Cosmology

Song: Twinkle, Twinkle Little Star

I'm sure that the Musical Prelude has been familiar to most of you for a major part of your life. I fondly remember singing it to my children, and my mother and grandmothers singing it to me.

I wanted to begin this morning's journey on this familiar path in the hope that it could provide some comfort when we run up against the complicated and perhaps intimidating images conjured up by a word like cosmology.

Twinkle, twinkle, little star,
How I wonder what you are.
Up above the world so high,
Like a diamond in the sky.
Twinkle, twinkle little star,
How I wonder what you are.

This beloved song is a small part of that timeless quest by humans to answer some basic questions, starting very early in our lives.

What are we made of? Where do we come from? Are we alone? How do we relate to whatever is out there, "in the heavens"? And most importantly, what is life and death about, and do we matter?

Throughout history, culture after culture had its own view of the cosmos which provided answers to these questions, and its own songs, stories and metaphors, whose purpose was to explore what anthropologists call cosmology, the culture's "Big Picture" or "founding myth".

In this meaning, cosmology is a shared view of how human life, the natural world and the spiritual world fit together. It is usually described metaphorically, using elements familiar in people's daily lives … like the diamond in the sky ... and often has a God or gods, an established order, and directions for living.

In all cultures that I know of, cosmology in this sense had a profound impact on people's daily lives, and assured them that they had a central and significant place in the cosmos.

I had a recent experience of the power of this form of cosmology when I attended the funeral of my Uncle Bill. I suppose that most of you could recall similar experiences.

Bill was a good man who lived most of his life as a devout fundamentalist Christian. The service was full of metaphorical assurances of the central place he and his family shared on this earth and in heaven, and of the love that had been showered on them during his life, and would continue to be, throughout eternity. It was a message of hope and love at a time of great loss for his family, when they needed to be comforted. Cosmology had real human significance.

This morning I want to explore some of those questions based on an emerging scientific view of the cosmos provided by our unprecedented access to technology, observation, and scientific theory.

My premise is that science can also provide a powerful and instructive explanation of the human place in the universe, which can be appreciated by all humans, regardless of their religious or cultural perspective. Modern science is beginning to provide the first creation myth that may actually be verified by anyone with the appropriate tools and inclination.

By doing so, it can play a unifying role in the world, assist in the development of a truly global culture, and otherwise serve the global good.

When I last spoke in this place, many of you will have heard my belief that Canadian Unitarians have a unique opportunity to contribute to world unity, peace, and understanding based on our principles, and our ability to relate to, and to bridge, different religious perspectives.

Today I want to add a scientific understanding of modern cosmology to that list of tools we Canadian Unitarians could contribute to those important tasks.

So, with that map in hand, let us begin the journey.

Opening Words

The opening words this morning are from Joel Primack and Nancy Ellen Abrams. Primack is one of the world's foremost cosmologists. Abrams, his wife, is a writer on the history, philosophy and politics of science. These words come from their recent book ***The View from the Centre of the Universe*****:** on which much of this service is based.

We humans are significant and central to the Universe in unexpected and important ways. We are discovering this fact at a moment in history when so much is at stake. It is our hope that this new picture of the universe will help convey the preciousness of the cosmic experiment on planet Earth. An understanding of our universe and our extraordinary place in it may reveal solutions to the problems that confront us personally and globally.

Chalice Lighting

Every Sunday, Unitarian and Universalist congregations light a chalice. This symbol has many meanings: a symbol of hope, of life, of human community, the beacon of truth.

Many cultures use light and fire as significant symbols. The reading is from the traditions of the Huichol Indians of Mexico.

Grandfather Fire is the original light, the original wisdom, the universe's own memory. In the beginning he took the raw energy of creation and transformed it into vision by creating colours and images, and into sound by singing. In this way he gave us human knowledge and we are forever grateful. Grandfather Fire is alive in every flame and spark, and fire is to be treated as an honoured being.

Song #34 Though I May Speak With Bravest Fire

This song reminds us that no matter what else we may do, love is an essential ingredient in life.

Story For All Ages
Calvin and the Cosmic Vacuum Cleaner

Do any of you have a cat? I do, and his name is Calvin. I brought a picture of Calvin to show you. Does your cat like to play games? Calvin does. And one of his favourites is "The Gravity Game".

Calvin plays this game whenever he is up on a flat surface like a table or a bed or a counter top. If there is something sitting there, like a pencil, or a spoon, or a salt shaker, Calvin will take his paw and will push that object slowly over to the edge.

When it falls off, he will peek over the edge and watch it very intently for a minute or so, and then will jump down and sniff all around the object on the ground. He seems to enjoy this game very much.

Now of course we all know that a ball will fall down when it is pushed off the table. But why does it do that? I'm going to try to answer that question in two different ways. One is called a myth, and the other is called a theory.

A myth is a story that explains something. It is just made up by the story teller. It may not be actually true, but a good myth can explain a lot and can be quite helpful for people who hear it. Much of our best literature is myth in this sense, conveying sometimes profound meaning in a story which is not factually true.

A theory is a scientific explanation, often one that uses mathematics. A good theory has to be able to predict things that can be actually observed, so it has to be true in addition to explaining a lot. A theory is a myth with a reality check. The very best theories also explain things that we didn't even know about yet!

So here is my myth, a story I made up to explain how Calvin's Gravity Game works.

It is really quite simple to explain. The answer is … it is all because of the Cosmic Vacuum Cleaner!

The earth has something inside called The Cosmic Vacuum Cleaner. This Cosmic Vacuum Cleaner sucks very hard on everything above the earth. When the ball is on the table, the Cosmic Vacuum Cleaner can't suck on it because the table is in the way. But when the ball is somewhere in the air, it can get sucked right up against the earth. Like that!

But there is more than that. Big things like a ball can get sucked on much harder than little objects like a feather, so the ball gets sucked down to the ground much faster than the feather. We can all see that happening with our own eyes.

And the Cosmic Vacuum Cleaner, like all vacuum cleaners, can't suck up things that are very far away. Therefore, even though the moon and the sun and the stars are just sitting there in the air, they must be too far away for the Cosmic Vacuum Cleaner to work. That's why they don't come crashing down to earth like a ball does.

That's a pretty neat idea, right? It really explains a lot! Now let's try a theory about how Calvin's Gravity Game works.

This time the answer is … it is all because of Isaac Newton's Theory of Gravity. It goes like this:

The earth has something called Mass, and so do the ball, and the feather and the sun and the moon and the stars. In fact every object has mass. Big objects have a lot of mass and small objects have only a little mass.

Now masses find each other very attractive, and they want to be as close to each other as possible. So each mass pulls on each other mass to try to get close together.

We all know that a small mass is easier to move when you pull on it than a big mass, so small objects like the ball are drawn toward the large object like the Earth. That is why the ball falls down to be next to the Earth instead of the Earth jumping up to be near the ball.

Now that is all pretty much the same as what we could explain using the Myth of the Cosmic Vacuum Cleaner.

But actually the Theory has some advantages. Newton was able to calculate how big the pull was and then measure it to find out if he was right. He could also calculate how fast an object would be moving after falling for a certain time, and his measurements showed he was right about that too.

And he was also able to show that the strength of the attraction was reduced when objects were far away. In fact he was able to calculate very precisely how objects moved, and how strong gravity was, and every time he made a calculation it turned out to be precisely in agreement with measurements.

And based on this Theory of Gravity, he was able to explain why the earth went around the sun and the moon went around the earth, and a lot of other things besides, that the Cosmic Vacuum Cleaner could not explain.

So, what I want you to remember is that scientific theories which can be proven by measurements give us more useful information than stories that are made up by a story teller. But stories like The Cosmic Vacuum Cleaner can still be a lot of fun.

Readings

A Shared Vision of Reality
by Joel Primack and Nancy Ellen Abrams

In their hearts, most people are still living in an imagined universe where space is emptiness, stars are scattered randomly, and common sense is a reliable guide. In this imagined universe, we humans have no special place and often feel insignificant. But today's golden age of astronomy is revealing that this lonely understanding of the universe is misguided. Our universe is rich, fascinating and meaningful, and in it, we humans occupy an extraordinary place.

If you close your eyes and try to picture the universe as a whole, what do you see with your mind's eye? Shooting stars, spiral galaxies, an ember red moon rising over an unknown planet? Images like these can evoke the strangeness that lies beyond the earth, but they don't represent the universe as a whole any better than a single atom would or your own face. The strange fact is that in this information age, when powerful and fast paced images are our currency of communication, most of us have no idea how to picture

the universe. But every pre-scientific culture did, and in their own cosmos they had a central and significant place.

Pre-scientific people had believable answers to big questions that became impossible to answer once we started to demand scientific accuracy. Does time run in one direction or is it cyclical? Has the universe always existed, or did it come into being? If it had a beginning, how did it start? What is it made of? How does it work? How do we humans fit in? People hardly even ask such fundamental questions any more, or appreciate the answers affect not only how we live but what we believe is possible, including all our goals and plans. Ours is probably the first major culture in human history with no shared picture of reality.

The main threats to our survival result from the almost total disjunction between the power of our technologies and the wisdom required to use them over the long period during which their effects will last.

The modern science of cosmology is discovering the universal reality in which we are all immersed.

What is emerging is humanity's first picture of the universe as a whole that might actually be true. There have been countless myths of the origin of the universe, but this is the first one that no story-teller made up … we are all witnesses on the edge of our seats.

Reading Two

Knowing the Universe in Detail (Except for That Pesky 96 Percent of It) By DENNIS OVERBYE, New York Times ESSAY, October 24, 2006

Hardly anyone remembers now, but 1991 was a bad year for the Big Bang.

Astronomers were having more and more difficulty reconciling their models of the explosion that gave birth and impetus to the expanding cosmos with the structure of the modern universe, in particular the discovery of strings of clusters and so-called super-clusters of galaxies going hundreds of millions of light-years across the sky.

There was a rash of articles in prestigious journals like Science and even this newspaper saying that major elements of the model, or even the Big Bang itself, might have to be junked. "Big Bang Blown to Bits," read one headline I remember.

I took all this rather personally because the publication of my first book, which was about cosmology, coincided with the appearance of these headlines. The cosmic jig was up, and I wasn't getting invited onto any talk shows.

But in April 1992, George Smoot from the University of California, Berkeley, announced that the NASA satellite Cosmic Background Explorer, or Cobe, had detected faint irregularities in a bath of microwaves that pervade space.

The microwaves are presumed to be cooling radiation from the original fireball, and the splotches were the right size to one day grow into giant clusters of galaxies.

"If you are religious, it is like looking at God," Dr. Smoot said.

This month Dr. Smoot and John Mather, of the Goddard Space Flight Center, the head Cobe scientist, were awarded the Nobel Prize in Physics. There was much talk that Cobe had marked a turning point, the beginning of a "golden age," in which cosmology went from a collection of vague ideas to a precision science.

Indeed, subsequent observations have parsed the meaning of those lumps, allowing cosmologists to converge on a remarkably detailed picture of the universe. The Big Bang, they now say, happened 13.7 billion years ago, plus or minus 150,000 years. That is a far cry from the days when some astronomers were ready to go to the mat over whether it was 10 billion or 20 billion years ago and when others shrugged and said a factor of two was pretty good in cosmology.

Moreover, they now say, ordinary atomic matter of the kind that makes up you, me and the stars is 4 percent of the cosmos; dark matter that floats as gravitational glue between the stars and galaxies is 20 percent; and dark energy, which is apparently accelerating the cosmic expansion, pushing the galaxies faster and faster apart, is 76 percent, plus or minus 2 percent.

You might wonder just exactly what kind of triumph "precision cosmology" represents when 96 percent of the universe is unknown dark stuff. Stars and people we know about. But the best guess for dark matter is that it is some kind of subatomic particle that will be discovered someday.

Dark energy was a complete surprise. How often do you toss a handful of gravel into the air and the rocks speed up as they leave your hand and disappear into the sky? The leading contender for an explanation is a fudge factor representing the repulsive force of empty space that Einstein danced in and out of his equations 75 or so years ago. But no one really knows.

Apparently we now know enough to say that the universe is precisely "preposterous," in the words of Sean Carroll, a physicist and blogger at the California Institute of Technology. Michael Turner, a cosmologist at the University of Chicago, likes to say, "We know much, but we understand little."

Critics of the Big Bang mutter darkly that all these mysterious elements in the equation are reminiscent of the epicycles, circles upon circles added to the orbits of the planets back in the Middle Ages to maintain the appearance that they were circling the Earth. Sometimes I wonder if the astrophysicists have been too glib for their own good. By adding dark energy and dark matter on top of black holes, they have overextended the "dark" brand just when we need a fresh dose of wonder.

But I didn't buy the death of the Big Bang 15 years ago, and I don't buy the criticism now. Particle physicists had already predicted the existence of extra "dark" particles before cosmologists put them to work. And antigravity, the dark energy, in precisely the amount discovered by two rival teams of astronomers in 1998, turned out to be the ingredient that made the Big Bang models finally work. Nobody had a chance to jiggle the numbers.

Sometimes the game comes to you. It was by following the light that cosmologists were led into the dark.

Still, the universe can always use a new Copernicus or Einstein. Thanks to the Cobe scientists and their successors, these are boom times for the Big Bang. After all, 96 percent of the universe is still waiting to be found.

Cosmology

What is Cosmology? There are two very different meanings.

As we discussed before, for anthropologists, cosmology is the culture's Big Picture" or "founding myth".

The Big Picture makes sense of the world, and provides a context for life in which human affairs acquire meaning on a higher scale. It provides a shared understanding of why good and bad events happen. How should one behave in particular situations? Which gods need to be appeased, and what rituals are to be used to do so?

These cosmologies are not factually correct, but they have power because they offer guidance to humans about how to live in the world those humans actually experience. They are the Cosmic Vacuum Cleaners.

Today I want to explore the cosmic equivalent of Newton's Theory explaining Calvin's Gravity Game. To me, being factually correct is an essential feature. That is the "bravest fire" part. But I also want to explore what a scientific understanding can do for those other things that are central to humanity. That is the "love" part.

An early advocate of this approach was Joseph Campbell a long time student of myth and prolific author.

In Campbell's his last book *The Inner Reaches of Outer Space*, Campbell argued that humanity desperately needs a new story of reality that can be shared by all, not just a particular chosen group. This story must at the same time demonstrate humanity's connection to all that is, and be consistent with scientific discoveries. He placed his faith in physics to lead the way. When he died in 1985, modern cosmology was just about to undergo its own Big Bang of creativity.

What Campbell was searching for was a new myth, a higher order explanation that people use to explain reality and their place in it. It is that sort of myth that I believe may be provided by cosmology, a reality that can be tested and verified by people from all cultures.

Religious myths are used extensively by people within that religion, but can seem arbitrary and nonsensical to outsiders. Religious myths can not provide such a basic human need for all of humanity.

For scientists, cosmology is a branch of astrophysics studying the origins and structure of the universe as a whole. It does so by developing intricate mathematical theories and testing them against the evidence provided by sophisticated instruments.

Scientific cosmology does not set out to say anything about human beings or how they should live.

However, it can provide scientific explanations of our human place in the universe which can be verified by any individual in any culture. It can play a unifying role in the world, assist in development of a global culture, and otherwise serve the common global good.

In other words, I believe that scientific cosmology can also say a lot about human beings and how we should live. And I believe Unitarians are well placed to play a positive role in this endeavour.

We are able to draw on spiritual insight wherever we find it, while at the same time not getting tied up in religious restrictions imposed by received knowledge. This can be a very useful advantage.

Now we need to say something about that word “theory” that is at the core of cosmology.

In common usage, there is a tendency in our society to downplay “theories” as being merely someone’s preferred guess or hunch. Much of the heated debate about “Darwin’s Theory of Evolution” arises from a fundamental misunderstanding of the meaning of the word theory. The idea that Darwin is “only a theory, not a fact” and that it is only fair to allow other explanations, like creationism, to be taught is profoundly mistaken.

To scientists, a theory has to make predictions that are testable, and which could result in the theory being proved wrong. A theory which can explain all possible data … such as “God did it” … is not scientific because it can never be proven wrong.

Much of science is focused on stress testing theories … trying to find the most definitive way to confirm or deny the predictions.

The game never ends. A theory can be disproved by a single counter example, but it can never be proved correct. That is because if it was proven to be true it could never be wrong, which places it in the realm of faith, not science.

Modern cosmology is based on two well established theories, Einstein’s general theory of relativity, and quantum theory.

They have both been rigorously tested for nearly a hundred years. They have never been found to make predictions that are inconsistent with the data and most of their predictions have actually been discovered … with the notable exception of gravity waves.

There is very high confidence in these theories, but there can never be certainty. However, it is well known that one or both of these foundations is incomplete. It has so far been impossible to construct a quantum theory of gravity. Every attempt to do so has produced some basic inconsistencies in the predictions.

Probably the most certain way to fame as a scientist … a nearly instant Nobel Prize … is to find data which refutes the predictions of such widely tested theories.

Now we turn to what cosmologists do.

To begin, cosmologists make some basic assumptions. It is assumed that the laws of physics, as we now understand them, are constant over both time and space. They are valid not only here and now, but also there and then. That is important because the universe is both vary large and very old.

It is also assumed that the fundamental constants of physics, such as the strength of the gravitational attraction or the strength of the electromagnetic interaction, are likewise constant.

It is important to understand that these are assumptions. There is much evidence to support them, but some limited hints that they may be incorrect.

The cosmologist then constructs a theoretical starting point, and uses a supercomputer to create a detailed image of what the universe would look like today if the theory was correct.

The predictions are then tested against the actual observations. Those theories that produce a modern universe inconsistent with the data are discarded.

Before proceeding, we also need to say some things about “common sense” because much of cosmology defies so called “common sense”.

This is inevitable. Common sense arises from our intuition, fed by our life long experience of the world in our immediate vicinity. It is nothing more than the totality of our experience, interpreted by our brains. It lets us create myths like the Cosmic Vacuum Cleaner that “make sense”.

But we have never experienced the speeds, pressures and temperatures that are commonly found in stars, galaxies and exotic objects like black holes. Our common sense is useless in considering what is predicted about such objects, and needs to be abandoned, or at least rebuilt of experiences based on the data from those environments.

In other words, it would be dangerous to expect the predictions of cosmology to make “common sense”.

By the way, this is a good lesson for us in other circumstances as well. Our intuition may also prove faulty in other ways when humans are presented with circumstances outside their direct experience, and will need to be reset. For example, exposure to an unfamiliar culture can lead us to make incorrect assessments about issues like freedom, equality and the use of force. Hopefully George Bush will learn.

Now I want to turn to some results of cosmology.

The first question is “What are we made of”?

Humans and our immediate environment, the Earth, are made of atoms. Except for hydrogen, which makes up about 10% of our weight, we are made of stardust, the rarest material in the universe.

How more central and important could humans hope to be than to be made from the rarest material in the universe?

This “stardust” is the heavier atoms … that is, heavier than hydrogen … that were formed during the nuclear fusion process that produces the energy of a star.

During the catastrophic explosive death of a star, the heavier atoms were scattered out into space, and over long periods of time were collected together to form our earth, and ultimately us.

This is a somewhat revised version of the myth that it took a death that we might live. It also provides an indisputable and profound connection between humans and the stars.

What else is in the universe? Before answering, it is important to recall that Einstein’s famous equation $E = mc^2$ tells us that mass and energy are equivalent and can be interchanged. Mass is essentially a highly concentrated bundle of energy, so we need to keep track of both the material and the energy.

At the end of the 20^{th} Century it had become apparent that about 70% of the density of the universe is something called “dark energy” which is everywhere and causes space to expand ever faster. Remember here that you have to set aside your “common sense”!

Most of the material of the universe, making up 25% of the density, is “cold dark matter” an utterly strange material that is not even made of the protons, neutrons and electrons that make the atoms in our bodies.

About 4% of the density of the universe is made up of atoms that we can not see. 0.5% is made up of visible hydrogen and helium, which is what gives us the light of the stars and the galaxies like the one on the front of the order of service.

Only 0.05% of the density of the universe is composed of those other visible atoms which form us, all other living things, and all the rocky planets. Among that 0.05% only a vanishingly small part makes up humanity.

Finally, 0.01% is the heat radiation from the Big Bang, and 0.001% is all the light from all the galaxies that have ever shone.

Put another way, humanity makes up a vanishingly small part of the cosmic density, and yet it is that vanishingly small part that is able to make observations and try to make sense of the vast expanses of the universe. We could hardly be more central!

Primack and Abrams use a visual aid they call The Cosmic Density Pyramid as a representation of the contents of the universe.

At the base of the pyramid is the dark energy and dark matter, making up the vast majority of “what is”. Only the top 0.5% or so of the pyramid is visible to us. And at the very peak is that vanishingly small amount, the stardust that is us. It has an exceedingly sharp point, and we are it!

But the Cosmic Density Pyramid has a greater meaning still. The vast amounts of dark energy will cause an exponential increase in the amount of space between the galaxies, causing all the other galaxies in the universe to ultimately disappear from our view.

When that happens, the night sky will look much the same because the stars we see are all in our galaxy. But the stars and galaxies observed by instruments like the Hubble Telescope will disappear into the distance.

What this means is that we are at a central time in the history of the universe. The universe has existed long enough for intelligent life to evolve and develop the means to make observations of the galaxies, but not long enough that the galaxies have disappeared from view.

That leads us to a discussion of time, another important feature of the universe.

When we look up at the sky we are looking backward in time. Light from the sun takes about 8 minutes to arrive, so we are “seeing” the sun as it was 8 minutes ago. Light from other stars in the Milky Way takes as much as 100,000 years to arrive. Light from the Virgo Cluster of galaxies takes about 60M years to arrive. The sky is the ultimate time machine, giving us a snapshot of a vast amount of the universe’s history.

Primack and Abrams use another visual aid, The Cosmic Spheres of Time.

Our galaxy, the Milky Way, is at the centre of a sphere which contains our visible universe. This is not a great cosmic coincidence, or an act of God putting his stamp of approval on our ascendancy. It is an inevitable fact of physics that every galaxy will be at the centre of its own spherical visible universe.

Light comes from all directions toward us, but beyond a certain distance, no light or information of any kind can ever reach us.

This Cosmic Horizon occurs because any galaxy that lies far enough away that light from it has not had time to reach us in the entire life of the universe is beyond our cosmic horizon. We will never see the light from there.

However, strangely enough, cosmologists can use their models to calculate what must be beyond our horizon in the larger universe created by the Big Bang. This is one of the very few occasions where human intelligence can manage to exceed the bounds of physics.

However, even then it is futile. We can never be sure that our calculations are correct. Even if they exactly match the known visible universe, a theory which predicts what lies beyond observation can never be tested, and fails the test of being science. We would be relapsing into faith.

The Big Bang is believed to have occurred 13.7B years ago, plus or minus 150,000 years. That is a very long time. It also means that the universe open to our observation is very large.

It would take 13.7B years for light to reach us from objects at our cosmic horizon. That corresponds to a distance of 10^{26} metres.

Where do we fit in a universe of this size? Interestingly, pretty much in the middle.

There is an enormous range of sizes in the known universe, about 60 orders of magnitude from the cosmic horizon, (10^{26} metres) to the shortest possible length, something physicists call the Planck Length, about 10^{-35} m.

There is no way of even thinking about a smaller size according to our current understanding of physics.

The Planck Length is a very special size where the maximum mass that relativity allows to be packed into a region without collapsing into a black hole is also the minimum mass that quantum mechanics allows to be confined in such a small region.

Interestingly, perhaps coincidentally, DNA falls right in the middle of this enormous range of sizes.

But human beings actually hit the sweet spot, the only size that conscious beings like us could be. Smaller creatures would not have enough atoms to be sufficiently complex to be intelligent (note the DNA). Larger creatures would suffer from slow communications, limited by the speed of nerve impulses, which would effectively mean they would be a community instead of an individual.

This is why there will never be a cosmic scale intelligence. The maximum number of bits of information that could have traveled back and forth across the Milky Way galaxy during its 10B year lifetime is about what an average human being experiences within our body every few minutes.

So now let’s turn to the question “And in the beginning ….”. What do we know about what the Big Bang … the moment of creation … was like?

In the early 1990s it was slowly recognized that the Big Bang theory was in trouble. The basic problem was that our universe had far too much structure.

It became clear that if everything came flying out of the Big Bang uniformly, there was no way that huge galaxy clusters and strings of galaxies could have resulted. Since there are more or less dense regions on a large scale today there had to have been differences in the density at the beginning.

This required that something must have happened before the Big Bang to make the initial conditions wrinkled. That something is called “Cosmic Inflation”.

This is another place where you have to set aside your “common sense”. What cosmologist’s models tell them is quite amazing.

During a time of 10^{-32} seconds prior to the Big Bang … less than the time it takes light to travel across an atom …there was an exponential inflation in the infant universe.

During this brief time, there were countless random quantum events occurring. Some took place earlier and some toward the end of this incredibly brief time. Any movement got expanded by 10, 20 or 30 orders of magnitude depending on when they occurred during the inflation. Those that occurred earlier got expanded more than those that occurred later.

Therefore, the combination of quantum fluctuations and rapid inflation caused irregularities in the densities of energy and matter. When the Big Bang occurred, these irregularities in the original conditions … cosmic wrinkles, so to speak … led to the complex distribution of density and matter we see in the universe today.

Given the initial wrinkles, gravity alone created the universe as we see it, with no need of an outside force imposing order. The “blueprint” of the universe existed before the Big Bang in the form of these cosmic wrinkles, but it was randomly generated by the combination of quantum fluctuations and cosmic inflation. There was no Creator or Intelligent Designer, beyond the laws of physics.

Even more exotic is the suggestion that this cosmic inflation was like a rapidly expanding bubble that culminated in a Big Bang that created our universe.

Were there other bubbles at other times, and other Big Bangs leading to other universes, which would be found beyond our cosmic horizon? There is nothing to suppose otherwise, but we will never know because they are beyond our cosmic horizon.

So what does all this say to us?

The new cosmology is a rich source of metaphors for life. Most of us are stuck with cosmic imagery left over from the flat earth of the Bible, the crystal heavenly spheres of the Middle Ages, or the cold and emptiness of Newton’s universe. There is a great difference between the richness of cosmic reality and the sterility of these old images and the religious language in which they are framed.

We have abundant scientific proof on which we can build a new centrality to the universe and to our place in it. We are not the insignificant beings in a vast, cold, and mostly empty space, in need of Gods to give life meaning. We are central and significant in at least seven well established ways:

We are made of stardust, by far the rarest material in the universe.

We live at the centre of a cosmic sphere of time with our cosmic horizon at its surface.

We live at the midpoint of time, which is the peak period of the evolution of the universe, a golden age which will disappear as the distant galaxies disappear over the cosmic horizon

We live at the middle of all possible sizes in the universe, the only place where life of our complexity is possible.

We live in a universe that may be a rare bubble in space and time. Outside is neither space nor time as we know it, but inside there is time for evolution and space for connections and structures to develop.

We live at more or less the midpoint in the life of our planet. We have about 6B years to go before our sun swells into a red giant star and evaporates the Earth. Given a mere 5,000 years of recorded history of our species, that is a potential beyond imagining.

We live at a turning point for our species, where we have identified problems that need to be solved, but have done so early enough to have hope of solving them.

This is not a self constructed centrality arising from a longing to be significant. It is much more than a statement that we are of central importance to ourselves. It is the universe itself … its structure and its history … that makes us central. It is not of our choosing. It arises from principles, and we are the first generation to know it. Now it is up to us to use this centrality wisely.

Song #345: With Joy We Claim the Growing Light

Closing Words
From Gaelic Runes

Deep peace of the running wave to you.
Deep peace of the flowing air to you.
Deep peace of the quiet earth to you.
Deep peace of the shining stars to you.
Deep peace of the infinite peace to you.