Cosmological Models

Cosmology became a branch of science in 1917 with a paper by Albert Einstein in which he used his brand new General Relativity Theory to model the universe. Einstein based his first cosmological model on

Albert Einstein

Albert Einstein (1879-1955) is probably the best known and most admired scientist of our time. He is the father of both the Special and the General Relativity theory. In 1905, he published three important papers: an interpretation of the photoelectric effect based on the hypothesis that energy of light comes in quanta; the statistical theory of Brownian motion; and The Special Relativity theory. He received the Nobel Prize for the first two papers in 1921. In 1915, he published the General Relativity theory in its final form.

Einstein's most unusual quality was his strong conviction that the secrets of nature are accessible to human intelligence and may be revealed to a mind free of conventions and preconceptions. His approach was to ask himself what would be the most simple and logical design of the universe. This led him to the conviction that the force of gravitation and the force of inertia must be manifestations of the same phenomenon, which would explain why inertial mass and gravitational mass are equal. Gravitation was no longer a mysterious force reaching out over empty space but instead a feature of spacetime itself.

The General Relativity theory provides a strong connection between spacetime and matter, and suggests that spacetime may contain energy. In the EST theory, it is the spacetime energy, not matter or radiation, that is of primary importance.

only two assumptions: that the universe does not change with time; and that matter is evenly distributed throughout the universe. He also implicitly assumed that matter is the only type of energy to be considered.

Einstein assumed that matter is distributed evenly in space on a large scale (in an isotropic and homogenous distribution) but found that such a universe could not remain static without a force counteracting the gravitational pull. He therefore added a new term, the Λ Cosmological Constant, to his General Relativity equation. Later, with the discovery that the universe seems to expand, the Cosmological Constant was no longer needed, and Einstein regretted ever introducing it.

When Einstein wrote his paper, a static universe in equilibrium seemed very reasonable. It agreed with the ancient view of the universe as being something infinite and eternal. A few scientists remarked that the equilibrium in Einstein's model was unstable. Any perturbation of the mass distribution, no matter how small, would grow larger with time thus destroying the assumption of homogeneity. Since Einstein's model was beautifully simple and since the master himself suggested it, his static model soon became well known among both scientists and laymen.

A few years later in 1922, the Russian mathematician Alexander Friedmann found that Einstein's General Relativity equations also can be solved assuming an expanding universe. However, he carefully pointed out that this assumption was only mathematical and did not suggest that the universe actually was expanding. The importance of Friedmann's work was not recognized before the cosmological redshift that suggested expansion had been discovered.

The Discovery of Redshifted Light from Galaxies

Around 1920, astronomers had begun to realize that the fuzzy Λ nebulae that seem to crowd the sky in every direction could be of extragalactic origin, not objects within our own Milky Way. After considerable debate and controversy, it was determined that these objects actually were other galaxies.

In observing these distant galaxies, astronomers, one of the most notable being Edwin Hubble, found that the light frequencies coming from these galaxies were shifted to the lower, or red, frequencies. The weaker the light, the larger was the observed Λ redshift.

Since weaker light usually means that a galaxy lies at a greater distance, the redshift seemed to increase with distance. This is the famous Hubble redshift-distance relation. The redshifts observed from distant galaxies increase in proportion to the distance.

Redshift Caused by the Doppler Effect Implies a Big Bang

What could cause the light from galaxies to be redshifted? The simplest explanation known at the time was that the redshift was a Doppler effect caused by the galaxies moving away from us at great speeds.

Everyone has experienced the Doppler shift of sound frequencies at a railroad crossing. When a train goes by blowing its whistle, the whistle frequency drops when the train passes. As the train travels away, the sound waves are essentially stretched out in the air making the frequency (and corresponding sound energy) lower. Astronomers were quick to attribute the redshift observed from distant galaxies to the Doppler effect.

The Hubble redshift-distance relation would then imply that the more distant galaxies recede faster, which suggests that the universe may be subjected to a uniform expansion whereby the average distances between galaxies increase with time. If the galaxies are traveling away from each other quite rapidly, they must have been very much closer together in the past.

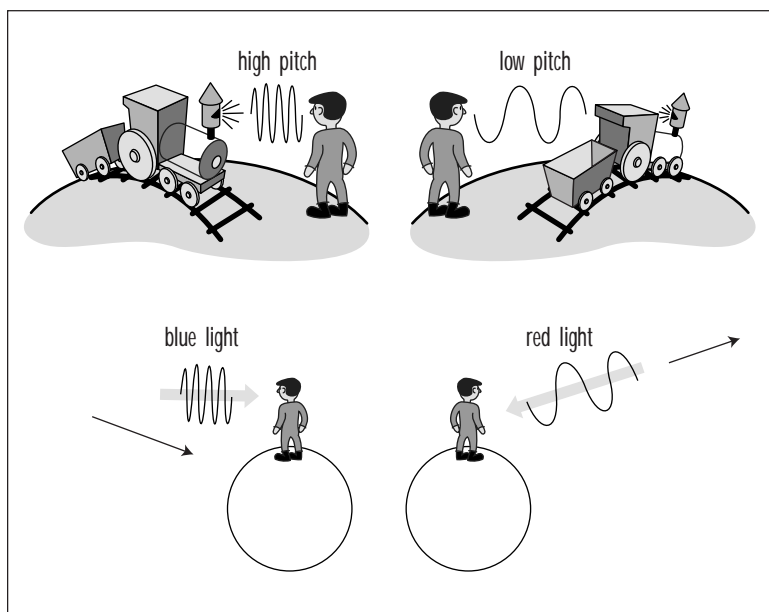


Figure 2.1: The sound of a train whistle drops in pitch as the train passes since the sound waves are stretched out when the train is moving away. In the same way, light from a receding galaxy drops in frequency and becomes more red.

In fact, tracing a uniform spatial expansion back in time, it appears that all matter in the universe could have originated from an infinitely compact state: the Big Bang. So the observation of the redshift, the Hubble redshift-distance relation, and the assumption that the redshift is caused by the Doppler effect initially motivated the Big Bang theory.

The Big Bang theory became the predominant model upon which other inquiries were built. Even though observations have uncovered many weaknesses in the theory, the Big Bang remains fundamental to most cosmology research today in the absence of a coherent alternative.

Expanding Universe Models

After Einstein applied his General Relativity Theory to modeling the universe, others soon followed his lead. An early version of the expanding space model was implicitly suggested by Friedmann (Friedmann A., 1922) and later, with the discovery of the Hubble redshift, openly and forcefully advocated by Lemaître (Lemaître G., 1927).

The basic idea of these expanding space models is that the universe evolves by expanding space while keeping the pace of time the same. This idea is philosophically attractive since it replaces Newton's absolute space with a space that expands, which eliminates the conceptual difficulty associated with an expansion into an absolute space that must have preceded the Big Bang. The universe in this model expands by stretching space rather than by motion of galaxies into some preexisting space. However, several problems with this concept are pointed out by Einstein in his book *The Meaning of Relativity* from which the following quote is taken:

Some try to explain Hubble's shift of the spectral lines by means other than the Doppler effect. There is, however, no support for such a conception in the known physical facts. According to such a hypothesis it would be possible to connect two stars, S1 and S2 by a rigid rod. Monochromatic light which is sent from S1 to S2 and reflected back to S1 could arrive with different frequency (measured by a clock in S1) if the number of wave lengths of light along the rod should change with time on the way. This would mean that the locally measured velocity of light would depend on time, which would contradict even the special theory of relativity. Further it should be noted that a light signal going to

The Line Element in Cosmological Models

The line element expresses the relationship between space and time by specifying the metrics as a function of location. It tells you the speed of light in different directions and how the pace of time changes between spatial (and temporal) locations.

Although it is called a line element, it has nothing to do with a line. It is just a way to specify the geometry of spacetime. It is a mathematical starting point for developing cosmological models, which is used with Einstein's General Relativity equations.

Making an assumption about how the line element acts is fundamental to developing a cosmological model. The assumption made for the line element used to develop the EST theory is only slightly different than the assumption for the line element used to develop the Big Bang model.

The line element in the Big Bang model assumes that the pace of time does not change with temporal location, i.e. that three dimensions of the line element (the spatial dimensions) expand while the fourth (the temporal dimension) is fixed. Mathematically, this means that three of the dimensions of the line element are multiplied by an expansion factor, while the fourth dimension is not.

The line element in the EST model assumes all four dimensions expand. All four dimensions are multiplied by the same expansion factor.

Perhaps the main reason for assuming a constant pace of time in the past when modeling the Universe has been the difficulty of trying to model a time that expands relative to itself. How can the length of a second continuously increase relative to itself? The EST model circumvents this difficulty by realizing that slowing down the pace of time and expanding space by the same fraction is equivalent to changing the scale of everything (changing the scale of spacetime). The scale becomes a new parameter by which we can imagine the slowing pace of time. The larger the scale, the slower the pace of time.

This leads to a very different conceptual view of our Universe. Instead of a cosmological expansion beginning with a Big Bang about twelve billion years ago, we are now considering the possibility that the expansion could be eternal without any absolute reference in space or time. Although mathematically the change in the line element is quite small, an expanding time and scale would imply a dramatic revision of our cosmological view. Some of the surprising implications of the EST model are presented in the next chapter.

and from between S1 and S2 would constitute a clock which would not be in constant relation with a clock in S1. This would mean that there would exist no metric in the sense of relativity. This not only involves the loss of comprehension of all those relations which relativity has yielded, but it also fails to concur with the fact that certain atomistic forms are not related by similarity but by congruence (the existence of sharp spectral lines, volumes of atoms, etc.).

Einstein at First Rejects Early Big Bang Models

Einstein makes the important observation that any expansion of space without a corresponding adjustment of the pace of time in an atom will alter the quantum mechanical wave solution and destroy the necessary relation between space and time, which makes possible the existence of the atom.

Thus Einstein concludes that in the Big Bang universe, the redshift must be due to a Doppler shift that only can be caused by relative motion between galaxies. His observation seems to contradict the fundamental idea of an expanding metric that stretches space in which galaxies are at rest relative to space.

Historical Support for the Big Bang

The assumption that the observed redshift is caused by the Doppler effect is one of the pillars that support the Big Bang theory. But since the discovery of the redshift, two other observations have been put forth to support the notion of a Big Bang.

These two additional pillars of support for the Big Bang theory are the light element abundances and the Cosmic Microwave Background radiation (CMB).

Light Element Abundances

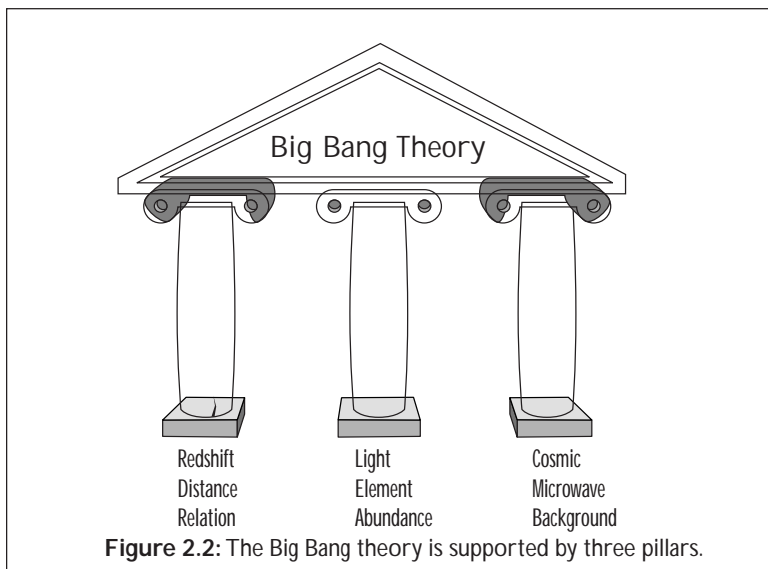
Elementary particle physicists are able to estimate the abundances, i.e. the relative proportions, of light elements in the universe like hydrogen, helium, and lithium, which may have been created in the Big Bang. They do this by speculating on the extreme conditions of high temperatures and pressures that may have been present during the first moments of the Big Bang creation event. These estimated abundances appear to agree fairly well with those currently observed in our local universe. This agreement is taken as strong support for the Big Bang theory.

Cosmic Microwave Background Radiation (CMB)

The third pillar of support is the CMB, which in the Big Bang scenario is interpreted as redshifted radiation from the $\hat{O}\hat{O}$ primordial fireball. $\hat{O}\hat{O}$ This radiation has a very low temperature of 2.73 Kelvin and has an almost perfect $\hat{O}\hat{O}$ black body $\hat{O}\hat{O}$ spectrum, just as we would expect if the radiation originated from a very hot gas in thermal equilibrium. The black body spectrum, which relates various frequencies of electromagnetic radiation, always has the same shape, but the location of the maximum peak changes with temperature so that the frequency at the peak increases with temperature.

The expansion and redshifting of the opaque $\hat{O}\hat{O}$ photon gas $\hat{O}\hat{O}$ that supposedly filled the universe with black body radiation after the Big Bang explains the low temperature of the CMB radiation we see today. Like a gas that loses temperature when it expands, the temperature of the CMB radiation decreases when space expands while preserving the black body spectrum. A very hot, intensely radiating, primordial $\hat{O}\hat{O}$ fireball $\hat{O}\hat{O}$ at several thousand degrees just after the Big Bang is today a very low temperature radiation at 2.73 degrees Kelvin, i.e. about -270 Centigrade.

These supporting arguments for the Big Bang theory are addressed in Chapter 4, *Enigmas and Discrepancies in the Big Bang Theory*.



The Cosmic Microwave Background

Around 1960 cosmologists Robert Dicke and P.J.E. Peebles at Princeton University speculated that if there were a Big Bang, the radiation from the very hot universe immediately afterward might still be detectable, reaching us from extreme distances. They thought that this electromagnetic radiation ought to have a black body spectrum with a temperature of around 10 degrees Kelvin. They started to develop a special radio receiver capable of detecting cosmological radiation at microwave frequencies.

Around 1963, two scientists at Bell Labs, Arno Penzias and Robert Wilson, had built a receiver to be used for radio astronomy. However, they could not make it work properly due to an unexplainable static. They tried to find the source of the static for almost a year. This went so far as cleaning pigeon droppings from the receiver antenna. When they complained about their problem to a friend they finally learned of the work at Princeton and realized that the static might be of cosmological origin. Their subsequent investigation led to their discovery of the *Cosmic Microwave Background* (CMB). As a result of their discovery, the two Bell Lab scientists were awarded the Nobel Prize (while ironically no recognition was given to the people at Princeton).

In the EST theory, CMB radiation results from electromagnetic energy in thermal equilibrium. All the radiating sources in the universe continuously add energy, which is continuously dissipated through the Tired Light redshift. These two mechanisms reach equilibrium at the CMB temperature of 2.73 K.

Big Bang Alternatives

Probably the most familiar alternatives to the Big Bang theory are Cosmological Steady State theories, for example those by Bondi and Gold (Bondi and Gold, 1948), and by Hoyle (Hoyle, 1948). These theories are strongly motivated by the Perfect Cosmological Principle according to which all locations in space or time are equivalent.

These theories assume that only space expands. With this assumption, the expansion opens up voids between galaxies, which are filled by the creation of new matter. This continuous creation of matter and the nature of the CMB are problematic for these theories. It is very difficult to explain the CMB black body spectrum in a spatially expanding eternal universe. The spatial expansion distorts the shape of the black body spectrum.

Other cosmological Steady State theories have been proposed that explain the redshift in various ways other than the Doppler effect. For

example, it has been proposed that the redshift might be generated by a cosmological gravitational field or that it is a Tired Light type redshift caused by photons colliding with some kind of particles, perhaps electrons. However, it has been difficult to explain how collisions can occur without scattering and dimming the view of distant objects.

If we model expanding space in General Relativity, we find that as long as all velocities are much lower than the speed of light, the motions of objects are the same as if we had used classical Newtonian physics rather than General Relativity. People have seen this as an affirmation since it makes the cosmological expansion much simpler and easier to understand. The expansion looks like a motion of galaxies in space rather than an expansion of the metric. However, there could be a deeper significance; perhaps the General Relativity theory tells us that any expansion of space relative to time should be interpreted as motion in space rather than stretching of space. This suggests that there can be no continuous stretching of space without a corresponding stretching of time.

Arbitrary Constant Time in Expanding Space

Taking a critical look at the Friedmann/Lemaître model and the considerations behind this particular choice of metrics, we find, as was carefully pointed out by Friedmann, that the temporal metric of the line element was chosen due to its mathematical simplicity rather than from physical or philosophical considerations. This simple form can always be obtained by suitable coordinate transformations of any general line element based on isotropy and homogeneity. However, there is nothing to support the contention that the choice of temporal metric in the Friedmann line element coincides with the natural metric defined by the pace of an atomic clock. Therefore, conclusions based on the Friedmann model regarding the nature of the cosmological expansion could be misleading.

Since the coordinate distance in the expanding space model disagrees with the natural distance defined by timing a light beam, the model may give a distorted view of the nature of cosmological expansion. The same argument may be advanced regarding the temporal metric. The transformation $t' = T \exp(t/T)$ transforms the temporal metric, t , beginning at $t = 0$ to a new metric, t' , without beginning. Yet, both these metrics satisfy the same General Relativity equations and they agree at $t' = T$ and $t = 0$ where $dt = dt'$. So, how can we know which

representation is right in the sense that it correctly models the aging process?

The Expanding Spacetime Model

The Big Bang theory may be likened to a palace where each detail, looked upon separately, has been developed and finished beautifully. Yet, when viewed from a distance, one discovers that the whole structure is built on a crooked foundation. On the other hand, the Expanding Spacetime theory in its present state of development is like a roughly framed structure with beautiful proportions resting on a solid foundation but without the detailed finishing.

This new foundation—the uniform expansion of spacetime—means that nearly every aspect of how we think about the cosmos, astrophysics, and modern physics needs to be reexamined. The rest of this chapter explains the theoretical basis for this new foundation and begins to build the Expanding Spacetime theory point by point.

Searching for an alternate to the expanding space model among an infinite number of possibilities requires reliance on observational data and on fundamental principles. The Expanding Spacetime model is based on two fundamental principles: equivalence between locations in space and time (Spacetime Equivalence) and a constant speed of light relative to all observers.

This new model has the advantage of preserving the relationship between space and time so that the coordinate distance always coincides with the distance measured by timing a light beam. It agrees better with observations than the Big Bang model and it provides simple explanations to several unresolved cosmological enigmas. In addition, this new model implies the existence of a cosmological inertial reference frame and a new phenomenon—Cosmic Velocity Drag, which has been verified by observations as described in Chapter 5.

Two Assumptions of the Expanding Spacetime Theory

The EST theory is based on two postulates:

- A1. Spacetime Equivalence applies.
- A2. The measured speed of light is constant relative to all observers.

The success of Einstein's Special Relativity theory and his General Relativity theory suggests that principles of equivalence are of fundamental importance in the universe.

In his Special Relativity theory, Einstein assumed that coordinate systems moving with constant relative velocities are equivalent while in

General Relativity he assumed that a coordinate system freely falling in a gravitational field is locally equivalent to a coordinate system suspended in empty space without any gravitational field.

Making all locations in space and time equivalent will extend this equivalence principle further to the above-mentioned *Postulate of Spacetime Equivalence*.

In developing the EST theory, the concept of an absolute time is replaced with the Postulate of Spacetime Equivalence. Spacetime Equivalence is stronger than the Perfect Cosmological Principle since it implies that the geometry of spacetime as expressed by the line element of General Relativity always remains the same regardless of epoch or spatial location.

According to Spacetime Equivalence, the average distances between galaxies cannot change with time since all epochs are equivalent. How-

The Cosmological Principle, the Perfect Cosmological Principle, and the Postulate of Spacetime Equivalence

The *Cosmological Principle* used by most cosmologies is based on the idea that the laws of physics should be the same throughout the universe. Newton's law of universal gravitation is a good example of this principle. According to the Cosmological Principle the universe should *work* and *look* the same way independent of the location of the observer in the universe. This is a reasonable ground rule since we don't know how to otherwise approach cosmology.

The Cosmological Principle means that the density of the universe, the background radiation, the radiation pressure, and the number of galaxies and their properties should appear much the same regardless of the location of the observer.

An extension of this principle was made by the *Steady-State* cosmologists, Fred Hoyle, Tom Gold, and Hermann Bondi who said that not only should the universe work and look the same at any place but also at any time. They called this extension the *Perfect Cosmological Principle*.

The Big Bang theory obeys the Cosmological Principle but does not obey the Perfect Cosmological Principle since it concludes that the universe was much denser in the past. The EST model goes beyond the Perfect Cosmological Principle to *Spacetime Equivalence* by demanding that the geometry of spacetime including the average distance between any two galaxies remains the same everywhere in space and time. The EST theory models an eternally evolving, ageless universe.

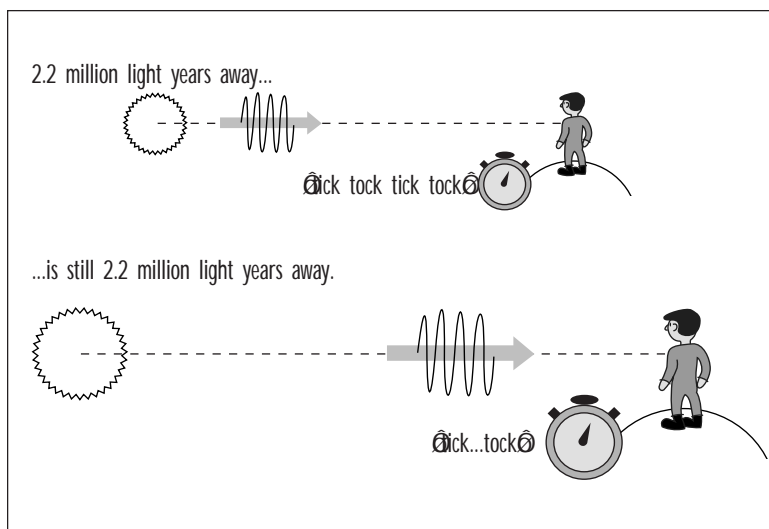


Figure 2.3: In a scale expanding universe, distances measured by timing a light beam stay the same because as space expands the clock slows down.

ever, the observable cosmos appears to expand. The only way expansion can take place without changing distances is by continuously changing the scale of the spatial metrics without changing the relative coordinate positions. This implies that there can be no absolute spatial metric.

In order to satisfy the requirement that a \emptyset light clock \emptyset between any two fixed coordinate locations in the expanding spacetime agrees with a local clock, the relationship between the temporal and the spatial metric has to be preserved at all times. Therefore, if the universe expands by changing the metrics of spacetime, the cosmological expansion must be symmetric in space and time. When space expands, the length of the second must also expand, i.e. time must slow down.

To satisfy A1, we must accept the possibility that the spatial scale expansion acts at all levels including at the elementary particle level. If this were not the case and the scale of material objects always remained the same, the length of, for example, a measuring rod, would define an absolute spatial metric. This conflicts with the conclusion that there is no absolute spatial reference.

Distances in the universe are measured by timing a light beam, which is why we refer to cosmological distances in light-years. In the Expanding Spacetime theory, spatial expansion is accompanied by tem-

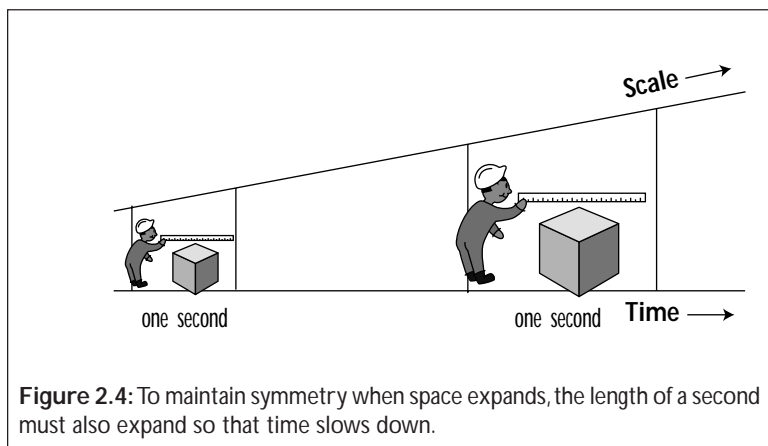


Figure 2.4: To maintain symmetry when space expands, the length of a second must also expand so that time slows down.

poral expansion of an equalizing scale so that all measured distances between galaxies and other bodies remain constant.

For example, if any distance doubles and at the same time the clock slows to half its pace, the distance measured by timing a light beam remains the same, assuming a constant speed of light as postulated in A2. Obviously this kind of expansion of spacetime could continue forever without ever changing the measured distance!

No matter how much spacetime expanded, the measured distance between bodies in the universe would still remain the same. The distances measured by timing a light beam would remain constant. Furthermore, since this expansion of spacetime could continue forever, the universe could be eternal.

The universe shows no preference for any particular scale of things. If it did, there must exist something absolute $\hat{O}\emptyset$ outside the universe $\hat{O}\emptyset$ that could determine that one particular scale is to be preferred over another. However, if the universe is self-contained, it cannot determine the scale of things by comparing it with something absolute $\hat{O}\emptyset$ outside the universe; $\hat{O}\emptyset$ all scales ought to be equivalent. This means that if the scale of an object increases with time, time must slow down to preserve the relation of space and time, and the properties of the universe. Accepting the principle that no particular scale is preferred means that the observed expansion of the universe must be symmetric in space and time.

Observations of distant sources agree with Spacetime Equivalence - the laws of physics do not change with time. Therefore, if the spatial

metric is changing for elementary particles, the temporal metric must also change in order to preserve quantum mechanical wave functions and spectral line relationships. In fact, due to the constant velocity of light postulated in A2, the pace of time must decrease when the spatial metric expands. This suggests that the natural metrics of space and time expand simultaneously and that the cosmological expansion may take place by changing the scale of spacetime. Since all epochs are equivalent, the appearance of the universe remains the same relative to a fundamental observer; Spacetime Equivalence applies.

Furthermore, since quantum mechanical wave functions depend on space and time, the scale of elementary particles must change with the scale of spacetime. This is also consistent with Einstein's General Relativity theory according to which the cosmological energy (mass) distribution determines the metrics of spacetime. Changing the scale of spacetime therefore implies changing the scale of material objects.

Conclusion

In the past, new insights often have been gained when ideas and concepts previously taken for granted have been questioned. When Einstein proposed his Special Relativity Theory, it was met with deep suspicion since people always had taken for granted that the speed of light depended on relative motion. Thus, the measured speed of light was believed to be higher when approaching a light source than when receding from it. Einstein greatly advanced our understanding of nature by questioning this preconception. He suggested that the speed of light is independent of relative motion, a suggestion that carried with it the surprising implication that mass and energy are equivalent.

Today, everyone takes for granted that the pace of time at any one location in our universe (like here on Earth) always has been the same. This deeply ingrained idea of a constant progression in time by which every second is ticking away at a constant rate has been taken for granted up until now. Accepting the idea that the pace of time may be continually slowing down is a key that opens the next door on our journey toward an ever deepening understanding of the universe.

When we look at the light from stars and distant galaxies, we are looking into the past. Until now, we have assumed the pace of time to be a constant no matter how far back into the past we look. The EST theory makes a strong case for refining this model. The parameter that we invented and called \hat{t} has not always been ticking away at the same pace as it does today.

The universe offers ample proof of time acceleration, and with the support of concepts introduced in Einstein's Special and General Relativity theories, there is no reason to assume that the pace of time is the same today as it was five billion years ago, or even a moment ago. Relativity implies that the metrics of space and time are inseparable. The EST theory takes that implication a step further by proposing that time and space must expand simultaneously.



Chapter 3: Implications of the Expanding Spacetime Theory

The mathematics describing the EST model of the universe arise by solving Einstein's General Relativity equations assuming that space expands and that the pace of time is not a constant but slows down with the spatial expansion. Although this slowing progression of time cannot be noticed locally, it carries with it several important implications. This chapter provides a fresh interpretation of the redshift, Hubble Time, Black Holes, Cosmic Time, and Quantum Mechanics and also introduces the new concepts of the Cosmic Energy Tensor and Cosmic Drag.

Tired Light

A significant feature of the EST theory is that it agrees with and provides a mechanism for the Tired Light redshift originally proposed by Edwin Hubble to explain the redshift of light from distant galaxies. Upon discovering the redshift, Hubble felt that the light must lose energy as it travels through spacetime. The Hubble telescope observations agree excellently with what would be expected from a Tired Light redshift model but poorly with the Doppler velocity explanation for redshift that is the foundation of the Big Bang theory.

It has been suggested many times during the decades since the discovery of the Hubble redshift relation that the redshift is Tired Light rather than a Doppler effect. Edwin Hubble and his contemporary astronomer

Fritz Zwicky compared Tired Light with Doppler redshift and found that Tired Light appeared to agree better with the observations. However, at that time observations existed for very small redshifts only, so this early finding was dismissed. Hubble seems to have favored the Tired Light model based on his observations, but there was no good theoretical basis for Tired Light, no apparent mechanism that would cause light to lose energy in this way. However, an acceptable explanation did exist for the Doppler redshift effect. So, the Doppler shift interpretation was eventually adopted over the Tired Light interpretation.

With advances in technology since the discovery of the redshift, our observational capabilities have steadily improved. Radio astronomy and other innovations have extended our observations deeper and deeper into space. With these improved capabilities, it has gradually become apparent that the observations simply do not agree with the Doppler shift interpretation. Paul LaViolette showed convincingly in an important paper in 1986 that the Tired Light model agrees well with all observations.

How Tired Light Explains the Redshift

The Doppler effect is not the only way in which light can be redshifted. Simultaneously expanding space and time will cause a redshift that depends on the distance light travels rather than on the velocity of the source. When photons move through expanding spacetime, they gradually lose energy. The frequency becomes lower and the light is shifted toward red in the spectrum. This type of redshift has been considered in the past and is usually referred to as *Tired Light*.

Although Tired Light seems to agree with observations better than the Doppler effect, it has been difficult to explain what could cause it. Some have tried to explain it by assuming that the photons collide with other particles on their way and therefore lose energy. However, collisions would cause the photons to change direction, which ought to make the image of distant galaxies fuzzy like a street light in fog. In the EST theory, the cause of Tired Light is the uniform expansion of spacetime.

The Doppler redshift model can only be made to comply with selected data sets by assuming evolutionary Ω_0 scenarios in which the observed sources have changed with time in just the right way. In these scenarios, the Big Bang model's agreement with observations can only be reached by assuming that galaxies were smaller, more luminous, and that their density in the night sky was higher in the past.

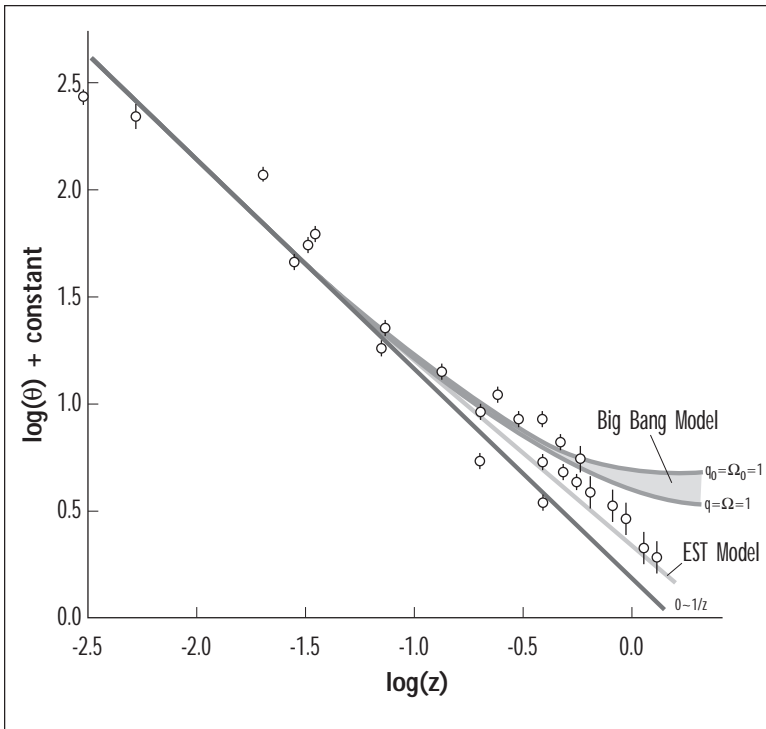


Figure 3.1: The EST model agrees well with the angular size vs. redshift data.

Two of the several cosmological tests that support the Tired Light redshift model are the simple angular size test and the galaxy density test. Both of these tests are described next.

The Angular Size Redshift Test for Tired Light

The angular size redshift test is particularly decisive. In this test, the angle under which an object like a galaxy is seen is recorded as a function of the redshift. Figure 3.1 is from a 1981 paper by Djorgovski and Spinrad. The expected angular size-redshift relation for the Big Bang model lies in the shaded area between the two upper curves in the figure. These Big Bang predictions clearly deviate from the observations at large redshift (z) values. Predictions based on the Tired Light model show a striking agreement with observations.

The Galaxy Density Test for Tired Light

The galaxy density test requires counting the number of galaxies within a given luminosity range and plotting this number as a function of apparent luminosity. In a paper from 1995, Metcalfe et. al. summarize the results from sixteen recent papers presenting observations of number count versus luminosity magnitudes with magnitudes ranging from 14 to 27.5. Some of their results are presented in Figure 3.2 (which is Figure 10 in Metcalfe et. al.).

The Tired Light redshift model fits the data. The agreement with the observations is excellent over the whole range, much better than several attempts to fit the Big Bang model to the data based on various evolutionary scenarios.

The close agreement between the expanding-spacetime-driven Tired

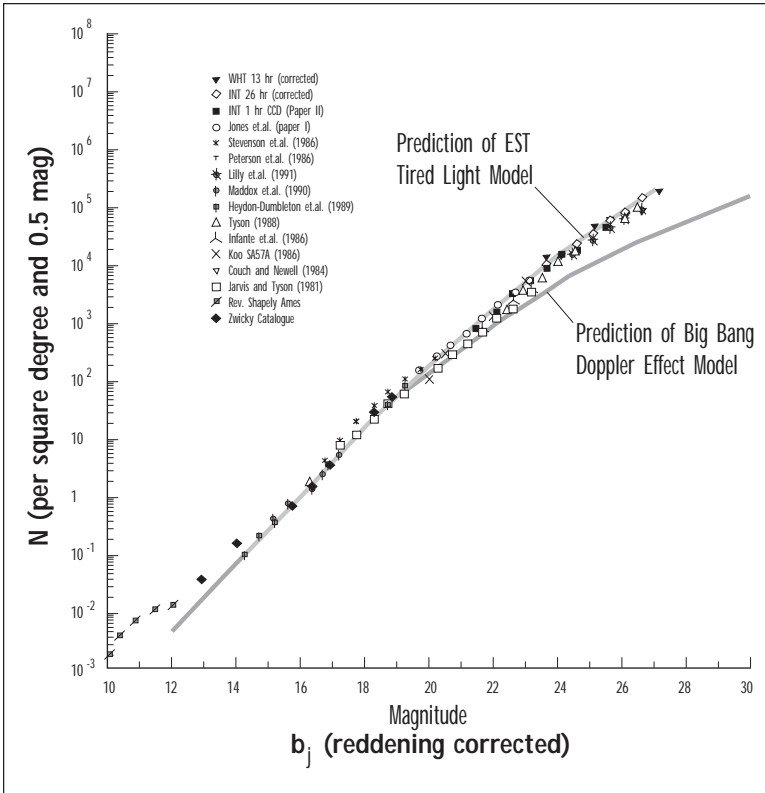


Figure 3.2: The EST model also fits galaxy density vs. luminosity data.

Light model and the data of Figure 3.2 suggests that the Tired Light curve that is fit to the data may be used to estimate the average galaxy luminosity and the galaxy number density (the abundance of galaxies per unit of space). Using a Hubble Time of ten billion years, the EST Tired Light curve fits the data as shown in Figure 3.2. (Refer to page 30, *The Meaning of Hubble Time in EST*, for a discussion of the use of Hubble Time.)

The result is an estimated average galaxy luminosity as follows:

$$L_{gal} = L_{sun} \times 10^{43} \text{ erg/s}$$

The average number density is estimated at:

$$n = 10^{-75.35} \text{ galaxies per cm}^3$$

This implies an average inter-galaxy distance of about 12 million light years. Both the estimated mean galaxy luminosity and the galaxy density agree well with currently available estimates from other sources.

Tired Light Redshift in the Expanding Spacetime Theory

Previously proposed models explain the Tired Light phenomena as resulting from an interaction between photons and particles of some kind. But these models don't work because such an interaction would cause observable scattering effects like a street light seen in fog. Since no such scattering is seen, it has been difficult to justify the Tired Light redshift in the past. With the EST Theory, that has all changed.

Tired Light, redshifted light, is an intrinsic property of expanding spacetime. It occurs without collisions or scattering; it results from the modified spacetime geometry caused by the in-scale expansion. Light waves lose energy as they travel through expanding spacetime. In the redshifted light from distant galaxies, we are observing spacetime expansion.

The expansion of spacetime is the missing mechanism for the Tired Light redshift. It provides a logical explanation for the redshift we observe from distant galaxies without the conclusion that the galaxies are moving away from us. Since the galaxies are not moving away from us, they were never much closer together than they are now. The EST's Tired Light explanation for the redshift thus eliminates the conclusion that the universe started with a Big Bang.

Cosmic Time

A key concept underlying the current popular cosmological theories is the idea of a universal time reference common to all observers regardless of their location in spacetime. All of our observations and intuitions lead us to believe that some \emptyset root \emptyset time reference exists. The Big Bang satisfies this feeling by proposing a distinct \emptyset beginning of time. \emptyset

The idea of a root time reference is certainly quite alien to the theory of relativity. As relativity was initially constructed, time is treated as one of four dimensions in the local spacetime geometry. However, the Big Bang proposal of an absolute beginning of time seems to contradict the spirit of General Relativity. So our observations and intuition have led us one way, while modern physics points in the opposite direction.

As mentioned on page 17, the idea of a Cosmic Time in an expanding space was introduced by the Russian mathematician Friedmann in 1922 and follows from the kind of geometry he selected to model the universe. However, in selecting this model, he was careful to point out that his particular choice of representation has no basis in physics or philosophy. It was chosen solely to simplify the calculations.

In a universe where the pace of time is constant and only space expands, the role of time may be defined by Weyl's Postulate according to which the mass density at each instant of cosmic time is the same throughout the universe. This corresponds to a universal spatial expansion by which the distance between galaxies increases with time and is the currently accepted picture of the relationship between time and space.

The contradiction continues between theory and intuition. Our intuition demands a universal time reference, while relativity rejects the concept that any one unique time reference applies to all observers. The Big Bang theory feeds into our notion that such a reference exists, but relativity does not imply such reference.

Weyl's Postulate

Weyl's postulate defines a universal time base for the spatially expanding Big Bang universe. According to Weyl's postulate, time is a universal parameter for the scale expansion so that the time is the same at all locations in the universe at the same stage of the expansion. This very natural assumption says that if we synchronize all clocks at fundamental locations (i.e. \emptyset -moving \emptyset galaxies) at a certain time, then these clocks will still be synchronized at some later time when all distances between galaxies have increased by the same proportion.

But the EST theory allows both a universal time reference and relativity to coexist. It provides for a very simple and natural way of defining a universal time reference since its space, absent of matter, is flat at each instant. Flat space preserves the relationship between space and time everywhere. This is the kind of space we usually think of. There are no curved light rays and distances can be defined in light years everywhere. In such a flat space, distances and time intervals have their usual meanings. Clocks may be synchronized by light signals assuming a constant speed of light just like in special relativity.

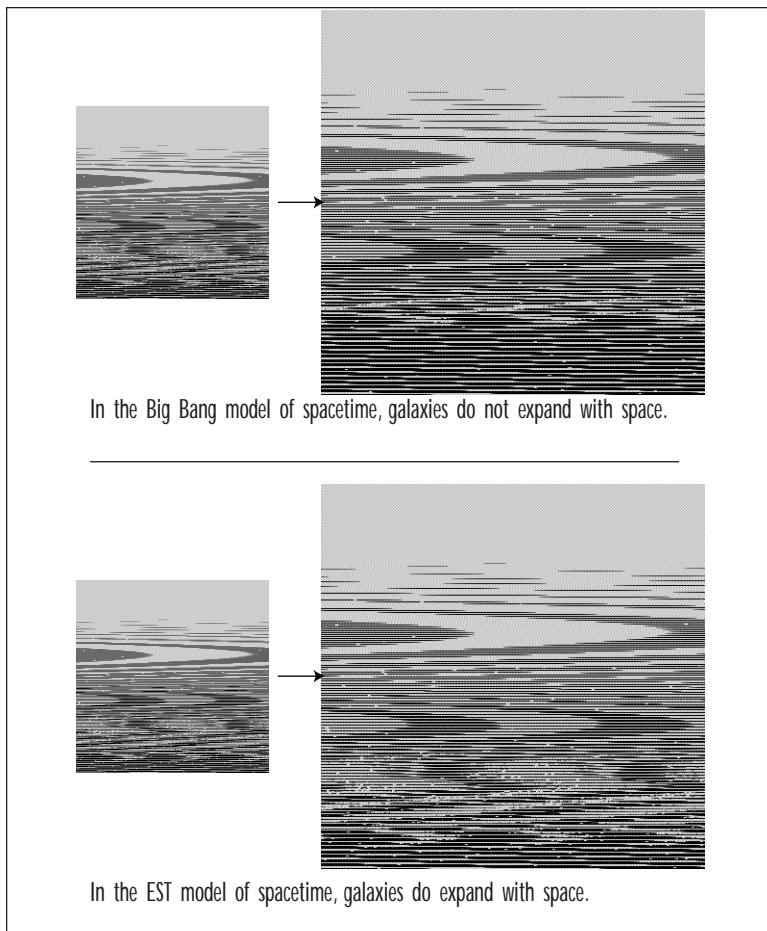


Figure 3.3: Spacetime expansion in the Big Bang and EST models.

Although a relative universal time reference exists in the EST, there is no absolute reference, i.e. there is no beginning of time. Both space and time are relative concepts in the EST, which is in agreement with General Relativity.

Time Progression and Time as a Spacetime Dimension

The EST theory makes a clear and important distinction between two time concepts—the progression of time and time as one of the four dimensions of spacetime.

The progression of time is directly related to the changing scale factor (the expansion of spacetime) while the time coordinate is simply part of the geometry of spacetime. The interaction between these two temporal concepts creates new properties. This clarification removes one of the main obstacles encountered when modeling the universe by General Relativity where there is no clear-cut mechanism for handling the progression of time.

No Beginning of Time

The Postulate of Spacetime Equivalence, described in Chapter 2, is the basis for this implication of the EST Theory. The EST theory assumes equivalence in physical laws between temporal epochs and between all locations in space; i.e. we make the sensible assumption that the universe looks and acts the same on a large scale as viewed from any location in space and time.

This means that the length of the present second should relate to the length of the previous second in the same way that the length of the next second relates to the present second. In other words, the length of a second should increase by the same percentage for each tick of the clock.

This kind of expansion is called an exponential expansion or a geometric expansion. With such an expansion, all epochs become equivalent—time has no beginning.

The Meaning of Hubble Time in EST

Using the Big Bang model, astronomers estimate the age of the universe by tracing the Hubble expansion backward in time. By measuring the present expansion rate from the observed redshift of distant galaxies, they can determine when all matter supposedly was compacted into one singular point assuming that the redshift is a Doppler effect.

In the EST theory, Hubble Time is an expansion constant unrelated to age the universe. The universe will always appear to have the same

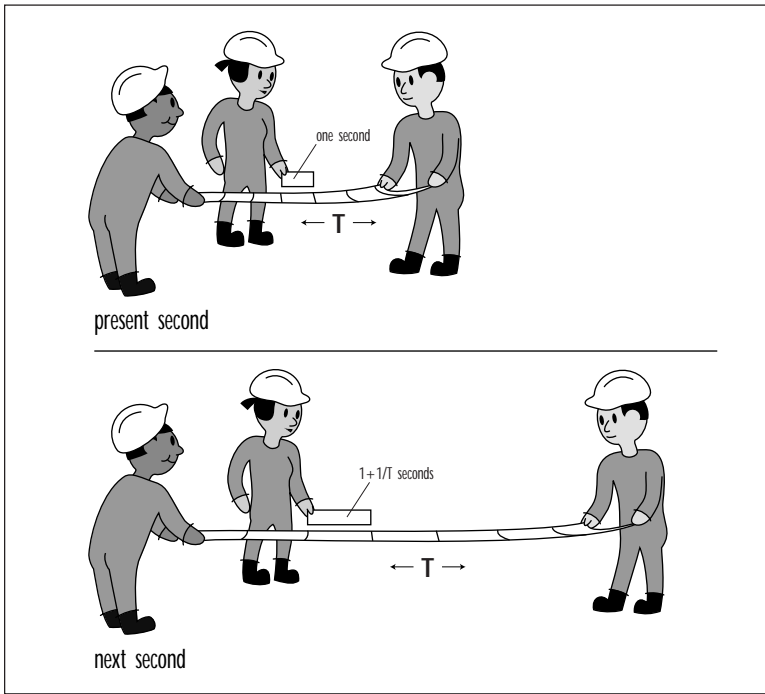


Figure 3.4: Imagine representing the age of the universe by a number of tick marks on a piece of elastic, each tick mark corresponding to billions of years. Stretching the elastic doesn't change the number of tick marks. In the same way, time expansion doesn't change the apparent constant age of the universe. (In the figure, all measurements are in the current time base.)

age, ten to fifteen billion years, regardless of the epoch, because of temporal expansion.

Note the very significant point that in a temporally, exponentially expanding universe, the length of the second no longer has an absolute meaning, only the relations between consecutive seconds have meaning. The concept of a beginning of time disappears; we are suspended in an eternal flow of time without beginning or end.

To understand how this can be possible, assume that the apparent age of the universe as measured by the present second, is T seconds. T seconds is on the order of four times ten to the seventeenth power (equivalent to twelve billion years), which is the Hubble Time. Assume further that the length of the second at this precise moment is unity. Then the age of the universe after the next second with the present time base is

(T+1) seconds. If the next second is longer by the fraction $(1+1/T)$ as measured in the present second's time base, the age of the universe after the next second (as measured by the next second's time base) is still T seconds since $(T+1) \div (1+1/T) = T$. The continuously changing time base therefore gives the illusion that the age of the universe is always T.

Although the aging time can be infinite, the universe always appears to be about twelve billion years old. The sum of an infinite number of time intervals back in time, each being a small fraction shorter than the following, appears finite. Figure 3.5 shows the relationships between the aging time and Hubble Time, T.

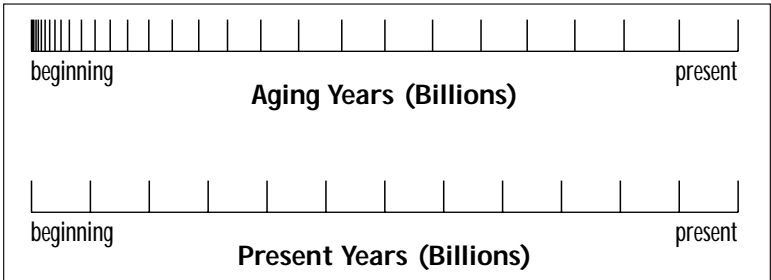


Figure 3.5: The universe is about twelve billion years old if measured in the present time base but infinitely old if measured in aging time.

Cosmic Drag and the Cosmic Reference Frame

According to relativity, there should be no preferred reference frame in the universe, yet observations show that galaxies are almost stationary with respect to each other compared to the speed of light. This indicates the presence of such a preferred rest frame. These difficulties are resolved by the EST theory.

Cosmological models of the universe assume that a rest frame exists, and the EST theory does not differ in that respect. However, the advantage with the EST theory is that the expansion of spacetime generates such a reference frame.

Cosmic Drag

Cosmic Drag is a property of expanding spacetime. Particles moving relative to each other in expanding spacetime will gradually lose kinetic energy. If a particle has positive mass, its velocity decreases with time, while a photon instead loses energy by redshifting. This energy loss is very gradual and amounts to about 60% in twelve billion years (the Hubble Time).

Big Bang Reference Frame

The spatially expanding Big Bang model retains the idea of a cosmological reference frame in a somewhat modified form. The expanding space model is based on Weyl's postulate, which states that the universe expands by continuously increasing the distances between galaxies in such a way that the universe is homogenous and isotropic at each instant. This implies that there is a cosmological time reference which permits the synchronization of clocks at fundamental locations, tracing trajectories of galaxies throughout the universe. These trajectories will, together with the Cosmic Time, define a reference frame at each location in spacetime.

In the Big Bang model, the small relative velocities between neighboring galaxies mean that the cosmological expansion must be very uniform. However, detailed analysis and simulation cannot explain the observed small relative velocities. There is no mechanism in the Big Bang model that guarantees that the relative velocities between galaxies always will remain small.

The idea that moving objects will slow down is quite old and had its followers in ancient Greece. However, with Galileo and Newton this belief was replaced by the idea that freely moving particles without external influences will always continue to move at constant speeds. With the EST the circle is closed.

Cosmic Drag is an outcome of General Relativity and the EST model. Cosmic Drag causes the relative velocities between galaxies and their relative angular momenta to decrease with time at a rate that is in proportion to the magnitude of their current velocity divided by the Hubble Time. This explains the observations that the relative velocities of galaxies are generally much lower than the speed of light. Cosmic Drag defines both the direction of time and a cosmological inertial reference frame.

The Inertial Reference Frame in Cosmological Models

Inertia is that force you feel when your car accelerates or makes a turn. You feel you are being pulled relative to something outside the car. The question of what causes inertia has been an enigma since the time of Newton. The inertial force was the main motivation for Newton's assumption of an absolute cosmic reference frame that was thought to exist even in the absence of matter. All accelerating and rotating motions were thought to take place in relation to this absolute reference.

It is hard to understand how an accelerating motion could differ from a motion with constant velocity unless there is some kind of reference frame. Consider for example an accelerating body in a cosmos devoid of all other matter. How can we know that the body is accelerating? Would there still be an inertial force?

Newton would have answered yes since his inertial reference frame exists regardless of matter. The German physicist Mach would have answered no. According to Mach's Principle the inertial force is the result of acceleration relative to distant matter in the universe.

Einstein was strongly influenced by Mach's Principle, which motivated him in his struggle when developing the General Relativity theory. Although the General Relativity theory actually does predict inertial coupling between matter in the universe, the effect is far too small to explain the phenomenon of inertia.

Mach's Principle

Mach's Principle is an alternative to Newton's absolute space. According to Newton there exists a basic reference space independently of whether there is anything in the space or not. Space is viewed as something more fundamental than matter with the implication that space existed before the creation of the world. Newton reluctantly came to this conclusion after experimenting with a spinning bucket of water. He noticed that the water surface became concave when the bucket was spinning, which seemed to imply that the water in the bucket somehow knew that it was spinning relative to something fixed in the absolute space.

According to Mach's Principle the fixed reference space is not absolute but is defined by the presence of distant matter in the universe. Thus, according to Mach, it is distant matter in the universe that generates inertia. Einstein was greatly influenced by this idea when he developed his General Relativity theory hoping that his theory also would solve the mystery of inertia.

Since inertia undoubtedly exists, a cosmological model without some kind of inertial reference frame is unthinkable. In his static cosmological model of 1917, Einstein assumed that a fixed static reference frame existed. This assumption was supported by astronomical observations that the stars seem to be stationary. Einstein was well aware that the assumption of a cosmological reference frame appears to contradict Special Relativity, which postulates that all inertial frames are equivalent. His theory does not explain why the relative velocities between galaxies are so small.

The Inertial Reference Frame in the EST Model

In the EST universe, the expansion of spacetime generates the inertial reference frame. It is the reference frame that minimizes the relative motion of all bodies in the universe. It is the rest frame toward which all freely moving objects converge by reducing their relative velocities.

Since it is the rest frame for all objects in the universe, it actually coincides with Mach's rest frame. However, there is one important difference. According to Mach, matter at rest in the universe defines the rest frame, a somewhat circular reasoning in view of Einstein's Special Relativity theory according to which all inertial frames are equivalent. In the EST, the scale expansion of spacetime results in Cosmic Drag which defines the rest frame by reducing relative velocities. The inertial reference frame is where all objects will eventually come to rest.

Since galaxies on the average are at rest relative to each other, they define a rest frame much like in Mach's principle. Furthermore, since Cosmic Drag also applies to angular rotation, a rest frame for rotational motions is also defined by the scale expansion of spacetime.

Unlike Newton's absolute rest frame which is assumed to exist in the absence of matter, or the expanding Big Bang universe model where stable small relative velocities are postulated but not explained, Cosmic Drag is a feedback mechanism in expanding spacetime that guarantees that relative translational and angular velocities are small. These small velocities average together to define an inertial reference frame.

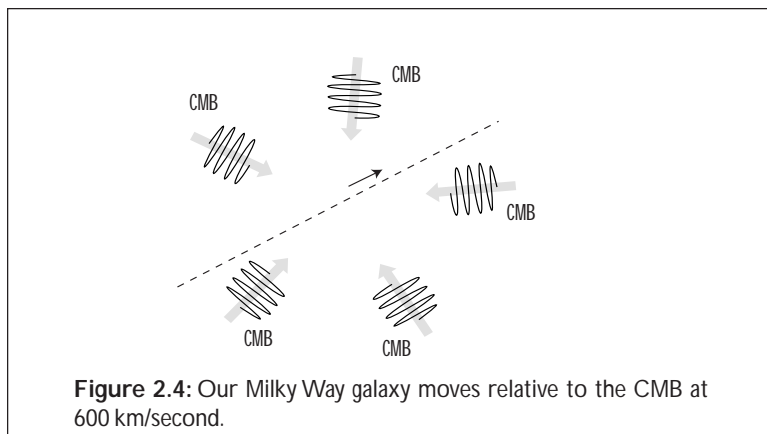
Observations of the Inertial Rest Frame

Currently, we know that the Milky Way is in motion relative to the CMB. We know this by measuring the temperature of the CMB in different directions in space. A slightly elevated temperature in a certain direction shows that we are moving in that direction. Doing the calculations reveals that the Milky Way is traveling at a velocity on the order of 600 km per second and directly confirms that a cosmological reference frame exists.

The existence of a cosmological rest frame invalidates one of the main postulates of dynamic motion put down by Galileo: that all inertial coordinate systems are equivalent. Although Special Relativity is based on this assumption, it does not invalidate this theory, since the speed of light is still the same to all observers.

However, we have to accept that a cosmological reference frame does exist and that inertial reference frames are not equivalent since it is possible to measure absolute motion relative to the CMB. The apparent

contradiction that a cosmological reference frame exists but that Special Relativity still applies is explained by Cosmic Drag, which only decreases the velocity of particles moving slower than the speed of light.



Expansion of Material Objects

Simultaneous expansion of the metrics of both space and time means that material objects also expand. The expansion of material objects along with the expansion of spacetime is another implication of the EST theory. At first this seems unbelievable, if not ridiculous. But the EST theory concludes that matter, energy, and spacetime are so tightly related that they are the same in essence, which makes the expansion of material objects make sense.

Consider a cosmos devoid of matter and radiation, i.e. a perfect vacuum with no energy. Let us play God and create an object, for example an apple. How big shall we make this apple? This is obviously not a simple question since there is nothing to compare it with. The concept of size has no meaning in an empty universe. There can be no absolute size or scale of material objects. As soon as we specify a certain size, we also implicitly specify the metrics of spacetime.

Conversely, the metrics of spacetime determine the scale of matter. Expansion of spacetime must imply a simultaneous expansion of material objects, not just the spatial expansion, but the expansion of all

four dimensions, including time. The scale of every subatomic particle increases and the scale of time increases in a way that physical laws are not affected.

This conclusion agrees with the General Relativity theory, whose relations are not altered by changing the scale of spacetime metrics. A universe where everything is twice as big including the length of a second is completely equivalent to our universe. If the universe expands by continuously changing the metrics of spacetime, the expansion must be a scale expansion of everything.

This expansion rate is quite slow; the diameter of the Earth increases by 0.1 centimeters (0.04 inches) per year. Such a small rate cannot be measured, not only because it is small but because all possible measuring devices (both reference distances and reference processes which are dependent on time) change as well.

Since the physics of everything remains the same, how can we know the scale is expanding? Just as one notices acceleration in space through the inertial force, the accelerating spacetime expansion has observable inertial effects, one being the redshift and another being Cosmic Drag. What other inertial effects might we notice? To answer this question, let us conduct two thought experiments looking at time expansion and space expansion separately.

Temporal Expansion

Assume that you can step in and out of a $\hat{O}0$ time expansion $\hat{O}0$ capsule with transparent walls through which you observe the outside world. When you step into the capsule where time is expanding, your own pace of time slows. Your clock runs slower and your heart beats at a slower pace. Inside the capsule, you will notice that everything outside the capsule seems to move faster. Molecules in a gas are moving more rapidly, which you interpret as a higher temperature of the gas, and the frequency of light is higher, which you interpret as higher energy. In short it appears that, when you step from the outside of the capsule to the inside, everything outside the capsule becomes more $\hat{O}0$ energetic. $\hat{O}0$

We may therefore guess that a continuously slowing progression of time may have the effect of increasing the energy density everywhere throughout spacetime. Since energy per volume element is equivalent to force per surface element, which is pressure, the slowing progression of time ought to create a cosmological $\hat{O}0$ field pressure $\hat{O}0$ that acts at all levels, i.e. spatial dimensions.

Spatial Expansion

Next, assume that you can step in and out of another capsule that is a \emptyset space expansion \emptyset capsule (without time expansion). Again, this capsule has transparent walls through which you can observe the outside world. When you step into the capsule, everything outside the capsule expands. Everything is in proportion, but the universe outside the capsule has a larger spatial scale.

Compared to the space inside of the capsule, the space outside appears diluted since the distances between all objects are larger and all objects are inflated over larger volumes. In short, it appears that when you step from the outside of the capsule to the inside, everything outside the capsule becomes less \emptyset energetic. \emptyset A continuously expanding spatial metric has the effect of reducing the energy density everywhere throughout spacetime.

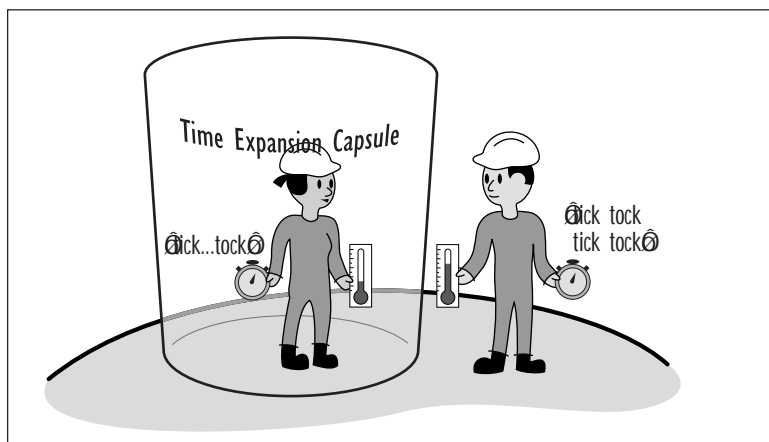


Figure 3.6: There is a higher energy density outside the time expansion capsule.

The Cosmic Energy Tensor

The inertial effects generated by the scale expansion are confirmed by modeling the spacetime expansion using General Relativity. The corresponding energy-momentum tensor is called the \emptyset Cosmic Energy Tensor \emptyset in the EST model. The Cosmic Energy Tensor expresses the vacuum energy density in a spacetime that is expanding in scale. It contains negative energy related to the spatial expansion and positive energy in the form of a pressure corresponding to the temporal expansion.

In the EST theory, the Cosmic Energy Tensor may be thought of as consisting of energy generated by the temporal and the spatial expansion. The spatial expansion provides negative net energy associated with a cosmological constant. The temporal expansion contributes with positive energy in the form of a cosmological field pressure. However, the total cosmic gravitational energy density is zero since the positive (temporal) component in the Cosmic Energy Tensor exactly cancels the sum of the three negative (spatial) components.

In the EST theory, spacetime equivalence and symmetry between the metrics of space and time determine the energy-momentum tensor. This is different from the standard approach by which the energy-momentum tensor is postulated based on some assumed cosmological energy density. Of course, if this assumed energy density is wrong, the resulting theory is flawed.

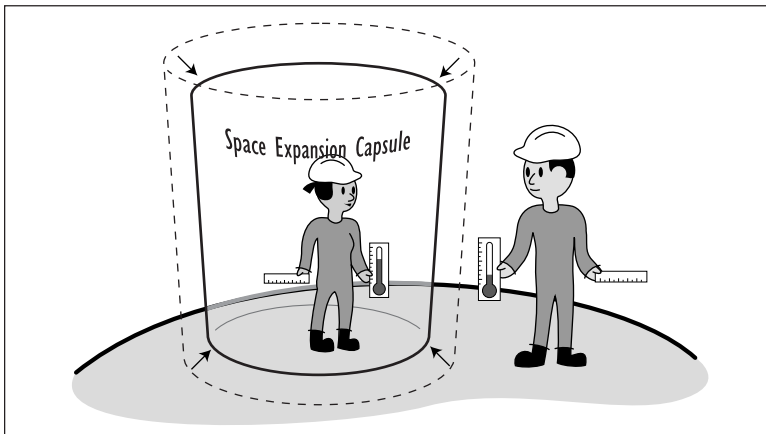


Figure 3.7: There is a lower energy density outside the space expansion capsule.

The EST theory adopts the point of view that spacetime rather than mass density is the primary constituent of the universe. The scale expansion defines the energy momentum tensor for a vacuum. The scale expansion generates positive and negative components in the energy-momentum tensor that cancel each other. The positive temporal component, which corresponds to mass density, has just the right energy to explain the missing Dark Matter of the Big Bang Theory. This suggests that the missing matter is nothing but spacetime energy and that the net energy density of the universe is zero.

The Energy-Momentum Tensor

A *tensor* is a mathematical object containing quantities called *components*. The *energy-momentum tensor* is a four-by-four tensor consisting of sixteen components, which specifies how energy is distributed in space and time. In an isotropic and homogenous universe (without shear stresses) it reduces to four numbers, one for time and three for space, out of which the three spatial components are equal. The standard thinking is that the energy-momentum tensor specifies the curving of spacetime and also the gravitational field. Extending this thinking to the cosmos, this tensor also controls the expansion of space in the Big Bang universe. Thus, the cosmological mass density controls the Big Bang expansion.

However, there is an opposite, equally valid, point of view that the curving of spacetime defines the energy-momentum tensor. This makes *spacetime* rather than *mass density* the primary constituent of the universe.

A net cosmic energy density equal to zero resolves the classical problem of an infinite space with constant positive energy density. In such a space, the gravitational potential at the surface of a sphere goes to infinity with the radius unless the net mass (energy) density is zero, which is the case in the EST theory. (In the section below titled *Matter and Gravity in Expanding Spacetime*, we explain that the presence of matter does not change the average energy density in the universe.)

Explaining Low Relative Velocities

In the EST theory, relative velocities of freely moving particles moving at speeds lower than the speed of light will decrease gradually with time. Einstein's equations tell us that photons and other subatomic particles moving freely at the speed of light will continue to move at the speed of light. The speed of light therefore remains constant in the EST theory, and the Special Relativity theory still applies locally.

The prediction that the relative velocities of freely moving particles will decrease with time is a new and bold proposition, but it matches our observations. If all relative velocities were equally likely, we ought to see a large scatter in galaxy velocities. However, the observed relative velocities between galaxies are generally quite small (less than one tenth of a percent of the speed of light) which suggests the existence of some mechanism that reduces relative velocities.

In the EST model, Cosmic Drag is a retarding force proportional to the velocity of galaxies. Cosmic Drag explains why the relative velocities of galaxies are a small fraction of the speed of light. Since these velocities are small, we can define a reference frame to be, for example, the frame that minimizes the kinetic energy of all moving objects in the universe. This reference frame could be considered to be the universal \bar{O} rest frame.

Explaining the Large-Scale Motion of Galaxies

With Cosmic Drag acting in proportion to velocity, all inertial particles left to coast forever would eventually come to rest relative to each other. But such a state of rest is never reached due to the effect of the field pressure generated by the slowing progression of time. This pressure could stimulate relative motion of galaxies much like a gas pressure causes molecules in a gas to move.

The influence of field pressure resulting from the spacetime expansion could explain the recently observed large-scale motion of galaxies and galaxy clusters within regions several hundred million light years wide. Such large streaming motions can hardly be caused by gravitational effects but could be caused by \bar{O} spacetime winds due to field pressure gradients generated by slightly different expansion rates across different regions of spacetime. Such \bar{O} spacetime winds could serve to equalize the expansion rate throughout the universe much like winds in the atmosphere equalize the air pressure here on Earth.

Einstein's Cosmological Constant

Einstein introduced the *Cosmological Constant* to solve a problem with his static universe. In such a universe, the gravitational attraction between galaxies would eventually cause all of them to converge to one location. He solved this problem by assuming that, in addition to gravitation, there is repulsive force acting throughout the universe of just the right strength to counteract the gravitational contraction. This force appears as a constant in his General Relativity equations—the Cosmological Constant. Later, when the expanding universe was discovered, he realized his Cosmological Constant no longer was needed and regretted ever suggesting it.

The Cosmological Constant is not dead; it has been revived from time to time for various reasons. In the context of the EST theory, it reappears in combination with a cosmological pressure. This combination generates positive and negative energy densities, which cancel each other. As a result, there is no net gravitational energy in the EST universe.

Geodesics

Geodesics are trajectories followed by very small freely moving particles. In the absence of forces, these trajectories are straight lines, while in gravitational fields they may be curved. In classical physics, a freely moving particle keeps moving forever at the same speed in a straight line. In the EST theory, it still moves in a straight line but the velocity decreases. The length of the geodesic trajectory becomes finite when the particle stops. (An exception to a finite trajectory occurs when the mass of the particle is zero, as is the case for a photon. A photon loses energy by redshifting rather than slowing down.) The reason a particle having mass slows down is Cosmic Drag, which causes all particles to lose kinetic energy relative to the cosmological rest frame.

The Progression of Time Driven by Energy Flowing from Time to Space

If we model temporal expansion without the corresponding spatial expansion in General Relativity, we find that all components of the energy-momentum tensor are zero. Thus, if there is no spatial expansion, changing the pace of time will by itself not change the cosmic energy density. The implication of this simple observation is that the pace of time only has physical meaning if space expands (or contracts). In other words, it is the expansion of the universe, the expansion of spacetime, that causes time to progress. The ticking of the clock is directly related to the cosmological scale expansion.

On the other hand, if we model an exponential expansion of space without the corresponding temporal expansion, we find that the net energy density in the universe is negative. Spatial expansion decreases the energy density since space is diluted and there is less energy per volume element. Adding the temporal expansion counteracts the effect of spatial expansion and makes the net energy density zero. This demonstrates that a slowing pace of time has real physical effects when combined with spatial expansion. In this case, a continually slowing progression of time releases energy.

Thus the EST theory tentatively answers the age-old question about the nature of time and what makes it progress. The temporal and spatial expansion could together create the energy flow that powers the universe. Energy released by the slowing progression of time in the form of a cosmological pressure eternally flows into expanding space. In the process matter, light, and life are created. Light is redshifted to keep the energy density of the universe at a constant. This is similar to

how energy flowing from the Sun, some of which is radiated back into space, sustains life here on Earth.

Time cannot progress without spacetime expansion. Thus, the cosmological expansion is not just an interesting property of the universe; it is necessary for our existence. This also brings us a small step closer to the answer of one of the most fundamental questions of all: Why is there anything rather than nothing? The EST theory suggests that we exist because space and time in the universe happen to expand. In a static universe, time would stand still and there would be no energy, no matter, and no life.

The universe exists because of a tension between space and time. This duality between two opposing but cooperating forces appears to be a fundamental symmetry property of the universe. Perhaps this is the ultimate expression of a totally relativistic universe where there are no absolutes and where any feature or property only has meaning in relation to a corresponding contrasting symmetry.

Expanding Spacetime has no Black Holes

Shortly after Einstein published his General Relativity theory in 1916 a young mathematician, Karl Schwarzschild, published a paper presenting a static, spherically symmetric, solution to Einstein's equations. This solution, which assumes that the energy-momentum tensor for vacuum is zero, implies that matter under the pull of gravitation may collapse into an infinitely small point and form a Black Hole. This Black Hole is surrounded by an event horizon located at a distance from the center where the gravitational field is so strong that not even light can escape.

Much time and effort has been expended trying to make sense of the Schwarzschild solution inside the Black Hole event horizon. Perhaps this solution simply does not exist in reality. The strange behavior of the Schwarzschild solution inside the horizon should perhaps be taken as a clear indication that something is wrong with the standard model.

Schwarzschild's Black Hole solution to the equations of General Relativity crucially depends on the assumption that all components of the vacuum energy-momentum tensor disappear. In the EST theory, the Schwarzschild solution no longer exists with a vacuum energy given

by the Cosmic Energy Tensor. Therefore, Black Holes do not exist in the EST model. This is comforting since Black Holes cannot exist in an eternal universe because all matter could eventually end up in Black Holes if they did exist.

In retrospect, one may wonder how people started to seriously consider Black Holes in the first place. Undoubtedly, these singularities should not exist in the universe. However, Einstein's equations seemingly tell us that they do, so where lies the problem? Perhaps this is a case where we are attempting to force reality to fit our model rather than adjusting our model to match reality. In all other cases of physical models which have solutions that approach infinity (called singularities), the models have needed to be adjusted in order to describe what really happens.

Black Holes

The General Relativity relations (assuming an energy-momentum tensor with zero components) predict that nothing can prevent a gravitational collapse if the mass density becomes high enough. It is generally believed that a star several times larger than the Sun might, after all nuclear fuel has been expended, collapse under gravitation and reach a state where nothing can prevent further collapse into a singularity of infinitely small size. This is a *Black Hole*, which gets its name from the fact that gravitation is so strong in its vicinity that not even light can escape its pull. Obviously, if Black Holes really exist they are very strange objects indeed. Although people speculate that galaxy cores may contain Black Holes, nobody has been able to prove that they really exist.

In the EST theory, the energy-momentum tensor is not zero, and as a consequence, Black Holes are not a possible outcome according to Einstein's equations.

General Relativity is based on the fundamental principle of equivalence, and there is no reason to doubt that the theory is right. However, to paraphrase Einstein, the left side of the equations may be likened to a beautiful palace of perfect proportions while the right side is no more than a paltry shack. The left side expresses the geometry of spacetime and the right side the energy distribution of a vacuum.

The problem is that we do not really know much about the vacuum energy. Since we do not know, we have assumed that without matter or radiation this energy is zero. It is this assumption that permits a singular solution to the equations (which we call Black Holes). However,

with a vacuum energy as predicted by the EST theory, Black Holes cannot exist. The EST theory suggests that a vacuum may contain energy in a form different than matter or radiation. This energy will prevent the formation of Black Holes.

Chapter 7 presents results from the EST model and proposes that quasars are what our universe produces where Schwarzschild's math predicts Black Holes.

Matter and Gravity in Expanding Spacetime

When modeling the universe, a standard approach is to derive the solution to the General Relativity relations with an energy-momentum tensor corresponding to some postulated cosmological mass distribution, which usually is assumed to be homogeneous and isotropic. In the EST model, the symmetric spacetime expansion controls the form of the energy-momentum tensor.

We have shown that a slowing progression of time may release energy throughout the universe and that this could be the main source of energy in the universe. We also conclude that material objects must expand together with spacetime. Next we ask whether there is a relationship between matter energy and spacetime energy.

Solving the General Relativity equations assuming vacuum energy like the Cosmic Energy Tensor rather than one identically equal to zero, the initial result is that oscillating metrics of space and time inside a spacetime bubble under certain conditions could create a gravitational field outside the bubble. To an outside observer, this vibrating spacetime bubble would look like a mass particle.

This indicates that the essence of matter could possibly be vibrating spacetime energy and that the negative energy of spacetime including the gravitational field could equal the positive energy of the mass element that creates the gravitational field.

The formation of matter from spacetime energy could create a region with depleted, negative energy surrounding the mass and the gravitational field. This suggests that matter could be created from spacetime energy without changing the net energy in the universe. Matter would only create minor, local distortions of the cosmological energy distribution. If matter were a form of spacetime it would be quite natural that matter and spacetime expand together.

Gravitational Energy

It is widely accepted that the gravitational field surrounding a mass element contains negative energy that seems to balance the positive mass energy. However, in the standard theory there is no trace of this energy in the energy-momentum tensor, which is equal to zero. This is puzzling since the negative energy of the gravitational field ought to express itself in the energy-momentum tensor relative to *some* reference frame. Yet, all components of this tensor are zero regardless of the frame of reference.

In EST theory, a gravitational field cannot exist without modifying the vacuum energy momentum tensor and creating negative field energy. Perhaps a gravitational field cannot exist without the cosmological expansion? It may be the scale expansion of spacetime that creates the energy for matter and generates the gravitational field.

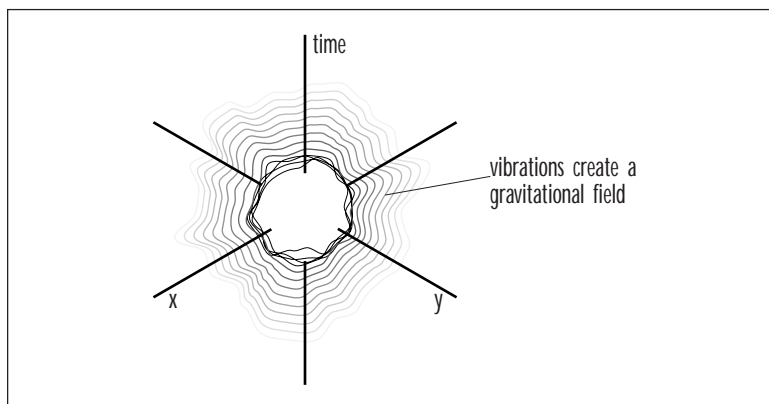


Figure 3.8: A vibrating spacetime bubble looks like a mass particle.

Quantum Ontology, Explaining the Quantum World.

The mathematical underpinning of the EST theory is uniquely elegant. Not only does it describe our observations of the distant cosmos, but it also provides a theoretical basis for the quantum world. A single physical model that accounts for observations both at the cosmological and at the subatomic level has never before existed. In the EST theory, it is the expansion of spacetime that explains both our observations at the distant horizon of the universe and our observations of the behavior of the tiniest particle.

Starting with Einstein's General Relativity equations, we make the assumption that the expanding metrics of spacetime and the discrete progression of time cause the metrics to oscillate during the expansion at very high frequencies.

Given this assumption, it is possible to derive the de Broglie matter wave, David Bohm's momentum relation, and the relativistic quantum equations of Klein-Gordon and Dirac. Furthermore, the Schrödinger Wave Equation appears as one part of a more general wave equation. These relationships make up the current foundations of Quantum Mechanics. Yet they are formulas that previously have not been considered derivable from any physical laws or fundamental principles.

Without the EST theory, the quantum mechanical relationships are essentially separate discoveries arrived at through trial and error. They are useful for describing the observed behavior of particles but are of unknown origin.

With the EST theory, the quantum mechanical relationships are natural consequences of General Relativity. In addition, the unexplainable double-slit particle interference experiment, which has confounded generations of students, has a simple and direct explanation.

A Quick Review of the Development of Quantum Theory

Basic physics teaches us that light and radio waves are electromagnetic oscillations and that light waves will interfere and cause interference fringes. Newton thought that light came in particles rather than in waves, and from Newton's time to this day, people sometimes have favored the wave interpretation of light and sometimes the particle interpretation. Different experiments support each of these different perspectives.

By the end of the 19th century, the emphasis was firmly on light as a wave phenomenon, since this explained interference and diffraction. However, at the beginning of the 20th century, after Planck proposed

his black body radiation law, which was based on light as $\hat{\phi}$ quanta, $\hat{\phi}$ the particle interpretation returned. Einstein suggested that light came in particles, later called photons, realizing that these particles could explain the photoelectric effect, which cannot be explained by the wave theory.

Louis de Broglie then made a bold speculation: If light really is made up of particles that act like waves, then why shouldn't particles in general also have their own waves? De Broglie used Einstein's relation for the energy of a photon and its frequency suggesting that the corresponding relation also might apply to particles like the electron, proton, and neutron.

Then Erwin Schrödinger, one of the founders of quantum theory, picked up de Broglie's idea and carried it further to arrive at the famous Schrödinger wave equation. Today, more than anything, the Schrödinger wave equation is associated with Quantum Mechanics.

Niels Bohr and The Copenhagen Interpretation

De Broglie tried to further develop his proposal that all particles also behave as waves, but his effort dissipated in a whirlwind of the rapid development of quantum theoretical formalism in the 1920's. This mathematical formalism, which was championed by Werner Heisenberg, Max Born, P. A. M. Dirac, Pascual Jordan, and others, was based on Heisenberg's algebraic method. It became a dominant approach and a school of thought that gathered around Niels Bohr in Copenhagen. Later this mathematical formalism of Quantum Mechanics became known as the Copenhagen Interpretation of quantum theory.

Bohr was faced with the enigmatic and unresolvable problem that matter seems to behave both like particles and waves (known as the particle-wave duality). Bohr developed the philosophy of $\hat{\phi}$ complementarity, $\hat{\phi}$ whereby no attempt would be made to explain this strange dual property of matter. Instead, Bohr insisted, we should accept as a fact that matter has two different faces that cannot be reconciled.

This way of dealing with an unsolvable problem might be acceptable while awaiting some resolution. It allows developments to continue without getting sidetracked by philosophical speculation. But such a position is inadequate in the long run. Adopting this pragmatic view of complementarity means that the outcome of an experiment depends on what we are looking for (how we design an experiment). If we design an experiment to look for particles, we will find particles. If we

design an experiment to look for waves, we will find waves.

Unfortunately for the future development of quantum theory, Bohr's dominance carried his philosophy of complementarity beyond its initial pragmatic position. He argued that the quantum world is such that two complementary viewpoints are needed and *always will be needed* in dealing with quantum phenomena. To Niels Bohr, it was not only futile but also wrong to seek a deeper explanation.

Although many prominent people of his school did not subscribe to Bohr's view, his influence was such that generally these people officially supported the Copenhagen Interpretation. This support can be seen as a closing of ranks in the struggle between two groups: Bohr's school in Copenhagen and a loose alliance of prominent but dissenting scientists, most notably Schrödinger and Einstein.

Quantum Dissention

Schrödinger was convinced that his wave equation could describe both the particle and wave aspect of nature, and he suggested different ways to incorporate the particle into the wave equation. Einstein, with his unerring feeling for physics and honest intellect, objected to the very suggestion that no deeper explanation for quantum phenomena was possible and insisted that quantum theory in its current form must be incomplete. He strongly felt that something was missing.

Einstein could not tell exactly what was wrong, but he sensed that the mathematical quantum formalism, and Bohr's complementarity, fell far short of a complete theory. He repeatedly challenged Bohr over many years. Bohr's dominating influence is evidenced by the common perception today that Bohr won these arguments with Einstein and that quantum theory in its current form is a complete theory that tells us all we ever can know about the subatomic world.

With the development of the EST theory and the proposal that the stepwise spacetime expansion creates an underlying spacetime oscillation, it seems that Einstein was right. Not only can the quantum world be understood, but it also has a simple and elegant structure of its own.

David Bohm and the Pilot Wave

In the beginning of the 1950's, a remarkable scientist and philosopher, David Bohm, embarked on a lonely quest in search of the underlying explanation to the quantum world, which he sensed must be there. He showed that, if particles were assumed to move under the influence of a certain guiding function derived from Schrödinger's wave equation,

all the results of Quantum Mechanics could be explained.

After publishing a paper on this in 1952, he found out that the same idea had been suggested earlier by de Broglie, who now joined Bohm in a revival of his ψ pilot wave theory from the Solway conference of 1927.

Einstein, still a vocal critic, stayed out of this development. Perhaps he felt that introducing this rather magical guiding function wasn't much of an explanation. But the importance of Bohm's and de Broglie's work is that it showed that there was at least one other approach to quantum theory that might open up the possibility for further research and a deeper understanding.

Unfortunately, Bohm's new theory was not received well by the scientific community. Why abandon the standard interpretation in favor of a new speculative theory unless it could offer some practical advantages? Furthermore, the spirit of Bohm's theory went against the now dogmatic Copenhagen Interpretation, since it suggested a possible physical explanation for quantum theory based on particle motion.

Today, discontent with Quantum Mechanics in its current form is evident and is growing stronger day by day. The theory in its current form as strongly influenced by the Copenhagen Interpretation simply cannot be understood. Quantum theory is a memorization and rule-based way of doing physics that delivers the right results but there is no explanation of why it works as well as it does.

Even the most competent specialists, for example the late Richard Feynman, have admitted this fundamental shortcoming. Recently a growing movement is aimed at introducing Bohm's theory into the mainstream epistemology by having it taught as an alternate approach to quantum theory. This is a sound development that will hopefully gain impetus from the new insights described here and in scientific papers on this subject.

The Particle, the Matter Wave, and Oscillating Spacetime Metrics

In the EST theory, the universe expands in both space and time with the pace of time changing in discrete steps. This mode of expansion causes high frequency oscillations in spacetime everywhere in the universe. As space expands, spacetime repeatedly becomes incrementally ψ stretched. This is countered by an incremental expansion of the pace of time that ψ resets spacetime to preserve a constant scale.

If we model these high frequency oscillations in General Relativity, we find that they might exist at infinitely many frequencies without

generating gravitating energy. However, we also find that there may be modes of oscillation within small regions that create gravitating energy.

If the oscillation frequency is such that, when multiplied by Planck's constant, it equals the rest mass energy, then this region looks very much like a particle. If such a small region were to move through space, it follows directly from Special Relativity that it will be accompanied by a spatial modulation of spacetime, which looks exactly like the de Broglie matter wave.

Thus, oscillating spacetime metrics could generate both the particle's rest mass energy and its accompanying matter wave!

The matter wave is a spatial modulation of the amplitude of the temporal oscillation in spacetime metrics that creates a particle's rest mass energy. When a particle moves through space, the amplitude of the high frequency oscillation that sustains it changes with position creating a matter wave with a wavelength that decreases with increasing velocity.

Thus, the rest mass energy of a particle is at least partly created out of nothing but oscillating spacetime (some of the energy might be electrostatic). And, as a consequence of a modulation in the amplitude of this spacetime oscillation, a matter wave is created when the particle moves. In this view, the particle and wave aspects are inseparable since they are created by the same source - oscillating spacetime metrics.

Particle Interference and the Double-Slit Experiment

One of the first things a beginning student of quantum theory encounters is the double-slit particle interference phenomenon. Particles pass through two narrow slits in a screen and then impinge on a second screen making small dots. After many particles have hit the second screen, an interference pattern develops in the form of light and dark stripes similar to light interference fringes.

It looks like we are dealing with waves passing through the two slits together with the particles, but the interference pattern appears even if the particles arrive at the screen one at a time. It appears that a particle somehow interferes with itself, but how can this be possible?

It was this strange phenomenon and the inability to explain it that motivated Bohr to develop his idea of complementarity. After having struggled with this riddle and discussing it with leading scientists over a long time, he came to believe that it was impossible to explain the particle-wave duality and that we just have to accept that nature is

strange. Somehow matter is both particle and wave.

In standard Quantum Mechanics, the double-slit problem is handled by assuming that the particle passes through both slits simultaneously so that it can interfere with itself. Although this doesn't make much physical sense it seems to give the right answer. The standard interpretation by which a wave function expresses probability helps, since it can be argued that we are dealing with probabilities rather than with actual events. Still, this doesn't really explain why interference appears with just one particle passing through the slits at a time.

The first indication that it might be possible to explain single particle interference came from David Bohm who used his guiding function to explore the trajectory of a particle. This was a significant step since it showed that interference fringes would appear if the particle went through one of the two slits being guided by a wave function emanating from the two slits. However, it went only part of the way, since the wave function seemingly still had to go through both slits, which would imply that the matter wave and particle must follow different trajectories. It is difficult to understand how the particle can be guided by interfering waves coming through both slits when it already has passed through one of these slits.

An EST-Based Explanation

In the EST Theory, the high frequency oscillations of spacetime expansion create small regions of gravitating energy that are particles of matter. When such a small region of gravitating energy (a particle) moves through space, its motion creates an accompanying wave called a matter wave. In the EST interpretation, the matter wave is a modulation of the amplitude of the very high frequency oscillation in spacetime metrics that defines the particle. It is a relativistic phenomenon generated by the particle's motion. As the particle moves, this standing wave modulation would extend both in front of the particle and behind it.

Let's assume that a particle has just passed through one of the two slits. Its matter wave extends backward to the screen with the two slits. Let's further assume that this matter wave does not vary at the screen. This is a boundary condition that fixes the position (phase) of the wave along the screen.

The phase of the matter wave is constrained at the screen, but the two slits do not constrain the phase of the matter wave. The matter wave extends backward through the two slits unconstrained. Because of this, an interference pattern develops on the particle side of the slitted

screen that surrounds and extends in front of the particle. This interference pattern makes the amplitude of the matter wave vary slightly from point to point.

At locations where the distances to the two slits differ by an integer number of matter-wave wavelengths, the amplitude of the matter wave is larger than at locations where the interference is destructive. As a consequence, the particle is surrounded by self-induced matter waves that vary with position. Note that this matter wave pattern is generated by the moving particle and that the pattern develops because of the double-slit geometry that the matter wave encounters as it extends behind the particle. Thus, we are dealing with self-interference. But, how can this affect the particle's motion?

The Generalized Guiding Function

If the particle changes direction under the influence of the wave field, as predicted in the pilot wave theory, we should be able to see this in the particle's geodesic. This geodesic is essentially the straight line through spacetime, as viewed by the particle. By starting with the General Relativity equations and assuming oscillating spacetime metrics, we can derive a generalization of Bohm's guiding equation.

With a mathematical transformation of the generalized guiding equation into the particle's coordinate system, we find that the generalized geodesic gives the direction and velocity of the particle. If the cosmological expansion occurs in steps so that the pace of time changes discretely, as suggested by the EST, the direction and velocity obtained from the generalized geodesic can be interpreted as indicating where the particle will be in the next step. In the discrete expansion mode of the EST theory, events progress like frames in a movie. There is no motion or velocity at any particular instant. Velocity and acceleration are concepts constructed after the fact from the particle's trajectory.

Over two thousand years ago, Greek philosophers argued that continuous motion is impossible. They used Zeno's paradox and reasoned that if a particle were to move between two locations continuously it would have to pass over infinitely many points between these two locations in a finite time, which in their view was impossible. They therefore concluded that the nature of all motion must be discrete.

With the EST theory, we arrive at the same conclusion by a different line of reasoning based on spacetime equivalence. If all motion is discrete, instantaneous velocity does not exist. Motion and velocity are associated with a sequence of locations. This might explain why veloc-

ity and position are incompatible concepts in quantum theory, where it is impossible to simultaneously determine both velocity (momentum) and position. We see that velocity is associated with a minimum of at least two positions. At a certain position, velocity does not exist more than as a potential. Given only the position, the velocity is undetermined. Conversely given a velocity, the position is undetermined. This is the essence of Heisenberg's uncertainty principle.

The generalized geodesic gives us the direction of motion for the particle. The motion of the particle creates matter waves that interact with the geometry of the double-slit screen, creating a rippled pattern in the spacetime surrounding the particle (as seen by a stationary observer). The geodesic guides the particle toward regions where the wave function's magnitude is large, which any given particle will see as a straight line through what the observer sees as rippled spacetime. Thus, according to the observer, the particles are deflected slightly to form an interference pattern.

From the observer's perspective, the guiding action of the geodesic is based on a feedback response. If, by chance, the particle initially moves into a region where interference is destructive and the magnitude of the wave function small, it automatically changes direction moving into a region with constructive interference. It appears that the magnitude of the surrounding wave function increases with time because the changing position increases the matter wave resonance. Since the particle prefers regions where the magnitude is large, it will together with other particles form an interference pattern on the screen.

All this follows from the generalized guiding function, which is sufficient to explain it. But what is the basic principle behind this guiding action? General Relativity can be derived from the minimum action principle, which says that nature always selects the path that minimizes energy expenditure. This is the golden rule of all physics dealing with motion. This principle is thus built into General Relativity.

Viewed from the moving particle, motion is always in a straight line through spacetime without forces or acceleration and without losing energy. The modulation of the spacetime metrics that create the matter wave bend spacetime relative to an outside observer. From this external viewpoint, the particle's trajectory might be curved.

Self-Interference

The above-described guiding action of the double-slit experiment, where a particle interferes with its own matter wave in a feedback process, is

a unique and central feature of the quantum world. Particles communicate via their matter waves and continuously sense their environment (spacetime metrics). Electrons in an atom move in regions where self-interference maximizes the amplitude of the wave function and are constrained to remain within these regions by the guiding action of the geodesic. Regions of resonance are regions of lower action potential and therefore stable, which explains the discrete energy levels of atoms. Matter wave interference takes place instantaneously; it does not propagate at the speed of light. It can span vast distances, which explains the non-local action characteristic of quantum theory.

Gravitational Bending of Spacetime

The bending of spacetime by gravitation is what creates the elliptical planetary orbits. Similarly the motions of electrons in an atom could be explained by spacetime modulation in the form of the quantum mechanical wave functions. Again, the electron moves in a straight line without forces in its local spacetime field.

The Collapse of the Wave Function

The philosophically problematic collapse of the wave function, where the mere act of observation selects one of its possible branches and seemingly alters the future course of events, has a very simple and direct explanation.

As Einstein suspected, quantum theory is incomplete: it does not take into account that the wave functions are actually spatial modulations of temporal oscillations, with each oscillation frequency corresponding to a certain energy state. This means that different branches of the wave function do not interfere since they oscillate at different frequencies.

The usual way of expressing a wave function, as sum of basis functions, cannot explain why they are not simultaneously active and do not continuously interfere. But if each basis function oscillates at its own frequency, they cannot interfere. Each will have its own unique geodesic; thus, each represents a different possibility.

Only one basis function can be active at any particular time since a particle cannot have different energies simultaneously. As a result, the measurement problem and the collapse of the wave function simply disappear. The particle is in one of the basis states regardless of whether or not an observation is made.

We can model this by multiplying each basis function with the corresponding oscillating term, which in effect tags it with a different label for each energy level. Only terms with the same label (oscillation frequency) can interfere.

This new representation can readily be adopted since it does not affect the practical use of the current quantum mechanical machinery. From this it is also clear that the basis functions do not exist unless activated by the presence of a particle. The different wave function solutions to a wave equation are no more than possibilities; most of them are empty in Bohm's language. They do not exist in reality other than as alternatives or propensities with certain probabilities. Like a hole in a flute determines a certain note, that is not heard unless the flute is played, a wave function represents a potential that is not realized unless a particle is present.

Schrödinger's Cat

A cat is locked inside a closed steel box together with an apparatus that releases poison gas upon the decay of a radioactive atom. (Apologies are in order for the insensitivity to the cat. Let us assume that it is old and should be put to sleep.) The time of this radioactive decay is completely random so that at any moment we don't know whether the decay already has happened or if the cat is dead or alive. In quantum mechanics the condition of the cat is modeled by two wave functions, one corresponding to the cat being alive, the other to it being dead. According to this model the cat is both dead and alive as long as we do not open the box and find out. The wave functions collapse into one of the two alternatives as soon as we know if the cat is dead or alive. This suggests that the cat is in a suspended state between dead and alive and that a conscious observer must be involved in the wave function collapse. Now, the scientist conducting the experiment, Wigner, asks a friend to look into the box and to tell him later if the cat was dead or alive. Did the quantum mechanical wave function collapse at the instant when the friend opened the box and found out, or later when he told Wigner what he saw? There is no answer to this question.

Deriving a Generalized Schrödinger Equation

The Schrödinger equation is and has always been the centerpiece of quantum theory. However, from the very beginning, when Edwin Schrödinger discovered this equation, the relationship between the Schrödinger equation and General Relativity Theory has been mysterious. Initially, he tried to derive a relativistic form, but found that it did not agree with the observed spectral line frequencies. He was surprised when he found that agreement with the non-relativistic form is excellent. Since then, all attempts to derive a relativistic form of the Schrödinger equation have failed.

The reason for this failure is that the true nature of the quantum mechanical waves has not been understood. These waves are thought to be probability distributions, but they are not. Instead, they are modulations of very high frequency oscillations in the metrics of spacetime.

Based on this new information, it is possible to derive a generalized form of the Schrödinger equation where the standard Schrödinger equation appears as one part of a more general solution. The new solution includes, in addition to the standard Schrödinger equation, a time dependent function expressing the quantum jumps between energy levels. This function is inactive and equals zero if the electron is in one of its stable states, but is activated when a jump occurs.

During a jump, the new function, the \hat{O} jump function \hat{O} controls the motion of the electron by smoothly adjusting its velocity to the new lower quantum state. When the electron drops from a higher to a lower level, it initially gains kinetic energy from the electrostatic field. Half of this additional energy must be bled off before it can resume stable motion at the lower level.

The jump function decelerates the electron sharply, and the emission of a photon sheds the excess energy. The adjustment to the new state takes place exponentially with a time constant equal to the light time of the radial distance to the nucleus. This means that the electron moves close to the speed of light during the jump.

The jump function guides the electron to peaks or valleys of the Schrödinger wave function. However, since the geodesic, which describes the electron motion, also contains random accelerations, the location of the electron will not be constrained to the peaks and valleys but will on the average stay close to these regions. This agrees with the standard probability interpretation but the new interpretation of the Schrödinger wave solutions also explains the underlying physics. The

new generalized solution for the Schrödinger equation, containing the jump function, for the first time describes the quantum jump as a well-defined dynamic process.

It is the realization that the wave functions are modulations of high frequency carrier oscillations that makes it possible to derive the generalized Schrödinger equation including the dynamic jump function.

A Birds-Eye View

Quantum theory, as taught today, is engulfed in mystery. It is a magic black box of unknown design that correctly answers most questions we put to it. By chance scientists have found this wonderful box, but what is inside it and how come it works so well?

Flying high over the ocean, you might see a ship moving at a steady pace in a fixed direction. At a lower altitude you see the ocean waves, and as you get closer you notice how the ship moves up and down and sideways by the wave action. A little closer and you see that the location and speed are not constant but vary slightly. A Ping-Pong ball is thrown overboard. Following its motion you find that both its velocity and position change unpredictably when it rides on top of the waves.

Like a Ping-Pong ball on the ocean, particles moving through the fluctuating spacetime metrics don't move in straight lines with constant velocities but move in increments with changing directions influenced by local fluctuations in the spacetime metrics. This is the world that the black box of Quantum Mechanics describes. To find out what happens to the particle, you could in principle either track the particle directly or follow it indirectly by noticing the spacetime fluctuations.

Quantum theory uses the latter approach. It is based on the spacetime waves, which are the solutions of wave equations. Thus, in Quantum Mechanics, velocity is defined using the wave shape (the derivative of wave function) on which the particle rides rather than the actual particle velocity; the particle's position is on the average determined by the crests and valleys of the wave function.

These solutions differ in principle from the real motion of the particle, which is well defined although unpredictable. Knowing that the particle is subject to the modulation of the spacetime metrics demystifies quantum theory, provides it with a firm basis, and opens up a new world of possibilities.



Chapter 4: Enigmas and Discrepancies in the Big Bang Theory

Having explored some of the implications of the Expanding Spacetime theory and seeing some of the ideas that emerge, it is now time to look at flaws and enigmas of the Big Bang theory and how the EST theory is free of these flaws and resolves the enigmas.

The Big Bang Creation Event

The most obvious conceptual problem with the Big Bang is the creation event, a moment when space, time, matter, energy, and all laws of physics, were created. The creation has to be taken on faith, since there is no physical explanation for the instantaneous creation of everything from nothing.

After tentatively accepting the creation event, several unresolved problems remain. If the universe really expands, what is it expanding into? It would be simple to understand the expansion if the creation took place in an already existing space. However, we would then have to explain where this preexisting space came from. If it was there $\hat{O}0$ from the beginning $\hat{O}0$ there must have been a $\hat{O}0$ beginning before the beginning. $\hat{O}0$ If a temporal or spatial edge of our universe exists, what is beyond the edge? This is an enigma without solution. The modern view is that matter, energy, and spacetime must have been created together at the same instant. However, nobody knows how or why this happened, or what existed before or even if there was a $\hat{O}0$ before $\hat{O}0$ before the Big Bang.

The Age Enigma

Some stars in the Milky Way and many distant galaxies appear to be much older than the age of the universe. Furthermore, large structure formations such as galaxy clusters, filaments and sheets stretching over hundreds of millions of light years cannot have had time to form since the beginning of time. This is known as the age enigma. The universe seems to be a lot older than predicted by the Big Bang theory.

When we look at the most distant galaxies, we are looking at light that left the galaxies billions of years ago. Far away we would expect to see images of new, forming galaxies. But instead we see fully formed galaxies at distances exceeding 12 billion light years. According to the most recent estimates, the universe is about 12 billion years old. There is a contradiction since galaxies take billions of years to fully form under the influence of gravitation.

To resolve this problem of galaxy formation within the framework of the Big Bang theory, scientists make the ad hoc assumption that Dark Matter exists. Dark Matter cannot be observed other than indirectly by its gravitational effect, therefore it exists only in theory. Dark Matter is said to help speed up galaxy formation, fixing the flaw in the Big Bang theory. However, this Dark Matter cannot by itself explain galaxy formation without an additional assumption that, from the beginning, there was a pre-existing bias in the Dark Matter distribution. This bias somehow created mass concentrations that provided the seeds for future galaxy formation.

In the EST theory, the universe is eternal. Galaxies and stars can be as old as they are observed to be. There is no need for Dark Matter or bias. Both the creation event and the age enigma simply disappear.

Galaxy Formation

Given a certain initial distribution of tiny particles (dust) in space we can compute how long it will take for the dust to condense into stars under the pull of gravitation and the additional time that would be required for the stars to congregate into galaxies. Furthermore, in order to create the universe we actually see, galaxies have to form galaxy clusters and clusters form sheets and filaments on a scale of hundreds of millions of light years. The time required for all this to happen is at least 100 to 200 billion years, an order of magnitude longer than the Big Bang age of the universe of 12 to 15 billion years. This is an acute unsolved problem for the Big Bang theory.

The Horizon Enigma

Another well-known Big Bang paradox is the $\hat{\infty}$ horizon enigma. $\hat{\infty}$ Looking out into space in two directly opposite directions we find that the universe looks exactly the same on a large scale. That is, electromagnetic radiation from very remote regions has the same temperature and spectral distribution.

In the framework of the Big Bang theory, this is difficult to explain. We ought to see some differences when we look far out in different directions into the cosmos. These very remote regions cannot have had time to communicate or equalize with each other since the beginning of time. Although light from the remote regions has had time to reach the Earth, situated at some point between them, they have not yet seen each other given the Big Bang age of the universe. How can they then appear to be so similar?

Unless we accept that regions in all directions emerging from the Big Bang were created with identical properties $\hat{\infty}$ from the beginning, $\hat{\infty}$ there must have been a mechanism whereby the energy in the universe could equalize very early.

The horizon enigma motivated the *Inflation Theory* according to which the cosmological expansion started out relatively slowly. During this initial slowly expanding epoch, energy had time to equalize across the whole universe. Then the expansion suddenly picked up pace and in a very short time, during which regions in the universe moved apart exponentially at speeds far exceeding the speed of light (which is believed possible since space itself expands), the universe was enormously inflated. After this inflationary epoch, the expansion slowed down again to assume the rate of expansion we see today.

This highly speculative scenario was originally invented solely to explain away the horizon enigma. The Inflation Theory also predicts a certain specific mass density, the $\hat{\infty}$ critical density. $\hat{\infty}$ However, observations show that the actual mass density in the universe is far below this critical density.

The Expanding Spacetime theory does not have the horizon enigma. In the EST theory, the average distance between galaxies does not change with time, and the age of the universe is unlimited. In such a universe, every remote area of space looks the same to our telescopes. Light will have time to reach everywhere, no matter how large the universe. Without spacetime expansion we would be able to see infinitely deep into the universe and, in fact, the night sky would shine bright with star-

light since every line of sight would eventually intercept a star. But the spacetime expansion dims the light from distant sources, redshifting the most distant sources to such low energies they disappear.

Because all regions of the universe communicate and have always done so, they ought to, and do have, the same average temperature. Thus, the Expanding Spacetime theory resolves the horizon enigma. An infinite redshift (when a source disappears) corresponds to an infinite distance in an infinite and eternal universe.

Non-Euclidean Geometry

From school geometry, everybody knows that a straight line is defined as the shortest distance between two points. Parallel lines are equidistant from each other and they never meet. Two lines that are perpendicular to a third line in a plane are parallel.

When we move from plane geometry to spherical geometry, we find that things are different. Once again, the shortest distance on the surface between two points defines a straight line. On a sphere, like the surface of the Earth, the shortest distance is a great circle, or an arc of a circle with the center of the circle at the center of the sphere, or earth.

Airlines fly great circle routes between two cities to fly the shortest distance. Two lines perpendicular to the same line are *not* parallel on a sphere. They are not equidistant from each other. Great circles that are perpendicular to the equator meet at the north and south poles. Unlike plane geometry, a straight line on a sphere is not infinite in length but returns to the starting point after travelling the circumference of the sphere. A sphere has a finite area, whereas a plane is infinite in extent and area.

Einstein used geometry to model the universe. Rather than defining a straight line as the shortest distance between two points, he made a subtle, slightly different definition. Suppose you are out in space between galaxies and shoot a very tiny bullet from a gun. He called this giving a test mass an initial velocity. He defined the path that this test mass takes as a straight line. It is freely falling in response to gravity. The straight lines that result from this definition could follow the rules of a three dimensional geometry that is non-Euclidean, like a two dimensional spherical geometry where parallel lines cross. Einstein used a four-dimensional geometry, with time being the fourth dimension.

The End of the Universe Enigma

A major unresolved issue of the Big Bang theory is whether the universe is $\Omega = 1$ open or $\Omega > 1$ closed. According to the Big Bang theory, the universe has one of two possible ends: a Heat Death in which the universe continues to expand and cool forever, or a Big Crunch in which the universe contracts and then expands again, forever oscillating between Big Bangs and Big Crunches. Big Bang theorists try to determine which scenario is correct by contemplating the geometry of the universe and by measuring the universe's mass density.

When Einstein populated his universe with a constant density of mass and radiation pressure, he found that two lines perpendicular to a third in the same plane were not necessarily parallel. His static universe model is generally non-Euclidean. Depending on the amount of mass and radiation pressure in his model the universe is $\Omega = 1$ closed or $\Omega < 1$ open. If the mass density is high, space could be closed like the surface of a sphere. A free particle moving in a straight line would eventually return to its starting point. This closed universe has a finite amount of matter. On the other hand, a spacetime of lower mass density would extend indefinitely producing an infinite $\Omega < 1$ open universe with negative curvature.

The radiation level in the universe of today is quite low and the resulting radiation pressure is negligible. That is why Einstein added a cosmological repulsive force that exactly balanced the pull of gravitation in his static universe of 1917. Since then, his so-called Cosmological Constant has been discussed at length, and even today nobody knows if it really exists. However, it reappears in the EST theory together with a cosmological Field Pressure.

In the Big Bang universe, there is no need for a repulsive force since galaxies that started moving apart at the Big Bang event are gradually being slowed down by their mutual gravitational pull. If the mass density in the Big Bang universe is low, they will always continue to move apart without slowing down. This is the open universe that eventually leads to the Heat Death when all stars have burned out. If the mass density is high, the Big Bang expansion will at some time stop and a contraction phase will follow ending in what usually is referred to as the Big Crunch. This is the closed universe. If the mass density equals the Critical Density the expansion continues forever at an ever-slowing rate. This universe balances between an open and closed universe. The geometry is flat and the curvature is zero.

In the EST, none of these scenarios apply since the universe is infinite and always remains the same. The EST universe is neither open nor closed. Space (but not spacetime) is flat and the net gravitating energy density is zero.

The Enigma of a Universe Beyond Our Universe.

Because the observed mass density of the universe is below the Critical Density, the Big Bang expansion should continue forever according to known physics. Gravitational pull simply does not suffice to stop the expansion. If the Doppler effect is the reason for the redshift we see, galaxies are receding with velocities that increase with distance. At a certain distance called the Hubble distance, these velocities equal the speed of light and the redshift becomes infinite. Galaxies even further removed can never be seen since they are receding faster than the speed of light; they are beyond the horizon.

The disturbing implication of the Big Bang model is that there are vast, perhaps infinitely vast regions of the cosmos existing beyond our own time and space. Do these regions, with which we never will be able to communicate, really belong to our universe?

In the EST theory, all regions, even those infinitely remote, are within the horizon and within our universe. No additional universes need to exist beyond the outer edges of our spacetime.

Observational Discrepancies

The most significant and embarrassing difficulty with the Big Bang theory is that it simply does not agree with observations. Although the discrepancies between the theory and observations have been known for a long time, cosmologists have ignored them, probably with the hope that further observations using more advanced tools would make the discrepancies disappear. Instead, the opposite has happened. The more we improve our observational capabilities the more apparent is the disagreement between observations and theory.

Recent Hubble telescope data clearly confirms that the Big Bang theory simply does not agree with the observations. However, rather than accepting these findings and admitting that there are unexplainable discrepancies, various modifications involving evolutionary scenarios are being suggested in an attempt to save the Big Bang theory.

The Expanding Spacetime theory, where both time and space are

Discrepancies with the Big Bang Found by the Hubble Space Telescope

The Hubble Space Telescope took the Deep Sky photographs in the visible wavelengths in 1995 and in the infrared wavelengths in 1998 that imaged faint galaxies within about 5% of the time to the supposed Big Bang. The 1995 visible images seemed to show lumpy galaxies that indicated that the galaxies at that time were different from nearby galaxies. This was because they were only imaging the young blue stars in the galaxy.

When this same field was imaged in infrared, the older, redder stars showed up. Their light had been redshifted out of the visible and into the infrared. The lumpy galaxies turned out to be spiral galaxies like our own Milky Way containing many old stars, far older than the age of the Universe according to the Big Bang theory. Some theorists have suggested that a galaxy must undergo many hundreds of rotations to form a spiral shape, but our own spiral galaxy is rotating at a rate that only allows a few tens of rotations since the Big Bang. At this rate, those spiral galaxies seen in the deep field would have had time to rotate only two or three times.

Careful measurement of the distance between galaxies shows that they are regularly spaced, and are not closer together as we look back in time, nearer to the time of the Big Bang. One would expect them to be closer together the farther back we look in time.

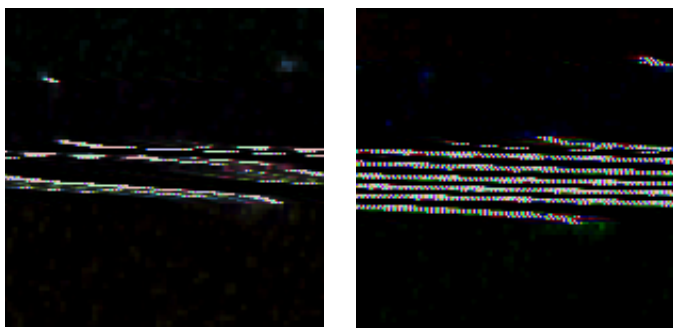


Figure 4.1: Hubble image from 1995 showing blue stars only and an image from 1998 showing all stars.

expanding, has so far proven consistent with observations. One goal of this book is to encourage observers to continue testing the EST theory against even more observations.

Let us next discuss the three main arguments used to develop the Big Bang theory in the light of the EST theory.

The Three Pillars of the Big Bang Theory

Let us take one more look at the three scientific pillars that support the Big Bang theory:

The Redshift

As discussed above, Hubble's redshift-distance relation suggests that galaxies recede from each other with the implication that they must have been much closer together in the past. However, recent observational data show that the Doppler type redshift mechanism which is predicted by the Big Bang model cannot be reconciled with observations. Therefore, rather than supporting the Big Bang model, the cosmological redshift is now refuting the model.

The Light Element Abundances

All of the heavier elements of matter in the universe are thought to form from light elements (hydrogen and helium) collecting through gravitation to form stars which ultimately produce heavier elements. But it is not necessary to assume that all the light elements in the universe were created in a single event. There may be ongoing processes with conditions similar to those proposed by the Big Bang theory that are responsible for adding new particles of matter to the universe.

One possibility for such a source of matter creation is quasars (see Chapter 7), objects that radiate with intensities far exceeding that of a typical galaxy and where the source of the radiation is confined to a relatively small region. Quasars may recycle heavy elements into light elements in mini Big Bangs. Thus, the fact that the light element abundances seem to agree well with the predictions from particle physics does not necessarily imply that the universe was created in a single Big Bang.

The Cosmic Microwave Background Radiation

Observations show that the CMB radiation is exceedingly smooth with very little angular variations. This smoothness creates difficulties when trying to explain the formation of large structures like galaxy clusters

and filaments, since such large structures ought to have given their imprints on the angular distribution of the radiation. The CMB radiation is simply too smooth. Thus, although originally predicted by the Big Bang theory lately the CMB has turned out to be a problem for the theory. The EST theory also predicts the existence of the CMB. This is explained in Chapter 6 in the section on Thermal Equilibrium.

Conclusions

There are several problems and unresolved puzzles with the Big Bang theory, some of them conceptual and others factual. Although these problems are well known in the scientific community and are acknowledged from time to time, scientists do not have an approach that can resolve them, so they continue to work within the framework of the original assumptions of the Big Bang theory. They either accept on faith that these flaws eventually will be resolved, or they suggest complex and somewhat contorted explanations that make the flaws fit within the framework. This arises from a traditional reluctance to abandon an accepted theory even in the face of irrefutable evidence against it and because a coherent alternative was not available.

The conceptually simple EST theory provides an alternative that resolves most Big Bang puzzles and predicts a new phenomenon, Cosmic Drag, which can be verified by testing its predictions. The EST theory also provides the missing connection between General Relativity and Quantum Theory, making it a comprehensive model of the universe.



Chapter 5: Evidence of Expanding Spacetime Close to Home

A new theory like the EST theory will gain acceptance only after there is strong, irrefutable, evidence for it. The General Relativity theory, for example, was not accepted until after the famous solar eclipse expedition lead by Sir Arthur Eddington in 1919 that confirmed the bending of starlight in the Sun's gravitational field. This chapter presents evidence based on existing data that confirms the EST theory by measurements within our solar system.

Secular Acceleration in our Solar System

The EST theory predicts that all planets slowly are falling toward the Sun with increasing angular velocities due to Cosmic Drag. Cosmic Drag steadily reduces the planet's energy, which is a combination of kinetic energy due to its motion and gravitational energy. The net result is that the planet accelerates in its orbit while slowly falling toward the Sun as shown in Figure 5.1. The relationship for the change in the angular velocity given by the EST theory is $dw/dt = 3w/T$.

In this relation the left side is the angular acceleration, w is the angular velocity, and T is the Hubble time. For the Earth, this means that the acceleration is 3 arcseconds per century squared and that the angular velocity of the Earth each hundred years increases by 3 arcseconds per century, assuming a Hubble time of about 12 billion years. At the same time the Earth falls closer to the Sun by about 25 meters per year.

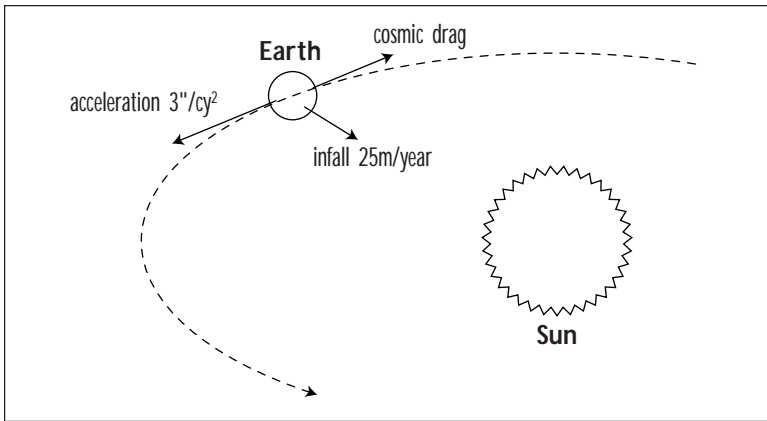


Figure 5.1: Cosmic Drag causes planets to accelerate in their orbits and to fall towards the Sun.

Based on the EST theory, the distance to the Sun will be reduced to half its present distance in about eight billion years.

Although the effect is extremely small, currently available astrometry techniques are capable of detecting and estimating even these very tiny discrepancies.

Very accurate observations are required to test the EST theory in the Solar System. Astronomers use observations of the positions of the Sun, Moon, and planets relative to reference stars to calculate planetary trajectories. All models developed for mapping observations to trajectories rely on three basic assumptions:

- Ø A time base can be chosen that is accurate and constant with time.
- Ø The locations of the reference stars are accurately known.
- Ø The planets move at constant angular momenta.

Accurate prediction of planetary positions based on Newton's law is possible only if all three assumptions are fulfilled. The greatest of these three challenges is the first one. Let's take a look at what is involved in finding a usable time base.

Solar Time (Universal Time)

Solar Time is based on the length of the day. If we use Solar Time, as determined by the rising and setting of the Sun (also called Universal Time), the length of the second will increase with time since the rate of the Earth's rotation slows down due to tidal braking. This decelerating time base will cause errors when estimating the planetary positions.

Secular Acceleration and Drift

An arcsecond (denoted ") is $1/3600$ of a degree (with 360 degrees in a circle). Angular velocity can be expressed as degrees per hour or if the velocity is very small as arcseconds per century (expressed as "/cy, or any other angular unit of measurement divided by a time unit). The Earth's secular acceleration is $3"/\text{cy}^2$, which implies a positive secular drift of 1.5" in one hundred years.

We can check if the time base actually decelerates by measuring the observed secular acceleration of an object that we know moves at constant angular velocity. If we detect acceleration it must be due to a decelerating time base. We can then find the time correction that makes the measured angular velocity constant. This makes it possible to adjust the Solar Time base and compensate for the spin-down of the Earth.

Since the planets, including the Earth, are currently believed to move at constant angular momenta, measuring the angular accelerations of a planet or the Sun is used to correct the Solar Time base.

Ephemeris Time

Ephemeris is a fancy name for the trajectory of a planet as seen from the Earth. The long established approach for constructing ephemerides is to base the temporal parameter used to define the orbital positions of a planet on the orbit itself, assuming that the motion is constant. By this approach the length of a second is a fixed fraction of the time it takes for the Earth to complete a full revolution around the Sun.

Thus Ephemeris Time is defined using the motions, or ephemerides, of the planets. Prior to the development of Atomic Time, Ephemeris Time was the accepted temporal basis in astronomy. Its use has been extended into the present on the assumption that Atomic Time and Ephemeris Time are essentially the same. Ephemeris Time can also be thought of as Solar Time corrected to account for the observed acceleration of the planets (which we know to be moving at a constant angular momenta).

However, if the planets slowly lose energy in their orbits and spiral inward toward the Sun as predicted by the EST theory, then Ephemeris Time base is not usable since it is based on the assumption that the motions of the planets are, on the average, constant.

Atomic Time

About forty-five years ago, scientists developed a new way to measure time, based on atomic vibrations. Atomic Time is clearly more uniform than either Ephemeris or Solar Time and it is currently used for measuring the spin-down of pulsars (and for many other purposes).

Atomic clocks are the most accurate chronometers available today. The average readings from several of these clocks provide a time base with accuracy and stability of about one millionth of a second in 100 years.

The Stellar Reference Frame

The second item needed to test EST predictions within the Solar System is a stellar reference frame. Planetary positions are observed in relation to background stars. The accuracy of these positions therefore depend on how accurate we know the positions of the reference stars.

If we use distant galaxies as references instead of stars in the Milky Way, the accuracy will be greatly improved since the directions to these distant galaxies change very little with time. Furthermore, the directions to distant galaxies can be measured within a fraction of an arcsecond using radio astronomy. Today the locations of the reference stars are therefore well known and the errors in the modern stellar reference frame are negligible.

Using Atomic Time as a uniform time base and modern stellar reference stars, it should be possible to achieve accurate measurements of the positions of the Moon, Sun and planets to test the EST theory.

Modern Ephemerides

Modern ephemerides are used by NASA and other agencies in the space program. Interestingly, new planetary observations seem to drift with time away from the ephemerides. This is blamed on observational errors rather than on a possible error in the time base or Newton's law of gravitation.

These variations have become accepted and are overcome by periodically updating the ephemerides based on the more recent observations and discarding older observations, considered unreliable.

Planetary Motions Predicted by the EST Theory

Planetary positions can be determined with great accuracy using worldwide measurements from the past forty-four years since Atomic clocks were developed. These measurements are available and the secular accelerations predicted by EST have been detected. However, since the observed accelerations of the Sun and the planets are very small, they have been attributed to other effects like measurement errors or errors in the stellar reference frame.

The drift of the Sun has been verified by many observers during the past twenty years, but no explanation has yet been found. The EST theory predicts this effect both qualitatively and quantitatively as resulting from Cosmic Drag.

A 1996 paper by Dr. Yuri B. Kolesnik at the Institute for Astronomy of the Russian Academy of Sciences reports the result of worldwide measurements of the motions of the Sun (the Earth) and the planets Mercury, Venus, and Mars over the period 1960 to 1994. Quoting from his paper: *“A spectacular 1"/cy positive secular drift of the Sun residuals is clearly manifested by the whole assembly of instruments.”*

In his paper, Dr. Kolesnik interprets the observational discrepancies as drifts that follow a linear relationship proportional to time. Using this assumption, he estimated a linear drift based on observations from about a third of a century worth of data to find that they yield a drift of about 1"/cy (one arcsecond per century) if extrapolated.

The EST theory suggests that these drifts are due to acceleration, so the estimated curve would be quadratic rather than linear with time. Dr. Kolesnik recently reinterpreted the estimates by fitting quadratic curves to the existing observational data. He found that the planetary accelerations predicted from observations agree well with the accelerations predicted by the EST theory (using a Hubble Time of 14 billion years):

	Estimated Secular Acceleration	EST Prediction
Mercury	$8.57'' \pm 3.07''/\text{cy}^2$	$5.77''/\text{cy}^2$
Venus	$1.92'' \pm 0.54''/\text{cy}^2$	$2.26''/\text{cy}^2$
Earth	$1.39'' \pm 0.18''/\text{cy}^2$	$1.39''/\text{cy}^2$

Hubble Time

Hubble Time is the apparent time to the Big Bang assuming the redshift is Doppler effect. In the EST model, Hubble Time is a constant unrelated to the age of the universe. The value of Hubble Time depends on the value of the Hubble constant, which relates redshift to distance. Measurement of a galaxy's redshift is easy, but accurately determining its distance is not. The traditional method of determining distance is to find a standard candle that is a star or galaxy of a known brightness. If a star can be found in a galaxy that is of a known intrinsic brightness, then its distance can be determined by determining its measured brightness since the brightness falls off as the inverse square of the distance. One such traditional standard candle is the Cepheid variable type of star. These stars brighten and dim at a regular period. Their intrinsic brightness has been found to be the same if their period is the same.

NASA sponsored a long-term program to find and measure Cepheid variables in 18 galaxies using the Hubble Space Telescope. After 8 years of data gathering, in May of 1999 it was announced that the Hubble constant was 70 kilometers per second per kiloparsec within an uncertainty of 10 percent. This translates into a Hubble Time of 12 to 13.5 billion years. Another group led by Allan Sandage immediately challenged this announcement. They determined the Hubble Time to be 14 to 18 billion years based on more than 30 years of ground-based observations. They used not only Cepheid variables, but also other standard candles such as a class of supernovae whose intrinsic brightness is determined from the time it takes to brighten and fade out.

A group at the National Radio Astronomy Observatory announced a new method of measuring galactic distances in June of 1999. Instead of using standard candles, this method uses very long baseline interferometry radio astronomy from many widely separated antennas. The result is a spatial resolution about 500 times better than the Hubble Space Telescope, but at invisible radio wavelengths. It measured the speed of orbital motion of a natural maser (or radio hot spot) orbiting a galaxy (NGC 4258) and determined its location at two different times relative to the galactic center. Then the distance to the triangle formed by these three locations was determined using straightforward trigonometry with an uncertainty of about 4%. This was one of the 18 galaxies whose distance previously had been determined by the Hubble Space Telescope using the Cepheid variable method. The Cepheid variable method calculated the distance to NGC 4258 as 28 million light years, whereas the radio astronomy calculation was 23.5 million light years. The new method when applied to this single galaxy produces a Hubble Time of about 10 billion years. In the future, hot spots found orbiting other galaxies should yield even better estimates of Hubble Time.

According to the EST model, the Earth accelerates around the Sun, and Ephemeris Time must accelerate relative to Atomic Time due to Cosmic Drag. There should be an increasing discrepancy over time between Ephemeris Time and Atomic Time. These studies might resolve the observational discrepancies between old and new planetary ephemerides.

Ephemeris Time versus Atomic Time

An important study by Oesterwinter and Cohen (1976) based the ephemerides on Atomic Time rather than Ephemeris Time during the interval 1955-1968. After having obtained a good fit between observations and the numerically integrated orbits of all the planets and the Moon, they proceeded to extend the orbital estimates backward in time using observations from 1912-1954.

They found that the early orbits drifted away from the orbits based on Atomic Time and that the difference implied a drift of Ephemeris Time relative to Atomic Time estimated at about 6.5-7.0 seconds in 50 years with Ephemeris Time running faster than Atomic Time. If this error is due to the secular acceleration of the Earth predicted by the EST theory, it would correspond to a Hubble Time of about 13.5 billion years.

The Oesterwinter and Cohen paper supports the EST theory qualitatively by showing that Ephemeris Time runs faster than Atomic Time and quantitatively by implying a Hubble Time very close to other estimates. Reasenberg and Shapiro (1976) report secular accelerations of the planets directly measured by radar ranging consistent with these results.

Since the phenomenon is secular accelerations rather than linear drift, the observed discrepancies increase quadratically with time and will become more and more obvious in the future. Continued measurements should be used to test the EST predictions.

Confirming the Cosmic Drag Effect

During the year of 1999, a small group of astronomers in Moscow lead by Dr. Yuri Kolesnik collected and processed optical observations of the inner planets and the Sun recorded from the seventeenth century up to our present time. In all, over 240,000 optical observations were collected from about 300 published sources representing about 95% of the total observational data accumulated by humanity during the era of classical astronomy.

These observations were adjusted to a modern extragalactic reference frame, which is considered to be free from secular rotational effects. They were also corrected to account for differences in the modern and historical astronomical constants to exclude any virtual secular effects. Then the observed positions for the planets extending backward in time were compared to what their computed positions would be based on modern numerical ephemerides.

Modern Numerical Ephemerides and Historical Data

Modern ephemerides are constructed by fitting recent data from precise radar range estimates of the inner planets. Radar range data used for this calculation is typically limited to a time interval of about 20 years. As soon as a new set of observations becomes available, the ephemerides are recalculated by refitting the new data. The updated versions are then distributed for common use. As observations age, they are replaced by more recent data in the calculations. So the modern ephemerides are always based on data from the most recent 20 to 30 years.

The model that is used to create the numerical ephemerides is based upon Newton's laws of motion. The ranges of planets are estimated with respect to Atomic Time, which was somewhat arbitrarily calibrated in the late 1950's. The ephemeris creation process re-calibrates the temporal argument by fitting it to the equations of motion based on Newton's law. Such a double fit of both the ephemeris position and the time scale guarantees a good agreement between the resulted ephemeris positions and the data used to fit them over a relatively short time interval.

Dr. Kolesnik's team compared recent numerical ephemerides with independent, historical observations of the planets, extending the comparison backward. Kolesnik's data extends much farther backward in time than the short-term data set used to create the ephemerides. But if the planets are behaving according to Newton's laws, the ephemerides should still predict their position; a comparison of the numerical ephemerides with optical observations of the planets should not yield any significant discrepancy.

However, the results of Kolesnik's comparison have revealed something dramatically different.

20th Century Acceleration

In the observations from 1900 to 2000, Kolesnik found clear evidence that the planets Mercury, Venus, and the Earth accelerate away from the ephemeris positions just as predicted by the EST theory.

Since the observations are taken from Earth and Earth's position enters into the formula for the estimated planetary positions, observations of the planets and the Sun indirectly gives information on the Earth's movement. Figure 5-2 shows the longitudinal drift of the Sun (which is actually caused by drift of the Earth) based on observations of the Sun, Mercury, and Venus in right ascension (east-west position) observations. Figure 5-3 is the corresponding estimates based on declination (north-south position) observations. Both figures show a quadratic trend away from the ephemeris position.

Interpreting these Results

Optical observations are typically associated with systematic errors which can significantly distort the results of a comparison. In view of the different techniques of observation, right ascensions (recorded time of planets' passage through local meridian) and declinations (recorded

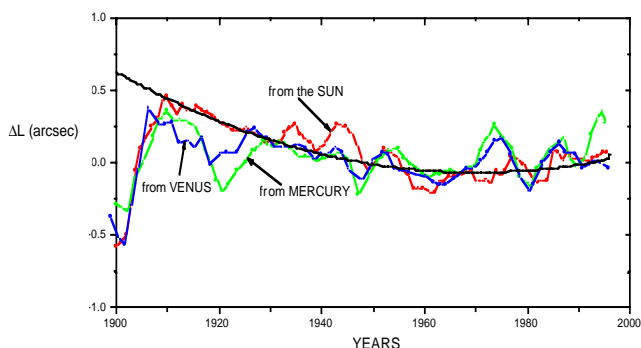


Figure 5.2: Correction to the mean longitude of the Sun from optical observations in right ascension.

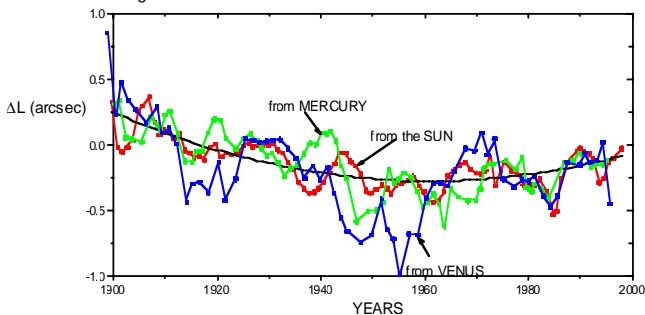


Figure 5.3: Correction to the mean longitude of the Sun from optical observations in declination.

angle between a planet and a local plumb line) have radically different systematic errors. This is also the case for observations of different objects (the Sun, Mercury, Venus). If results separately derived from right ascensions and declinations as well as from all three objects are similar, this is traditionally accepted as evidence that any observed trends are accurate. Thus, the observed quadratic drift away from what is expected must originate in something other than systematic observational error.

Specifically, a quadratic trend confirming planetary acceleration is clearly seen in the figures both from the right ascensions and the declination residuals. The estimated acceleration of the Earth, shown as parabolas in these figures, is approximately 2.9 arcseconds per century squared. Using this acceleration in the EST theory equations yields a Hubble time of about 14 billion years. This is in agreement with the best currently available estimates for Hubble time obtained by other independent methods.

In addition, Figure 5-4 shows that the estimated accelerations of corrections to the longitudes of Mercury and Venus are larger in strict proportion to their larger angular velocities. The variation of acceleration in proportion to increased angular velocity is the exact relationship for Cosmic Drag that is predicted by the EST theory.

Conclusions Based on 20th Century Results

Independent comparisons of the ephemerides yields a dramatic discrepancy between the positions predicted by numerical ephemerides based on traditional equations of motion, and the positions provided from observations. The origin of the discrepancy is neither in the precise radar observations to which ephemerides are fit nor in the less precise

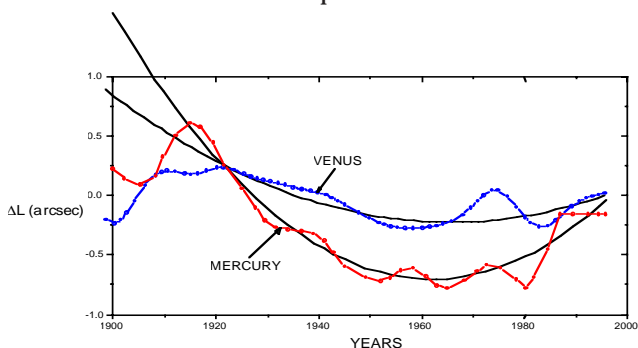


Figure 5.4: Correction to the mean longitude of Mercury and Venus from optical observations in right ascension.

optical observations, but in the equations of motion based on Newton's law which are used to create the ephemerides. This discrepancy disappears if the Cosmic Drag effect predicted by the EST theory is taken into account in the equations of motion.

Observations from Earlier Centuries

Kolesnik's results from observations of planetary positions during the eighteenth and nineteenth century are not as readily conclusive due to the method of calibration of the difference between Universal Time (used to record optical observations) and Atomic Time (the independent time used to calculate the modern ephemeris). The only possibility of independent calibration of this difference is in the analysis of lunar occultation, which is compared with a theory of motion of the Moon.

A long time ago it was discovered that purely gravitational lunar theory does not agree with the observations of the Moon. An empirical term accounting for the discrepancy, which has been an assumed tidal acceleration of the Moon, must be included in the theory to provide a satisfactory agreement with observations. This empirical term is traditionally determined from observations of the Sun and planets with the assumption that they do not accelerate. As a result, the estimate of the Moon's tidal acceleration correlates directly to the accelerations of the planets uncovered by Kolesnik's historical research but not accounted for in traditional motion based on Newton's laws.

Incorrect modeling of non-gravitational acceleration of the Moon will only marginally affect results of comparison in the 20th century (that is why the accelerations of planets are easily detected), but going backward in time this has a progressive affect. That is why, in the earlier epochs, the quadratic trend of corrections to longitudes of planets is not directly confirmed by observations. A correction between Ephemeris Time and Atomic Time is required.

As in all cosmological models, to predict an outcome and then find confirming empirical evidence is an important step. Kolesnik's results are clear. The resulting estimated acceleration of the Earth fits the EST model's mathematical predictions. This gives a strong mandate to continue research into the Cosmic Drag phenomenon predicted by the EST theory.

A 300-year-old Puzzle: The Secular Acceleration of the Moon

In 1695, Edmond Halley (discoverer of Halley's comet) was led to suspect from ancient and modern observations of eclipses that the mean motion of the Moon in its orbit is speeding up. His conjecture was confirmed in 1749 by Dunthorne, who estimated the secular acceleration, i.e. the acceleration in the angular direction of the Moon, to be 10 arcseconds per century squared ($10''/\text{cy}^2$). In 1757 Lalande obtained a value of $10''/\text{cy}^2$ in agreement with Dunthorne.

The tides on the Earth, caused by the combined influences of the Moon and the Sun, gradually slow down the rotation of the Earth. But there is a problem that has confounded scientists for centuries. The law of conservation of angular momentum dictates that the resulting loss of the Earth's angular momentum should be transferred to the Moon causing the Moon to slow down also, not to speed up.

Accounting for this acceleration of the Moon soon attracted much attention. During the middle of the eighteenth century, the Academy of Paris repeatedly offered awards for anyone who could contribute to the solution of the problem of the Moon's secular acceleration. Celebrated mathematicians including Euler, Lagrange and Laplace participated and won some of these awards but could not give a satisfactory explanation for the secular acceleration. Euler offered the tentative suggestion that the Moon must be subjected to frictional loss from some unknown medium in space.

Finally, in 1787 Laplace thought he had found the solution by taking into account the gradual decrease in the eccentricity of the Earth's orbit and the influence of Jupiter. He calculated an orbital acceleration of $10.18''/\text{cy}^2$, in good agreement with observations.

All was well until 1853 when Adams, an Englishman, found that Laplace had committed an error in his calculations that reduced the estimated secular acceleration by about fifty percent. This led to a chauvinistic exchange between scientists in England and France, but the question was settled about eight years later in the favor of Adams. This left about $5''/\text{cy}^2$ of the Moon's secular acceleration unaccounted for.

This problem remained unresolved until the beginning of the 19th century, when people recognized that the tidally induced spin-down of the Earth's rotation will result in a slowing Solar Time base. When using Solar Time the estimated accelerations will be larger than with a constant time base. Replacing Solar Time with Ephemeris Time, the corrected lunar acceleration is $-26''/\text{cy}^2$ instead of the $+5''/\text{cy}^2$ based on

Solar Time. Using Ephemeris Time to estimate the spin-down of the Earth's rotation due to tidal braking results in about $-700^{\text{m}}/\text{cy}$

These results are satisfying, since the secular accelerations for both the Earth and the Moon should be negative due to tidal braking. Since the angular momentum of the Earth-Moon system must be preserved in standard physics, the preservation of angular momentum provides a well-defined relationship between these two secular accelerations. Here we encounter another, modern, enigma with the secular acceleration of the Moon. The deceleration of the Moon is not consistent with the deceleration of the Earth's spin predicted from the preservation of angular momentum. There is no explanation for this discrepancy, leading to continued speculation about the phenomenon.

Solving the Moon Mystery

In the EST model, the Earth accelerates, the measured acceleration of the Sun is real, and the spin of the Earth does not slow down as fast as previously thought. This in turn means that Solar Time (Universal time, UT) does not decelerate as much as previously thought and therefore the motion of the Moon does not slow down significantly. Conversely, to show that Solar Time does not accelerate relative to Atomic time (AT) implies that the Sun must accelerate as predicted by the EST theory.

Historically, the motion of the Moon has been used to estimate fluctuations of the Earth's spin. These fluctuations are estimated from a record over the difference LET-UT, where LET stands for Lunar Ephemeris Time, which is based on the motion of the Moon. This is a record of the difference between a time base based on the length of the month and a time base based on the length of the day. The LET-UT record in the Russian Astronomical Almanac until 1975 is based on actual measurements through the year 1967. The twelve-year overlap of 1955-1967 enables comparison between the LET-UT record and the AT-UT record. The comparison shows that these two records are identical. Unfortunately, the twelve-year time span is too short to warrant a definite conclusion that the Moon does not accelerate relative to AT.

However, there is also a record of the difference AT-UT, i.e. between Atomic and Universal Time from the time of the inception of Atomic Time in 1955. Examining the 44 year record of AT-UT shows that this relation closely follows a straight line, indicating that UT has not accelerated significantly relative to AT since 1955. Since UT fluctuates over periods of five-to-ten years, this does not by itself definitely prove that UT is without acceleration. However, together with the Moon data

it supports the proposition that neither the motion of the Moon nor the pace of UT accelerates significantly.

If it were true that the Moon does not accelerate, it would imply that the Sun must accelerate at a rate that complies with the EST model with a Hubble Time of around 12 billion years.

Future confirmation that the motion of the Moon is constant or that UT does not accelerate significantly in relation to AT would provide strong observational support for the EST theory. Recent measurements of lunar motion would add supporting evidence. Unfortunately, it hasn't been possible to locate observations of the lunar motion during the last twenty years, probably since UT now is directly compared to AT, which eliminates the need for lunar ephemeris time.

If Ephemeris Time accelerates relative to Atomic Time as predicted by the EST theory, it would imply that the actual secular acceleration of the Moon is zero and that the spin-down of the Earth is about $-285''/\text{cy}^2$. Since the non-tidal acceleration estimated by Laplace and Adams is $+5''/\text{cy}^2$, the tidal acceleration of the Moon is $-5''/\text{cy}^2$. This means that the problem with the preservation of angular momentum in the Earth-Moon system disappears; the spin-down of the Earth is directly related to the Moon's acceleration and the 300-year-old lunar acceleration puzzle is finally solved.

Another Lunar Mystery: The Moon's Distance from the Earth
Measurements from within the Solar System that can be used to test the EST model include the distance from the Moon to the Earth. According to standard theory, the Moon ought to keep moving away from the Earth due to the transfer of the Earth's angular momentum lost from tidal braking. This means the Moon would have been in contact with the Earth about 1.5 billion years ago. But this does not agree with geological and biological aging data.

According to the EST model, the distance to the Moon increases much slower than previously estimated the Moon was in contact with the Earth five to six billion years ago instead of 1.5 billion years ago. This is about the same age as the Earth. The Earth and the Moon could therefore very well have been formed together in the very distant past.

Conclusion

The Expanding Spacetime model is consistent with the behavior of the Earth-Moon system with this exception: measurements based on lunar laser ranging report that the Moon drifts away by about 3.8 cm/year. The EST model predicts that the Moon recedes from the Earth at about 1 cm/year.

At this time it is unclear what causes the discrepancy. Could it be caused by the use of Ephemeris Time rather than Atomic Time in the early years of the Lunar Ranging program? This would introduce an error of +8.8 cm/year. More accurate measurements in the future and improved modeling including Cosmic Drag should resolve this discrepancy.

The existing observational evidence supporting the EST theory is consistent and supportive. Additional evidence will accumulate when the scientific community becomes aware of the EST theory and starts testing it.



Chapter 6: Other Expanding Spacetime Evidence in the Cosmos

Chapter 5 presents evidence for the Expanding Spacetime in the Solar System. This chapter describes other astronomical mysteries that may be resolved by the EST theory. The first three, spiral galaxy formation, the spin-down of pulsars, and the circularity and proximity of binary star orbits, can perhaps be explained as resulting from Cosmic Drag. Another mystery has to do with the temperature of the universe, and a final point helps resolve a more philosophical debate.

Spiral Galaxy Formation

The existence of spiral galaxies is a mystery. Modern physics cannot explain how a thin rotating disc of particles (in this case stars) can remain stable over time or how the spiral arm structure is formed and stabilized.

Stars in a spiral galaxy are believed to move in approximately circular orbits with velocities that depend on the distance from the center according to Newton's law of gravitation. These velocities, which decrease with distance from the center of the galaxy, strive to pull stars apart due to frictional forces between layers moving at different velocities (a shear effect). These shear forces between stars overcome the gravitational attraction between them. Gravity is not strong enough to keep a thin galaxy disc formation stable over time. Computer simulations show that stable arms do not form and that the thickness of the disc increases with time.

In order to explain these features with modern physics it has been necessary to speculate that some stabilizing agent exists, for example a spherical halo of invisible but gravitating matter. This is another motivation for introducing Dark Matter into the Big Bang theory.

In the Expanding Spacetime theory, the angular momentum of stars in a galaxy decreases with time due to Cosmic Drag, causing them to spiral toward the center. The simple explanation for the galaxy arms is that these arms are the conduits through which matter flows toward the galaxy core. Since the stars in an arm are in free fall there are no shear effects and gravitation will be able to form and preserve the arm structure.

The spiral galaxy may be likened to a slowly rotating fan with curved blades. The blades are curved since the angular velocity increases with

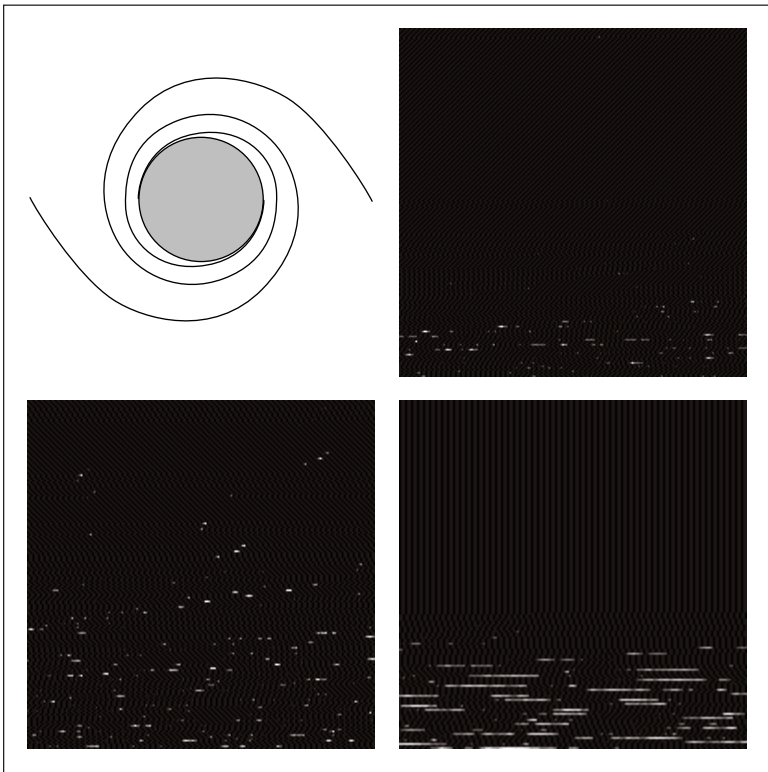


Figure 6.1: Spiral galaxy shape predicted by the EST model and actual spiral galaxies.

decreasing radial distance. The time for a star in the Milky Way to fall from a radial distance of 100 thousand light years to 60 thousand light years is about 3.5 billion years. During this time the outer part of the galaxy fan has turned about three revolutions. It will take another 3.5 billion years to fall another 25 thousand light years closer to the galaxy core.

A spiral arm structure predicted by the EST theory is shown in Figure 7.1. The shape of spiral galaxies is the elegant signature of the Expanding Spacetime theory.

The Spin-down of Pulsars

Pulsars are believed to be rapidly rotating neutron stars emitting radio wave pulses with extremely stable periods. They typically have masses comparable to that of the Sun compressed into objects twenty kilometers or less in diameter. Some pulsars rotate extremely fast, with periods on the order of a few milliseconds. Very precise measurements of the period have revealed that the rate of rotation of most pulsars is decreasing with time and that the rate of decrease has a time constant close to the Hubble Time.

Frictional forces or magnetic dipole braking cannot explain the spin-down. The estimated frictional force required to explain the observed spin retardation of a pulsar with a period of five milliseconds and containing mass comparable to that of the sun within a ten kilometer radius would be on the order of 2-3 million Newtons per square centimeters (a few million pounds per square inch). If such a pulsar were to be slowed down by friction only, the generated heat would be of the same magnitude as the energy radiated by the Sun.

Furthermore, the deviation from rotational symmetry should be negligible due to the enormous force of gravitation. Therefore insignificant energy is lost due to gravitational waves. Also, there should be insignificant tidal effects in such a compact object.

The fact that the signal frequencies of many independent pulsars are decreasing at the same rate strongly suggests that there is a common explanation for this phenomenon. Pulsar behavior has no explanation in current theory, but is consistent with the phenomenon of Cosmic Drag resulting from the EST model.

Binary Star System Orbits

The orbits of binary stars, formed by two suns rotating around each other, are often perfectly circular (or more precisely very shallow spirals). The very short orbit time for some binary star systems is another enigma. A tight orbit means that the two stars are very near each other. Since they cannot have formed initially at such a close proximity due to tidal forces, there must be some mechanism at work that diminished the distance between them over time.

Cosmic Drag predicted by the EST model dampens radial motions and causes all undisturbed orbits to become circular with time. Orbiting objects approach each other over time.

Thermal Equilibrium

In the early part of this century, several prominent scientists estimated the temperature of the universe based on the assumption of a stationary universe in thermal equilibrium. All of them concluded that the temperature ought to be close to 3 Kelvin. This agrees very well with the currently measured temperature of 2.73 degrees. These estimates were published long before actual measurements were available. Thus, it is well known that thermalization processes will generate black body radiation at the right temperature if our universe is in thermal equilibrium.

Thermalization will generally not result in a black body spectrum in a spatially expanding cosmos like the Big Bang universe since the superposition of black body radiation at different redshifts destroys the black body character of the spectrum. Therefore, all of the Cosmic Microwave Background radiation must in this case come from the primordial fireball of the Big Bang (as it was originally predicted). There can be very few thermalizing processes in the Big Bang universe if the CMB black body spectrum is to be preserved.

Black Body (Planck) Spectrum

When matter is heated, it starts radiating electromagnetic energy. If the temperature is high enough, the radiation becomes visible - the matter starts glowing. The shape of the radiation spectrum always is the same, but the location of the peak moves to higher frequencies with increasing temperature. This is the Black Body spectrum, or the Planck spectrum after its discoverer. Historically, this spectrum is of interest since it can be explained only by assuming that light comes in discrete quanta. This discovery by Max Planck became the first step toward the subsequent development of Quantum Mechanics.

In the EST model, the black body radiation spectrum of thermalizing processes is preserved. In this respect it behaves like a classic stationary cavity. This means that any region of the universe radiating with a certain black body spectrum will be in equilibrium with other regions radiating with the same spectrum.

Expanding spacetime is in thermal equilibrium. Due to the Tired Light redshift effect, all electromagnetic radiation loses energy at a rate of $1/T$ per second ($T = \text{Hubble Time}$). This being the case, there must exist a temperature where the energy added per second from all radiating sources equals the energy lost by the redshift. This is the equilibrium temperature.

The only thing needed to generate a black body spectrum in the EST theory is a source for the electromagnetic energy. If this energy is available, thermalization processes will automatically generate the black body spectrum given enough time, since this spectrum is the spectrum of highest probability (entropy).

Another way to see why expanding spacetime must be in thermal equilibrium is to note that the energy-momentum tensor remains unaffected by a scale expansion. The energy distribution in both space and time remains constant, which implies thermal equilibrium.

The Large Number Hypothesis and the Anthropic Principle

Measurements are typically expressed in invented units, for example centimeters or inches for length. However, there are dimensionless relationships that express physical properties and relations without the use of measurement units. These dimensionless relationships must be true in any system of units and are therefore fundamental and universal.

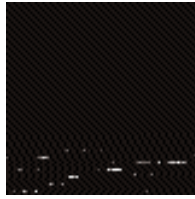
The relationship between the electrostatic and the gravitational forces between an electron and a proton is such a dimensionless number that is roughly equal to ten raised to the fortieth power. Another dimensionless number is the relation between the Hubble distance and the diameter of an electron that also is in the order of ten raised to the fortieth power. There are other large dimensionless numbers that are powers of ten to the fortieth. These large number coincidences have been the subject of much speculation.

Since the Hubble distance in the Big Bang model is equal to the age of the universe (Hubble Time) multiplied by the speed of light, it appears that the large number in the second relation mentioned above

changes with time in the Big Bang model when the universe grows older. This has been bothersome for people who are convinced that the large number agreements cannot be mere coincidences. But in the Big Bang universe, either these numbers must change with time or the radius of the electron must increase with time or the gravitational constant must change with time.

Others have used the large number hypothesis as the basis for the Anthropic principle, which says that the large numbers coincide because we happen to live at the right time when conditions are right for the evolution of human intelligence. According to the Anthropic principle the large numbers agree simply because we are here at the right time to observe them. They could differ before or after our time or in other universes where the conditions are unsuitable for intelligent life.

These bothersome aspects of the large number hypothesis are resolved in the Expanding Spacetime theory where the Hubble Time is a fundamental constant. (See Chapter 3, *The Meaning of Hubble Time in the EST*.) However, this provides an even stronger support for the proposition that the large number agreements cannot merely be coincidences but that they tell us something important yet to be revealed about the universe.



Chapter 7: The Quasar Puzzle

Quasars, or Quasi-Stellar Radio Sources, are radiating sources with spectra that differ greatly from that of a normal star or galaxy. Their behavior is unique and no convincing explanation exists for this phenomenon. According to Big Bang models, they seem related to Black Holes. In the EST theory, Black Holes do not exist, but quasar characteristics may result from high, saturated concentrations of mass and resulting phenomena.

Quasar Characteristics

It took some time after the discovery of quasars in the 1960s for people to recognize that the strange spectra from quasars actually are similar to the spectra from ordinary galaxies. The difference is that the lines in the spectra are shifted to much longer wavelengths—that is, to greater redshifts. The quasar redshifts are sometimes very large; the greatest redshift measured to date is 5, which means that the spectral line frequencies are 6 times lower than the normal line frequencies. (See the sidebar on the next page.)

If the redshift from quasars actually indicates the cosmological distance to the source, they would lie as much as 15-25 billion light years from the Earth using the Tired Light distance relation. But the quasars appear as bright as ordinary galaxies. In order to shine this brightly with this amount of redshift, the light output from quasars would be enormous—several thousand times the light from all the stars in the Milky Way.

Measuring the Redshift

The amount of redshift in light from a distant source (star, galaxy, or quasar) is measured by observing the frequency of a spectral line in relation to its nominal frequency measured in the laboratory. The formula is:

$$\text{Redshift} = [(\text{nominal frequency})/(\text{observed frequency})] - 1$$

Furthermore, the light intensity from a quasar often varies rapidly with time and can change significantly in a few days. This means that the source must be very small cosmologically, about the size of our solar system, otherwise the light from various regions within the source would overlap and smooth out the variations.

Often one or two narrow jets shoot out from quasars reaching distances measured in tens of thousands of light years. Also, their surroundings are strange. The light from a quasar sometimes reaches us through clouds situated between the Earth and the quasar. These clouds reveal their presence through dark absorption lines in the radiation spectrum from the quasar.

Summarizing the most pertinent quasar observations, we currently know that:

- ØØ Quasars are sources with very large redshifts.
- ØØ If they are as distant as the redshift suggests, they must be extremely powerful.
- ØØ They are often associated with host galaxies.
- ØØ Sometimes one or two narrow jets are ejected.
- ØØ The most common redshifts are between two and three.

We will look at each of these puzzling observations next.

Current Explanations for the Quasar Redshift

There is a great debate going on as to the cause of the large redshift in quasars. Advocates for the standard interpretation feel the redshift is cosmological (that the quasars are very far away and very, very powerful). Another relatively small group argues that the redshift is not due to their distance, but that quasars actually are much closer than what is indicated by the redshift.

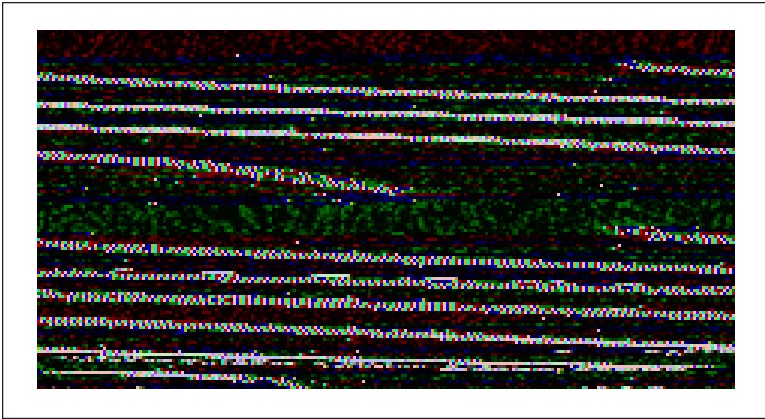


Figure 7.1: Radio telescope image of a quasar jet.

Quasars usually have redshifts between two and three; there are very few quasars with higher redshifts. Proponents for the standard interpretation believe that the numerous quasars that are observed in this particular redshift range provide evidence of evolution. Supposedly the quasars were created at an earlier epoch corresponding to a cosmological redshift in the range two to three and are no longer created at our epoch.

On the other hand, several researchers have published strong evidence in support of the proposition that the quasars are much closer than thought and are often associated with host galaxies. They believe that the redshift may be caused by a different effect, for example gravitation.

Currently there are three different ways to explain the large redshift:

Ø It is a cosmological effect caused by the expansion of the universe.

Ø It is a Doppler effect caused by relative motion.

Ø It is gravitational, perhaps associated with Black Holes.

Scientists usually reject the third explanation. Although gravitation can cause large redshifts, the spectral lines in light from a quasar are not what one would expect from matter falling into the gravitational field of a Black Hole. Superimposed radiation from different depths within a gravitational field would cause the redshifts of a given line to appear at many frequencies, effectively destroying the spectral line structure. But the spectral lines of quasars are well structured. It is difficult to understand how radiation can come from just one particular dis-

Quasar Jets

The jets emerging from quasars are best observed by radio astronomy very long baseline interferometry, using widely separated antennas. These observations have very high resolution and show bright spots along and at the end of the jets. These are sometimes described as "knots" in the jets. When the quasar jets are observed again at later times these knots are seen to have moved as the jet squirts farther away from the quasar. The ends of the jets and the knots move quite rapidly. If quasars are at the cosmological distances assumed by applying Hubble's law, then the observed rate of angular movement can be translated into a velocity by just applying ordinary trigonometry. If quasars are at these huge distances, then the jets must be moving faster than the speed of light as much as 10 times faster! They have come to be called "superluminal jets" for this reason. The speed of these jets is very difficult to explain and be compatible with special relativity. However, if the quasars are nearby, then the trigonometry does not involve such large changes in distances and the jets can be moving at much more reasonable speeds in agreement with special relativity.

tance away from a Black Hole if matter is continuously falling into it.

The Doppler effect would imply that all quasars are moving away from Earth at enormous speeds. If all quasars move this fast, some of them ought to be coming toward us having large blueshifts. Since blueshifts are never seen, the second explanation does not seem very likely.

The first explanation, that the quasar redshift is of cosmological origin, therefore gains credence. But recently, evidence has been accumulating that poses severe problems even for this interpretation. First, if the quasars were as distant as their redshift indicates and at the same time as compact as they appear, the light intensity emitted within this very small region would be so enormous that it would interfere with the very process that creates the spectral lines.

Secondly, many quasars have been observed inside or very close to galaxies with much smaller redshifts. This association between galaxies and quasars of different redshifts has been confirmed beyond reasonable doubt and suggests that the quasars are much closer than indicated by the redshift.

If the quasars are relatively close, their light output would not be significantly different from normal galaxies and their small size would not be such a big problem. But then, what would explain the large redshift?

What Is the Source of Quasars Power?

There is no good explanation for the source that powers a quasar. Some speculate that when matter falls into a Black Hole it is heated to very high temperatures by friction and starts radiating in the ultra-violet (UV) and X-ray region of the spectrum, producing a quasar. This radiation ionizes gas further away from the Black Hole and causes the observed lines in the spectrum.

A region associated with the central part of the quasar radiates with wide spectral lines, the so-called Broad Line Region (BLR). It is thought that the Doppler effect might cause this broadening of the lines, for example by swirling, ionized, gas clouds moving in different directions.

A significant fraction (25%) of the total light radiated by the BLR comes from ionized iron (FeII lines). This causes problems for the idea that the BLR is ionized primarily by radiation, since it has been shown that the observed strong FeII lines cannot be generated this way.

However, these lines can be generated by shock waves, for example by the bombardment of very high-energy particles, but there has been no explanation in the standard theory as to what might generate such shock waves.

Why the Jets?

The existence of the jets is another difficult-to-explain feature of the quasar. Some believe that a rotating Black Hole might be working like a dynamo to create a powerful magnetic field and that the jets are accelerated by some yet to be determined electromagnetic mechanism. However, it is unclear just how and why the jets appear. According to the Big Bang model, it appears more likely that matter falls into a Black Hole than is ejected from it.

Why Redshifts in the Range of Two to Three?

Finally there is no good explanation for the fact that a redshift in the range two to three is more common than other redshifts. Evolution, the catch all explanation for Big Bang flaws, is often used to explain this observation without offering any suggestion or justification for why an evolutionary process would have generated the quasars at this particular epoch.

There are many unresolved problems with quasars in the standard theory commonly accepted today. A possible explanation may be found by analyzing what would happen in the EST theory when a huge amount of matter is pulled together by gravitation.

The EST Model of Quasars

In the EST theory, the presence of objects like quasars is to be expected. In fact, it would be very surprising if we did not see them. Black Holes are not found in the mathematics underlying the EST theory (refer to *Expanding Spacetime has no Black Holes* in Chapter 3). Since a mass density cannot become infinitely large, a mechanism or physical process that prevents the accumulation of matter at arbitrarily high densities must exist.

In fact, the mathematics leading to the EST theory suggest that quasars might be powered by the EST version of Black Holes, where high mass densities cause gravitational forces producing unique phenomena. Black Holes are a purely theoretical phenomenon based on a mathematical solution that goes to infinity (because of a division by zero) using the standard assumptions. The analogous solution using the assumptions of the EST theory doesn't end in division by zero, but results instead in a solution that looks much like a quasar.

Saturated Accumulation of Matter (SAM)

According to the EST theory, the mass density inside any mass concentration must always be limited. Additional matter attracted to the mass concentration must remain outside a gravitational horizon, so any dense mass concentration defines a Critical Radius. The additional matter is attracted up to the Critical Radius then it is repelled and stops, defining a new Critical Radius.

In the EST theory, the Critical Radius represents the location of a physical change from the attractive force of gravitation to the repulsion of negative field pressure. This limits the total mass that may be located inside any given radius and therefore constrains the mass density as a function of the radius.

For a spherical mass concentration, the total mass inside the Critical Radius is proportional to the radius, and newly accreted matter always must remain outside the Critical Radius. Because of this, the mass density must on the average decrease more rapidly than inversely proportional to the square of the radius. Thus, there is a maximum mass density as a function of the radius that cannot be exceeded in a spherical mass accumulation. We call a mass accumulation for which all particles barely lie outside the Critical Radius at all distances from the center a Saturated Accumulation of Matter (SAM).

The mass density of a SAM must decrease faster than the square of the radius to prevent gravitational collapse. This means the mass den-

sity close to the surface of a large mass concentration will be quite low. For example, a SAM the size of one billion Suns would have a radius of about three light hours and a maximum mass density, at its surface, of about 0.06 kg/m^3 (5% of the density of air). Exceeding this critical mass density would imply that some of the matter would fall inside the Critical Radius, which is impossible in the EST theory.

According to the EST solution of the General Relativity equations, matter falling toward the SAM will slow down as it approaches very close to the Critical Radius. And because of the mass density constraint, matter cannot accumulate too close to the Critical Radius. It may be shown that the field energy rapidly becomes negative very close to the Critical Radius. This negative field energy could generate a repulsive force causing in-falling matter to change direction and start flowing outward. A particle suspended inside the SAM does not feel any gravitational field. The gravitational pull from matter closer to the core is perfectly balanced by negative field pressure. Any motion closer to the

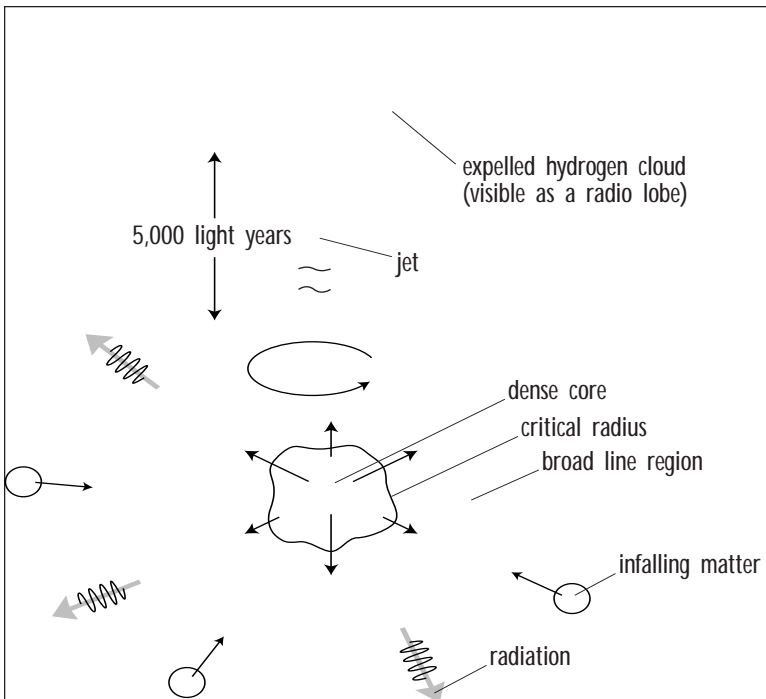


Figure 7.2: Saturated Accumulation of Matter may explain quasars.

core will increase the negative field energy and repel the particle. Conversely, any motion outward diminishes the negative field energy permitting gravitational pull.

The outside Critical Radius envelope of the SAM effectively acts like an outwardly pushing wall that sweeps away excess matter approaching the SAM if the density of this matter exceeds the density at the periphery of the SAM. As a result of this action the mass density immediately surrounding the SAM is maintained below the critical mass density. The SAM's Critical Radius envelope is quite unstable and fluctuates depending on the density of the surrounding matter and energy distribution.

A Possible Engine for the Quasar Radiation

An intermittently expanding Critical Radius will cause outwardly moving shock waves that could accelerate particles close to the speed of light. This could be the source for the intense quasar radiation. Shock waves of relativistic particles and electromagnetic radiation pressure might balance the pull of gravitation in the BLR region, which might be established fairly close to the SAM. Therefore, at least part of the quasar redshift might be gravitational. The outwardly pulsating movement of the Critical Radius, which would create a fluctuating gravitational field, could broaden the lines and together with Doppler velocities cause the broad line structure of the outer region known as the \hat{O} broad-line region, \hat{O} (BLR).

A picture emerges, illustrated in figure 7.2, of a dynamic object, the SAM, with an outside boundary determined by a continuously outwardly flaring Critical Radius which changes shape in response to movements of the surrounding matter, \hat{O} kicking away \hat{O} matter approaching too closely yet continuously attracting distant matter with its strong gravitational field. This would explain the characteristic quasar features.

Energy Source

The SAM could be the energy source of a quasar whereby gravitational energy is converted into kinetic energy and radiation.

Redshift

A more or less stationary radiation zone might be formed deep within the gravitational field, which could explain the large quasar redshifts and the BLR.

The mass density within this radiating zone must be quite low in order to remain outside the gravitational horizon. Remember: the mass density at the horizon decreases more rapidly than inversely proportional to the square of the radial distance. This provides a critical limit for the mass density as a function of radial distance, a limit that cannot be exceeded. Any attempt to increase the mass density beyond this limit results in an outwardly flaring motion of the Critical Radius, which reduces the mass density until it falls below the critical limit.

Spectral Behavior

Shock waves from the SAM blow away matter and prevent it from accumulating. This mechanism, pushing matter outward, and gravitation pulling it inward, traps gas at a relatively low density within a region at some distance from the SAM. This could explain the rapidly fluctuating quasar luminosities and the observed drift of spectral lines.

Jets

If the mass accumulation that forms the SAM rotates, matter in the accretion disk will spiral inward due to the loss of angular momentum caused by Cosmic Drag. However, this inward motion is halted when approaching the BLR.

In order to maintain its rate of loss of angular momentum, matter in the accretion disk will continue its spiraling path by gradually approaching one of the two poles at the axis of rotation. This causes matter to accumulate at the pole of the SAM at very high temperatures and pressures. Since it cannot fall inwards it will trigger repulsion and be ejected in a jet at speeds close to the speed of light. The jet flow close to the SAM has a high pressure which forms a tight nozzle directing the flow into a narrow jet.

Quasars with one jet are more common than with two jets. This could be explained if the asymmetry of the mass caused by the matter at the base of the jet would have the effect of diverting in-falling matter in the direction of the jet by gravitational attraction. It is also possible that a sustained powerful jet would cause the SAM to start moving, which also would favor the jet on the $\hat{O}\hat{\theta}$ downwind $\hat{O}\hat{\theta}$ side.

Quasar Summary

The EST model of quasars is highly speculative, but so are other explanations. In the Big Bang universe, the quasars are enigmatic objects for which there is no good explanation. However, in the EST they fill the necessary function of preventing gravitational collapse and the formation of Black Holes.

Much of this explanation for the quasar phenomenon directly and logically follows from the simple assumption that nature does not permit a singularity in the form of a Black Hole. Since matter tends to fall toward a SAM due to gravitation, the mass density constraint would be violated and a Black Hole formed unless there were some mechanism for preventing the accumulation of mass at the Critical Radius. Matter of high density must be prevented from approaching too closely to a SAM and the mechanism of repulsion must be forceful enough to guarantee that a Black Hole cannot be formed. This could explain the violent activities observed in the core of quasars. In fact, had objects like quasars not been observed it would pose a problem for the EST theory. Although the circumstance that these objects exist does not prove that the EST theory is right, it is consistent with the EST theory.

If quasars powered by SAMs are nature's way of avoiding the formation of Black Holes, the temperatures, pressures and tidal forces very close to the Critical Radius could be extremely large, possibly large enough to cause fission of all atoms but the lightest elements. Thus, quasars might be nature's way of recycling heavy elements into light elements that will fuel new generations of stars, in effect making each quasar a mini Big Bang. There is some observational evidence for this process since the light from many quasars contains hydrogen absorption lines at lower redshifts than the associated quasar. The quasar could have expelled these hydrogen clouds leaving them drifting in the surrounding space. Thus, quasars and active galaxy nuclei might form one link in a cycle of birth, life and death of the stars in galaxies. This is consistent with the idea of an eternal, ever evolving, ever renewing universe.



Chapter 8: The EST Theory and the Second Law of Thermodynamics

The second law of thermodynamics is an often-recurring stumbling block when considering the possibility of an eternal universe. It states that entropy always must increase in a closed system. The concept of entropy was developed when people started to investigate the efficiency of the steam engine. It is based on the fundamental observation that heat never spontaneously flows from cold to hot— it can only flow from hot to cold.

Heat is a measure of the random excitation of particles like atoms or molecules in a gas, liquid, or a solid. When two objects are brought into contact, the direction of heat flow from hot to cold means that the energy of more highly-excited particles with higher temperature gradually will spread to particles with lower excitation and temperature. If the two objects are insulated from the environment, they will eventually assume the same temperature.

Entropy may be viewed as a measure of probability. An isolated closed system always favors the most probable state. The state of uniform temperature is more probable than if the temperature of the two objects would remain different.

If an open bottle of perfume is left in a closed room, the perfume will evaporate and the perfume molecules will, with time, spread evenly across the room. This uniform distribution is more probable than if all molecules were to remain in the open bottle. The state with the perfume

molecules evenly distributed in the room has higher entropy than if all molecules were to remain inside the bottle.

The second law of thermodynamics says that a closed system with no energy interchange with the environment will always converge toward a state of highest entropy where the temperature and energy density is the same everywhere. In such a state, no further spontaneous action is possible, i.e. a thermodynamically closed universe would eventually die.

Of course, the scenario of continually increasing entropy is not a significant problem for the Big Bang universe. The violent creation event would have been high in energy and low in entropy. The universe could continue coasting for a very long time on the energy and the low entropy that presumably was imparted from the beginning. However, if the Big Bang universe were to continue expanding forever it would eventually succumb to high entropy and die. This is known as \emptyset heat death. \emptyset

Heat Death

Perhaps the most unattractive feature of the Big Bang theory is the prediction that space will expand forever with forever decreasing energy. Eventually all the energy in the stars will be depleted, they will stop shining and the universe will die a dark and cold \emptyset heat death. \emptyset The EST theory, on the other hand, concludes that there is no heat death. Stars may always shine in a continually evolving universe.

In a slowly expanding gas, the molecules are evenly distributed in space and in equilibrium. This is the state of highest entropy. However, the expanding Big Bang universe is quite different. Matter is not evenly distributed because gravitation assembles matter into galaxies and galaxy clusters. In a sense, gravitation counteracts the progression toward the highest entropy state. People have speculated that this gravitational intervention might prevent or at least delay the heat death.

Recent research on the thermodynamics of irreversible \emptyset dissipative \emptyset processes (for example by the Nobel Prize winning scientist Ilya Prigogine) demonstrates that irreversible processes sometimes can create order and decrease entropy. An ordered state usually is less likely than a disordered state and thus has lower entropy.

One example is a simple phenomenon involving heat convection which is known as Bernard instability. Bernard instability is regarded as a classical case of self-organization. At the beginning of the century,

a French physicist Henri Bernard discovered that heating a thin layer of liquid may result in unexpected ordered patterns. When a liquid is heated uniformly from below, heat flows initially by conduction. But if the temperature between the top and bottom surfaces of the liquid increases over a certain value, convection replaces conduction. Highly-organized flow patterns, such as hexagonal shapes, appear in the liquid.

This effect cannot be explained by standard thermodynamics which assume reversible processes. It only becomes possible if the processes are irreversible.

The appearance of a pattern implies increased order and reduced entropy. This simple example, where heat is continually added by the bottom heating plate and removed by convection, can be compared to the conditions here on Earth. The Earth receives heat from the Sun, most of which is then reradiated into space. This energy flow creates conditions removed from equilibrium that permit irreversible, dissipative processes on the surface of the Earth. This paved the way for the evolution that eventually culminated in life.

Time Acceleration Maintains Entropy in the EST Universe

Now consider the eternal EST universe in which all epochs are equivalent. There must be some mechanism that continually introduces energy and keeps the EST universe stable in entropy. This mechanism is the slowing pace of time. The EST universe is accelerating in time toward a future where time runs slower.

Since time also runs slower in a gravitational field, we could compare time acceleration in the EST theory with a situation of falling in a gravitational field. If we fall in a gravitational field we gain energy in the form of kinetic energy due to increasing velocity. Or instead of gaining kinetic energy we may use the gravitationally induced energy, for example, to generate electricity by letting falling water drive a turbine generator. Similarly, falling in time toward the future initiates a flow of energy in the universe, stabilizing the entropy.

This is a perpetual energy flow since in a geometric expansion like the EST universe, time can keep slowing down forever without ever stopping. The energy added by the temporal acceleration is absorbed by expanding space. This creates a similar situation to the example of the heated liquid or the conditions here on Earth.

The EST universe no longer is a closed system; energy flows from

time to space¹⁰ making possible irreversible processes that increase the order and reduce the entropy. The second law of thermodynamics no longer applies since the universe is an open system. The EST universe is thermodynamically displaced from equilibrium and from the reversible processes that characterize equilibrium. This is what makes life possible in the universe.

Conversely, the irreversible processes of the EST theory are directly connected to the scale expansion of spacetime and provide another explanation for the arrow of time. The forward movement of time is an irreversible process.

If matter as well as the accompanying gravitational field are generated from spacetime energy by the scale expansion, it would not be surprising that gravitation counteracts the tendency toward evenly distributed matter (The universe is not like an expanding gas with evenly distributed molecules in the state of highest possible entropy.) There might be a direct cause-and-effect chain: time acceleration induces spacetime energy flow, which results in the creation of matter, resulting in decreasing cosmic entropy by gravitation.

Without a counteracting effect, the universe could thus grow continually more ordered. However, the tendency toward decreasing entropy caused by expanding spacetime is counteracted by a tendency toward disorder and increasing entropy. For example, super novae explosions, quasar activities and other processes in the universe continually increase entropy. As a result, the average entropy could remain constant in the EST universe.

In the EST universe, both the net energy and the net change in entropy could be eternally zero.



Chapter 9: But Can the EST Theory Really be Right?

In discussion, it is not so much the weight of authority as the force of the argument that should be demanded. Indeed, the authority of those who profess to teach is often a positive hindrance to those who desire to learn; they cease to employ their own judgment, and take what they perceive to be the verdict of their chosen master as settling the question.

ØØ Cicero

Those considering the validity of the Expanding Spacetime theory relative to the Big Bang theory should consider the following fundamental questions:

- ØØ Is the instantaneous creation of everything out of nothing about twelve billion years ago more plausible than an ongoing expansion of both space and time?
- ØØ With the acceptance of General Relativity, which is based on a four-dimensional spacetime, is it even plausible for three of the universe's dimensions to expand without the fourth also expanding? Is the cosmological expansion three-dimensional with creation of new space or a four-dimensional scale expansion with no creation of new space?
- ØØ Which theory offers the simplest resolution of the Horizon Enigma, the fact that the universe looks the same in all directions?

- Which theory offers the simplest explanation for the age of stars and the time required for galaxy formation, which both exceed the Big Bang age of the universe (the Hubble Time)?
- Which theory implies the existence of a cosmological reference frame?
- Which theory best explains spiral galaxy shape and stability?
- Which theory explains the pulsar spin-downs?
- Which theory explains the secular acceleration of the planets and the Moon?
- Which theory agrees best with observations?
- Which theory is more plausible, the one that predicts Black Holes (which are difficult to explain and observe) or the one that doesn't allow Black Holes but in so doing offers an explanation for quasars?

Quoting Carl Sagan from his book *Cosmos*:

Science has two rules.

First: there are no sacred truths; all assumptions must be critically examined; arguments from authority are worthless.

Second: whatever is inconsistent with the facts must be discarded or revised. We must understand the cosmos as it is and not confuse how it is with how we wish it to be. The obvious is sometimes false; the unexpected is sometimes true.

Nature: Relative or Absolute?

The basic underlying principles of nature are logically consistent and simple. They are beautiful. Every age is constrained to judge and measure the world relative to its own perspective and present epistemology. In order to form a picture of the universe, observations and theory combine with preconceived notions and ideas of how the world really is or ought to be.

One deeply rooted concept is that physical measurements have absolute meaning. Thus, the scale of material objects always has been the same and time always has progressed at the same pace.

Richard Feynman, a Nobel Prize winning physicist, used to have a sign on his desk that read "Disregard" as a reminder to think independently. Einstein's approach was to try to put himself in the position of the Creator and ask himself what he would have done when creating

the world. Above all, he was interested in finding out if the Lord had any choice in creating the universe or if its design is predetermined by fundamental principles.

Contemplation along these lines leads to the conclusion that there can be no absolute things or conditions in the universe only relative relationships. Einstein's General Relativity theory points the way by showing that space and time only have relative meaning. There can be no absolute scale of material objects and no absolute pace of time. Spacetime is in a continuous flux.

Symmetry

A single fundamental principle, the Postulate of Spacetime Equivalence, forms the basis for the EST theory. This should by itself qualify the theory as a viable candidate for serious consideration. This candidacy is further strengthened by the simple and natural way in which several Big Bang puzzles are resolved and by the agreement with observations provided by the EST theory.

Cosmologists like to refer to Okham's razor as the criterion by which to select one theory over another. According to this criterion, the theory providing the simpler explanations to observations and phenomena is to be favored over the one providing more complicated explanations. The same idea may be found in Newton's *First Rule of Reasoning in Philosophy* which states:

We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

Three quarters of a century have passed since the Big Bang theory was first proposed. In spite of many modifications and refinements, several unresolved enigmas stubbornly remain and recent observations rather than helping are refuting the theory. In the absence of a coherent alternative, the entrenchment of the Big Bang theory has not changed even in light of this growing evidence. The Expanding Spacetime theory provides a welcome opportunity to participate in a paradigm shift the development of a new view of the universe.

Can Western Minds Embrace a New Paradigm?

The current Big Bang dogma has deep roots in Western thinking. The Western approach typically finds the cause of events or phenomena. For example, the blue color is caused by a certain wavelength of light, a meteorite may have caused the extinction of the dinosaurs, and so

on.

It is therefore natural for us to ask what causes the universe to exist. There are several possible answers to this question. Either God created the universe or there was some miraculous creation event like the Big Bang or perhaps there is continuous creation over time. We are naturally lead to the idea of creation by the Western scientific cause-effect chain of reasoning as well as by religious teachings.

Perhaps there can be no answer to the question of what caused the creation of the universe because the question is meaningless. In a self-contained and self-sufficient universe, the ultimate cause of any effect must be the effect. As in a closed loop control system where the output also is the input, the cause of the existence of the universe does not precede the effect, which is that it actually exists.

Like the chicken and the egg, the cause and effect coexist side by side. Like dark lines on a white paper will create a drawing, everything in nature might be formed by contrasting qualities.

This idea is closer to Eastern thinking, which views the universe as a state of ever-changing flow of energy between two opposite but complementary entities. In the context of the EST theory, these two entities could be space and time.

Thus, the Ôø dance of Shiva Ôø of Hinduism or the Yin and Yang of Taoism could correspond in the EST theory to the flow of energy between space and time. With this way of thinking, the momentary state or condition of the universe is of primary importance, not the chain of events leading from the past to the future. It suggests that the universe exists by itself and within itself without beginning or end.

A Discussion Between Proponents for the Big Bang Theory and the Expanding Spacetime

This is how a debate between proponents for the Big Bang theory and the EST theory might develop.

We start with the fundamental question of the nature of the cosmological expansion. Both proponents agree that the universe expands by changing the metrics of spacetime. However, the Big Bang proponent (BB) believes space expands, carrying galaxies with it, while the pace of time stays constant. The proponent for the EST theory (EST) thinks that the scale of spacetime expands keeping galaxies at fixed relative distances as measured by the co-expanding metric.

If the expansion could be likened to a swelling dough with galaxies being raisins in the dough, BB believes that the raisins (galaxies) do

not partake in the swelling while EST believes they do.

EST: I think it very important to clearly understand how the expanding metric affects physical entities like photons and elementary particles.

BB: I think that the spatial expansion will increase the wavelength of light but that it has no effect on fundamental particles, which don't expand with space.

EST: Does that mean that the scale of fundamental particles somehow is determined *a priori*, independently of the spatial and temporal metrics?

BB: Yes.

EST: Would this absolute scale of things also be the same in a perfectly empty vacuum, i.e. in a void without energy?

BB: Yes.

EST: I do not believe that this can be true since there is no reason why a particular scale should take preference in a complete void without references. Einstein's General Relativity equations do not suggest that there is such a preferred scale of things.

BB: Perhaps there is no preferred scale of things, but we know that things exist and that they have the scale they have. It is meaningless to discuss the possibility of a scale different from what it is.

EST: I disagree. I think the realization that the scale of things may not be predetermined is of fundamental importance for our understanding of the universe. As I said, Einstein's equations do not show any preference for a particular scale. If we change the scale, i.e. the metrics of both space and time, the equations are identical. Therefore, it is reasonable to assume that a universe with different scale would be completely equivalent to our universe.

BB: This does not mean that the scale of material objects change with time.

EST: I think it does. I believe that the universe expands by continually changing the scale and that this change of scale also affects material objects. For example, consider the value of the energy momentum tensor, i.e. the energy density of spacetime, at a certain point a few meters above the surface of the Earth. Now let us change the scale of spacetime so that the distance from the above mentioned point to the center of the Earth decreases by, say 1000 meters relative to the presumed fixed size of the Earth. According to Einstein's equations the energy momentum tensor does not change with this scale change. How-

ever, the new scale has moved the point well inside the Earth and we know that this means that the energy momentum tensor must change. Therefore, we have a contradiction unless the scale of the Earth changes with the scale of spacetime! I believe that there is a one-to-one correspondence between the scale of elementary particles and the scale of spacetime. The metrics of spacetime determine the scale of material objects and vice versa.

BB: You are trying to attach physical meaning to the changing metrics. However, in the Big Bang theory, the metrics used in the GR equations to model the cosmological expansion do not represent real distances. For example, distances between galaxies will increase with time and cause the redshift we see. This means that the expanding spatial metric in the GR model for the Big Bang universe does not correspond to the real measured distances.

EST: So the expanding metric is nothing more than a mathematical device used to model the expansion. It has no physical meaning?

BB: True, except that it stretches the wavelength of light causing the redshift.

EST: It has an effect on photons but not on other particles?

BB: Well

EST: Did you see Einstein's argument where he said that a stretching of the wavelength of light would invalidate Special Relativity? He concluded that in a spatially expanding universe the redshift must be a Doppler effect.

BB: Yes, this is one common interpretation.

EST: So we agree that the Big Bang expansion involves motion of galaxies relative to space or is there perhaps a continuous creation of new space?

BB: Some properties of the universe may be true but not accessible to what we call common sense. You must believe the mathematical equations.

EST: In the Expanding Spacetime theory, the expansion occurs everywhere, even locally. Matter, being part of spacetime, expands with spacetime. We observe the effects of the expansion at a distance, but even our own bodies participate in the scale expansion. Doesn't that make more sense from a modern physics standpoint?

BB: I don't see the problem with conceding that we don't know everything about the universe and therefore that some aspects of what we observe are unexplainable at our current level of understanding.

EST: True. However, I think the wonderful property of the universe

is that it is accessible to reason and that it is not beyond human intellect to discover how simple the grand design of the universe really is. The only thing that prevents us from seeing the truth are preconceived ideas based on sensory experience from our lives on a tiny speck in the universe for a very short time.

BB: Yes, I agree that this is what really limits our ability to understand. Distances are so large both in space and in time that it is difficult to see the design of the universe.

EST: Assuming that the design of the universe is based on reason, let's now see how much more reasonable everything becomes if we assume that both space and time expands, which by the way is equivalent to an expansion of the scale of spacetime. From what has been said above we realize that this expansion must include material objects, i.e. that the universe expands by changing the scale of everything. All distances between galaxies increase, but since our measuring rods increase at the same time, all measured distances will remain the same. Since there is no preferred scale of things all scales are equivalent and all epochs are equivalent. The universe expands while always remaining the same! We don't have any problems with the expanding metric. It agrees with the distance measured by timing a light beam.

BB: You think that the scale of everything changes with time. How do we know that this actually happens?

EST: The redshift is one piece of evidence. Actually, the Tired Light redshift associated with the scale expansion agrees much better with observations than the Doppler effect.

BB: The EST theory sounds like a steady state theory to me. If so, steady state theories have been ruled out long ago.

EST: Yes, the EST theory is a steady state theory in the sense that it does not include a beginning or an end of time. However, there was one fatal flaw with previous steady state theories—they could not account for the black body spectrum of the cosmic background radiation. The assumption of a spatially expanding universe was common to all these theories. In such a universe, a thermalized spectrum does not retain its black body character. It was impossible to explain the observed black body spectrum of the CMB. Another drawback was the assumption of continuous matter creation to fill in the voids opening up between galaxies. Although it perhaps could be argued that continuous matter creation is no less likely than the creation of everything in a single Big Bang, it was ultimately the almost perfect black body spectrum of the cosmic background radiation that killed the steady

state theories.

BB: You say that the EST is different?

EST: Yes, the remarkable thing with a scale expanding universe is that it retains the black body spectrum. The EST universe is in thermal equilibrium.

BB: How can that be? An expansion dilutes the energy in proportion to the changing volume, i.e. in proportion to the cube of the distance change. The black body spectrum will only be retained if energy is diluted in proportion to the fourth power of the distance.

EST: In the EST theory, expanding time is the missing fourth dimension. The easiest way to realize that the spectrum has to remain the same during the expansion is to note that, in expanding spacetime, the energy momentum tensor does not change with time. Since the energy momentum tensor describes the energy distribution in time and space, the spectrum of the cosmic background radiation does not change. This eliminates the fatal problem with earlier steady state theories. As a bonus, we note that the scale expansion does not require the creation of new matter. In fact, the EST theory completely moots the question of creation. The universe could be eternal.

BB: I still have difficulties with the idea of a scale expansion. If such a thing really exists, would there be any advantage of an expanding scale of things? Also, if the EST universe is eternal, where does all the energy radiated by billions of suns come from? It seems to me that you are invalidating the second law of thermodynamics.

EST: It is funny that you should mention the question of entropy and scale expansion together. Perhaps the most important feature of the scale expansion is that the temporal expansion continuously replaces energy lost by the spatial expansion. The EST universe is self-sustaining. Energy is added to the universe through the steadily decreasing pace of time. The universe is not a closed thermodynamic system. Obviously there is a very close relationship between the pace of time and energy. We know this already from Einstein's theories. All forms of energy are motion. Motion measured by an observer with a slower progression of time is perceived to be faster (higher energy) than for an observer with a faster progression of time. Thus, energy is relative; it depends on the pace of time of the observer. Now, if the universe expands by slowing down the progression of time, energy lost in radiation is restored by the slowing progression of time!

Consider the following thought experiment. Measure the temperature in a cooling pot of water at even time intervals and find that the

temperature decreases with time. However, the temperature is proportional to the kinetic energy of the water molecules. If we could somehow slow down our pace of time, the temperature we measure remains the same from measurement to measurement. This trick would, in effect, permit us to circumvent the energy conservation principle. Put more generally, the laws of physics as we know them do not necessarily apply in a universe with a changing pace of time.

BB: Now you are really going a bit too far. Do you want me to believe in a theory that violates one of the most basic laws of physics? To me this seems more like wild speculation than physics.

EST: Yes, I know that this is a problem. However, the EST theory is internally consistent and it agrees better with observations than the Big Bang theory. Also, the effects we are talking about are extremely small. The Earth's diameter increases by about 0.1 cm per year. Thus, all laws of physics are unaffected locally. We only see the effects of the scale expansion of spacetime at cosmological distances in space and time, and we may eventually show that they exist at subatomic levels. Therefore, it is possible that some laws of physics could be very slightly inaccurate (much as they were before Einstein introduced Relativity)

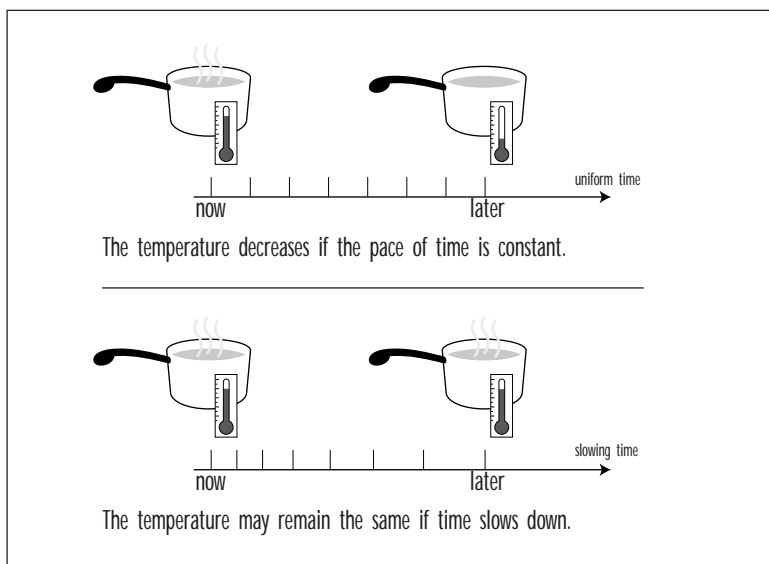


Figure 9.1: A slowing pace of time makes it possible to circumvent the conservation of energy.

and in need of revision.

BB: This is a tall order.

EST: There are only two things we can rely on when trying to solve the riddles of the universe—reason and observations. Nothing else will reveal its secrets to us. A reasonable and consistent theory that agrees with observations is the best we can possibly ask for. If such a theory is found, let us examine it with an open mind. The worst that can happen is that we find it to be wrong. The best that can happen is that we learn something new and important. However, closing our minds guarantees that we never will learn anything.

BB: Let's try to keep this discussion to the facts and not get carried away. Is there anything about the EST theory that could give me some real proof or at least a warm feeling that the theory might be right? Without this it will be very difficult for me to accept that all I have learned about the universe could be wrong.

EST: Well, for starters how about the measurable effects of Cosmic Drag? According to the EST theory all objects moving at speeds less than the speed of light will slow down with time, i.e. their relative velocities will decrease with time. Particles moving at the speed of light will continue to move at the speed of light, but their energy will decrease with time. The redshift results from this effect; the previously unexplainable spin-down of pulsars is another result. The accelerating secular motions of the planets a third. Cosmic drag in the solar system has been confirmed by direct measurements.

Other evidence for Cosmic Drag (and hence the EST theory) has to do with the small relative velocities of galaxies. Because of Cosmic Drag, the relative velocities of all moving objects in the universe decrease with time, the relative velocities of galaxies are quite small in relation to the speed of light. This agrees well with observations but cannot be adequately explained by computer simulations based on the Big Bang scenario.

BB: You say that all relative motion must decrease with time, yet we observe significant peculiar velocities of stars in galaxies and galaxies in clusters. The BB theory explains these velocities as being induced by gravitating dark matter. Does the EST theory provide an explanation?

EST: If the scale expansion is an ordinary physical process it is difficult to understand how the rate of expansion can be the same everywhere in the universe. It is much more likely that the rate of expansion varies from place to place in spacetime. It turns out that a randomly fluctuating rate of expansion in space and time will induce random ac-

celerations and random particle velocities. This random excitation is counteracted by the Cosmic Drag. The result is a steady state situation where particles are suspended in continuous random motion. The situation is not unlike the motion of the air molecules in the atmosphere here on Earth. To take this analogy further, cosmic winds may explain the large scale streaming we observe. Thus, in the EST theory, the peculiar velocities are due to spacetime turbulence rather than Dark Matter.

BB: This new Cosmic Drag seems to imply that the velocity of an inertial reference frame will change with time in violation of Newton's first law—the idea that an object set in motion will continue with the same velocity unless acted upon by an external force. Again, you are violating one of the most fundamental laws of physics.

EST: Newton's first law may be nothing other than a very good approximation. It has never been proven. It is not cast in concrete or God given. If it has to be modified to accommodate new data, so be it. This is the way our knowledge advances. Old theories are continually being modified when our awareness increases.

BB: Unfortunately, based on this I must conclude that the EST theory is unscientific. It violates both the law of energy conservation and Newton's first law.

EST: How about the Big Bang, doesn't it violate both physics and common sense that everything should have been created in singularity in space and time?

BB: I grant you this point. I must concede that the creation event is enigmatic.

EST: As you know there are many other unresolved puzzles in the Big Bang universe that forces us to make strange assumptions. Examples include the Inflation Theory and the assumption that there are Dark Matter particles that gravitate but cannot be seen. I think that's because we restrict ourselves to known physics. I suggest that there might be some small adjustment to the standard laws of physics, an adjustment so tiny that we do not notice its effect locally. However, on a cosmological scale, it could resolve many problems. If such an adjustment to the laws of physics can be found I think it should be considered seriously, in particular if it also eliminates the possibility of Black Hole type singularities.

BB: Are you telling me that there are no Black Holes?!

EST: It is funny how such a strange concept as a Black Hole can have gained such wide acceptance. We do not have any observational proof for it. The large mass concentrations that we see at the center of galaxies

do not necessarily have to be Black Holes. Not too long ago leading scientists like Einstein and Eddington would have welcomed any cosmological theory that excluded the possibility of Black Hole singularities. Whenever a scientific model of the natural world produces a singularity, it means that the model is inaccurate. We see singularities predicted in basic aerodynamic models and electronic models, but nature doesn't allow them. The mathematical models at the singularities must be redrawn.

BB: But the solution to Einstein's GR equations shows that nothing can prevent gravitational collapse when the attracting mass density is very large.

EST: The GR equations we use to arrive at this result assume that there is no scale expansion and that the energy of vacuum is zero. However, in the EST theory, vacuum has energy. The effect of the scale expansion is amplified greatly when the strength of the gravitational field increases. Using GR, it can be shown that the scale expansion counteracts gravitation and prevents the formation of Black Holes.

BB: What happens then in a gravitational collapse?

EST: There is no gravitational collapse. GR tells us that a particle falling in a gravitational field can never be sucked into a Black Hole but it does not tell us what happens instead. Einstein, with his unsurpassed instinct for physics, speculated that there might be a huge explosion. Perhaps this is true. Or perhaps quasars are the result. They could be nature's way of preventing gravitational collapse, at the same time recycling heavy elements into light elements like hydrogen. This scenario would close the loop since the new hydrogen will later burn in new stars leading to an eternal cycle of existence.

BB: I have no comments on this. It is all very speculative.

EST: Yet it suggests a beautifully simple and logical theory for the universe. It may be wrong, but do you want to take the risk of losing an opportunity to learn something new and important about the world we live in just because the theory seems to violate a few preconceptions?

BB: I am not prepared to throw everything I have learned overboard. The step is too big for me. It is too unsettling.

EST: You don't have to unlearn what you have learned. The current laws of physics are perfectly adequate for local phenomena. However, they may have to be modified on a cosmological scale of space and time in order to explain the universe.

BB: The arguments for the EST theory have to be really convincing before I am prepared to modify the two most basic laws of physics.

EST: I understand this attitude. However, it is interesting how a rea-

sonable and simple explanation to the cosmological puzzles is deemed unscientific off hand because it violates known physics. How can we ever move forward if we cannot accept the possibility that what is known to be true today may have to be modified tomorrow? The laws of physics are no more than rules that seem to work well in local experiments. Let us examine the EST theory with an open mind and judge it on its merits rather than deny it based on our preconceived ideas on how the universe ought to be. Otherwise, our theories are based on imagination rather than how we imagine a Creator designed the universe rather than reality.

BB: Please, let us leave the Creator out of our discussion. Many religious people are very comfortable with the Big Bang creation since the idea of such a creation of the world is supported by metaphysical interpretations of the Bible.

EST: Yes, perhaps we should leave the very significant religious and philosophical aspects of the EST theory to others who are more qualified to discuss them.

BB: I must concede that there is one interesting aspect of the EST; it seems to provide an explanation for the progression of time.

EST: Yes, the EST interprets the progression of time as resulting from the scale expansion, making it a well-defined dynamic process rather than a poorly understood phenomenon. The time-acceleration, which implies scale expansion, is a new and important feature. It seems to resolve many puzzles but will require a new way of looking at the world. Rather than the old view of empty space populated by fixed material objects, we are now dealing with a universe where space, time, and matter are in a continuous and perpetual energy flux.

BB: If the EST theory ultimately survives scientific scrutiny, it will be very difficult for many people to realize and accept that in the future most of their contributions to the field of cosmology will be seen merely as epicycles of a quaint and obsolete theory.

EST: Yes, unfortunately this is the nature of scientific evolution. It often destroys the old to make room for the new. What ultimately determines the success of a theory is not whether it conforms to or provides support for the prevailing worldview, but whether it agrees with observations and is logical, internally consistent, and free of contradictions. Fortunately, as humans we have the ability to recognize the truth by its simple beauty. The truth is accessible to anyone with an open mind.



Concluding Comments

The Expanding Spacetime theory tells us that we are traveling in time, carried forward by a continuously accelerating scale expansion. Positive and negative energy are generated by acceleration in both space and time. This energy powers the universe and permeates all levels. Matter, light, and life emerge as by-products of a cosmic energy flow without ever changing the net energy of the universe, which is zero.

The strong sensation we have of the flow of time is real and is caused by a continuously ongoing scale expansion that affects everyone and everything in the universe. Without the expansion, time would stand still; there would be no energy and no life. We exist because the universe expands.

The universe exists in itself and by itself without beginning or end. It just *is*.

The cosmos could be eternal and possibly of unlimited extension. Once again we are reminded of how small we are in comparison with the cosmic vastness.

It is comforting to know that the bleak picture painted by the Big Bang theory of a random birth followed by a cold heat death or big crunch could be false. Instead it appears that we may live in a universe sublime in its simple beauty, forever flowing with energy, light, and life.

In this book I have described a new way of viewing the universe. I have proposed a cosmological theory based on modern mathematics and physics. This is the approach presently favored in Western culture.

Here in the West, any theory or new idea regarding the universe or cosmology is promptly ignored unless it can be substantiated by scientific evidence based on science at its current level of development. In this scientific approach we try to explain the workings of the universe based on known science. Of course, the limitation of this approach is that it automatically constrains any theory to the domain of the presently known. This is a self-limiting process that implicitly presumes that a true understanding of the universe always might be found within currently known epistemology.

Looking back at our past history and noting all our past misconceptions of the world, we realize how foolish and shortsighted such a stance is. It has been said that God is a mathematician, but to think that He would constrain the creation to currently known mathematics seems rather naive. Yet, some of us seem to believe that a real and true understanding of nature and our world can be gained based on what is presently known. They are looking to science and to scientists for an explanation to the meaning of life, hoping that perhaps science has the answer. The past should have taught us differently. We should have learned by now that we don't know and perhaps will never know the true workings of the universe or the meaning of life. We must realize that our view of the world is evolving together with the human species and that our current level of knowledge most likely is totally inadequate for explaining all the wonders of the universe.

Numerous attempts have been made in the past to present various world-views and to explain the meaning of life. In fact, a human society without a worldview may never have existed. Examples are the various religious teachings that unfortunately have been as damaging as they have been helpful in bettering our quality of life and in improving human relations. Members of each religion typically see their own religion as the one and only truth and all other teachings as heresy. Yet, many religious ideas and convictions might lie closer to a true understanding of the world than the limited view that is offered by our present scientific understanding.

But how can we know which of these religious ideas and concepts might be valid? The only viable approach might yet be to use science as a tool in assessing our role and our place in the universe, since science is based on data and on logical reasoning that we all can relate to and believe in. Science provides us with a common basis on which to build a unified worldview. This is all well and good as long as we keenly understand and accept that the prevailing worldview always must be incom-

plete and that it sometimes might be completely wrong. Just because a certain scientific theory is consistent with our present level of scientific understanding does not guarantee that it is right. Unfortunately, we must accept this shortcoming and always keep our minds open to new discoveries that could bring us further along the road toward an ever-deepening understanding. Many have not yet understood or accepted that our present scientific knowledge is hopelessly inadequate compared to what will be known in the future and that to future generations our contemporary worldview might appear as quaint as the flat Earth hypothesis appears to us. We must all humbly realize that what we presently know is totally insignificant compared to what is knowable. Compared to what will be known by humanity in the future and to what might already be known by intelligence elsewhere in the universe, our present amount of knowledge is negligible.

In view of this humbling insight we realize that any new theory like the EST theory proposed in this book only can contribute a tiny step on our road toward enlightenment. However, if the new theory provides a better description of the world, we should make use of it fully while realizing that it is not the final theory but only one small incremental step. Future theories will most likely involve ideas and techniques presently beyond our comprehension.

We can make use of the new EST theory by playing a mind game. We can assume that the theory actually is right and that it gives a true representation of reality and investigate the possibility that the insights offered by the theory agree with our perceptions and observations. I have done this by comparing the theory's predictions with astronomical observations and found that it gives a superior description of the observed universe. However, there is another level on which we can compare the theory with reality, a somewhat subjective and philosophical level of perhaps even greater importance.

The EST theory tells us that everything in the universe is in a constant flux driven by the cosmological scale expansion. Everything exists on the leading edge of \emptyset becoming \emptyset or unfolding into the future. Nothing exists in the immediate future, just probabilities of what might happen. For example, it is very likely that the book you now are reading still will be there in the next moment, but it is not absolutely guaranteed. This dynamic becoming of the universe not only applies to all material objects including your body; it also applies to your thoughts. The workings of the mind reflect the evolution of the universe. The mind is never static but is a dynamic flow governed by complicated

electrochemical processes. The thought in your mind at this precise moment is a reflection of thoughts in the past and of new sensory inputs. Like everything else in the universe, thinking is part of the cosmological becoming.

The realization that we all are traveling on the crest of the wave of time toward an unknown future gives a better picture of our existence than the old way of looking at the world. This old description evolved as a result of the scientific revolution spearheaded by Isaac Newton in the 17th century. According to Newton's laws of motion, the trajectory of any particle is determined by the forces acting on the particle and the position and velocity of the particle at some earlier time. This idea combined with the notion of a coordinate system invented by Descartes provided us with a view of the universe as consisting of preexisting space in which particles move and events predictably unfold like acts of a drama on a stage.

Subconsciously we get the idea that our own existence merely is a short visit on this world stage, a stage that existed before us and that will continue to exist without us when we are gone. This picture, which appears to be completely wrong, has led to many misconceptions, for example dreams of traveling in time to the past or the future. The impossibility of such an enterprise may be directly understood by realizing that the future or the past does not exist, i.e. that the stage of the future or the past does not exist now. The universe is continually recreating itself in a process where every material thing and every event is interdependent to varying degrees. Like vortexes and ripples on the surface of a river, our existence is a temporary pattern in the universal flow of time and energy.

In a sense, General Relativity gives a misleading description of the world if it is interpreted to mean that the existing world is four-dimensional. This interpretation gives the wrong impression that the four dimensions actually exist at this very moment and that the progression of time somehow causes us to travel through a four-dimensional world along the time axis. This picture is reinforced in most books on relativity. Obviously, the four dimensions do not exist at any particular moment since time cannot exist in a moment. Time must progress to span the fourth dimension. We must realize that the four dimensional description of the world is not like a map describing the world as it is but rather a way of recording history. It is a record of past events showing their locations in space and time. Using this spacetime concept, Einstein, with his general relativity theory, found a deep underlying order in nature that relates

events in space and time and helps us predict the average course of events in the future. However, this future does not yet exist. It is continuously being created guided by the laws of Quantum Mechanics. Quantum Mechanics deals with the progression of time and the detailed process of becoming. General relativity describes the underlying structure that guides this process of becoming on a macroscopic scale. Time is continuous in General Relativity, while quantum mechanical events are discrete reflecting a step-wise progression of time.

The permanent aspects of nature are preserved in the underlying structure and laws that guide the process of becoming and in the inherent properties of spacetime that permit the formation of the material particles and objects that we perceive make up the world. Existence might be likened to a symphony in which the permanence lies in its structure and composition, both of which correspond to the laws of nature, and its performance with all instruments playing together is the act of becoming via the progression of time. With this new world-view in mind many mysteries find their natural explanation.

One of the most troublesome difficulties in modern physics is the already mentioned incompatibility of Quantum Mechanics and General Relativity. General Relativity is an extension of Newton's universe in that it treats spacetime as the stage on which events take place. The new and different feature of General Relativity theory is the realization that the geometry of this world stage is modified by the presence of matter and energy. However, the main features of Newton's world remain. Particles move on continuous trajectories in spacetime as visualized by geodesics in a four-dimensional world. Quantum Mechanics, on the other hand, gives a very different description of the world. By luck and ingenuity we have found the laws that govern atomic and subatomic processes without really understanding the reason for why these laws should apply. Nature never seems to lay down any law without a good reason, but the reason for Quantum Mechanics has in the past been lacking.

Perhaps the most troublesome aspect of Quantum Mechanics is that it gives a discontinuous description of the world. Particles no longer move on smooth continuous paths but jump around in a way that only can be described by probabilities. There is no explanation to this behavior. Everyone encountering Quantum Mechanics for the first time naturally suspects that something must be missing in our understanding. Einstein's famous comment "God does not play dice!" reflects this feeling of uneasiness. Quantum mechanics simply does not fit into our

classical view of the world.

The EST theory is a step toward resolving these rather confusing issues. It proposes that the cosmological expansion proceeds in discrete steps and that the future is being created or updated at each moment. The deeper reason for this discrete expansion mode seems to be that it preserves spacetime equivalence making possible evolution without cosmological aging. The discrete expansion mode immediately explains why the world on a very small scale is better described by probabilities and why particles do not move on smooth paths. The bubbling, frothing, spacetime generated by the all-encompassing scale expansion influences the measurement of every particle. The stepwise slowing pace of time continually releases energy quanta everywhere throughout spacetime.

Can this be the way the universe works? Judging from the past we should be suspicious. It is unlikely that the EST theory gives an accurate description of the world, but it might be a step in the right direction. It could help us improve our understanding and give us ideas for future explorations. This should be preferred over the current reluctance within the scientific community to search for any deeper truths, limiting the role of science to finding mathematical relationships that describe nature as observed without bothering with speculations on the true nature of things. Perhaps this stance is the natural result of the up till now unresolvable incompatibility between the classical worldview and Quantum Mechanics. However, a continuously evolving view of the world is a great asset that will guide us in our quest for enlightenment as long as we remember that this prevailing worldview may not give a true representation of reality. More will always remain to be discovered.

The most important proposition of the EST theory is that everything in the world is in a state of flux; everything is always changing with expanding spacetime. Our existence is a flow, a progression of fleeting moments. The old idea that the universe consists of space, which we inhabit, is misleading. When we look into the cosmos it appears that we are living in a three-dimensional space, but what we see is no longer there; it lies in the past. The material world exists here and now in our thought and heart beat, to be re-created in the next moment guided by the dynamic process of becoming.

The essence of all existence might be this process of becoming together with the structure, laws, and relationships guiding the underlying energy field that realizes our existence. Since we are intelligent (at least in our own opinion) and our thoughts are part of the cosmic energy

field, the universe is intelligent. Noting all the beauty in the world and its awesome elegant design, there is very little reason to believe that human intelligence is unique. Rather, it appears that reason and intelligence permeates the universe on all levels and that it might be the controlling force in the cosmological expansion. The universe is a flowing and vibrating energy field generated by the expansion of spacetime. Matter is created and sustained by this energy field that also includes all the laws and relationships that make life possible. We are all participating in the eternal flow of becoming which we perceive as the progression of time. Our inner life of thoughts and emotions and the outer material world are but different manifestations of a holistic living system, the universe.

Our existence is a happening, a dance of energy in space on the breaking edge of time.

A Personal Note

It is common practice in the scientific community to present the results from an investigation in the form of a scientific paper that is short and to the point. Such a scientific paper is designed to communicate what has been done, how it was done, the results and the conclusions. Nothing else. The result of many years of hard work, wrong turns, misunderstandings and frustrations is often communicated in just a few terse pages. The reader has no clue about the personal travail involved in reaching the results. The paper tells only part of the story, the part that can be substantiated and defended on a scientific basis. But often there is more, much more, hidden information of great interest. Ideas, guesses and feelings of the author are suppressed since they are considered unscientific. This is understandable if you are a professional scientist. There is nothing more detrimental to your career than to be considered unscientific by your peers. However, being an outsider to the scientific establishment and of independent means I do not have these qualms. Therefore, I would like to let you know a little more about how I feel about the EST theory.

If there were just one thing I would like you to know about my experience during the past six years, during which I have thought about the EST theory almost every day, it is a feeling of delight and awe. Perhaps it is the realization that I may have uncovered one of nature's wonderful secrets that has lain hidden from us ever since the dawn of humanity many millions years ago. This feeling of awe was with me at my first flash of insight and has stayed with me all the time during these years

of searching while uncovering one hidden truth after the other. Perhaps you object to me calling these observations truths and not just speculations. The future will tell if the EST theory is a step toward a deeper understanding of the universe.

I have offered you a very different view of our universe for your consideration: a scale-expanding world where everything always remains the same yet continually evolves. As far as I have been able to investigate the validity of this new worldview using modern physics, I have found it to agree well with observations and explain several unresolved cosmological puzzles. It is of course possible that the new EST theory might be wrong, but my hope is that it will be taken seriously by the scientific community and treated as a strong candidate in competition with the Big Bang theory. Proponents of the Big Bang theory are now faced with the challenge of demonstrating that the EST theory is inferior to the Big Bang theory. If they cannot do this convincingly, they should accept the possibility that the EST theory might give a better description of the universe even if this implies that much that has been done in field of cosmology during the past seventy-five years is obsolete.

The EST universe offers a delightful alternative to the doomed Big Bang universe. An eternal world everywhere flowing of energy that imposes no limits on our future. It holds out the promise of eternal life for our species and for all other beings. The spiritual implications are vast. Where will evolution lead us? What has happened to all the intelligent civilizations in the Milky Way and elsewhere that must have preceded us? Are we destined eventually to merge with a higher form of cosmic intelligence that we presently only vaguely sense as the presence of something spiritual or supernatural?

Although there may be no physical way for us to transverse the vastness of space and time in our quest for enlightenment, our spirits may fly free, reaching for the truth beyond both space and time.

We are the music-makers

And we are the dreamers of dreams

Wandering by lone sea-breakers

And sitting by desolate streams;

World losers and world-forsakers,

On whom the pale moon gleams;

Yet we are the movers and shakers

Of the world forever, it seems

Öö Author unknown



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