4 (really 5) Questions

There are several things that people often ask us about:

1) What makes a rainbow?

2) Why should the sky be blue?

3) Why is the Moon so much brighter when it's full?

4) What makes the "shadow bands" seen at the time of a Solar Eclipse?

Well, the last one is easy. The *shadow bands* are simply the shadows of the atmospheric turbulence seen with the slit illumination of the crescent Sun just before and just after Totality. If, at the time of a total eclipse of the Sun, you happen to be standing in a creek bed with high Maple tree over-cover, then, just before and after Totality you will see three and four inch pinhole images of the crescent Sun, under the tree, flickering over the stones. It's charming. Of course, you can always see pinhole images of the Sun on any sunny day, except during the time of a solar eclipse they are round and so attract little notice. However, at the time of an eclipse they become conspicuous in the direction parallel to the solar crescent. Then, only, do they appear as parallel waves moving with the breeze.

The *sky is blue* simply because the shorter wavelengths of the sunlight are more easily scattered by the molecules of the atmosphere (and the sky is brighter in ultraviolet than it is in blue). Actually it is blue for the same reason that Crater Lake is blue. The shorter wavelengths are scattered back. And the distant mountains appear blue because there is blue sky between them and you. Sometimes, when the sun goes down, the sky appears to be orange or red because more of the longer wavelengths now get through. Yet sometimes, if you look to the east (as the sun has set in the west), you can see the blue light being scattered back.

The *rainbow* is in the form of a circle around the shadow of your head. The size of this circle is determined by the wavelength of the light. That is what separates the colors of the rainbow. In a prism the refraction of the different colors comes at slightly different angles, and, for the same reason, they come at slightly different angles from raindrops. Sometimes you can see a second rainbow, with the colors reversed, making a larger circle around your shadow. When you see a circle around the Moon, or "Sundogs" around the sun, they are in the opposite direction from the shadow of your head. This phenomenon is caused by ice crystals refracting the light in the upper atmosphere.

But, why is the *Moon so much brighter when it is full*? (The full Moon is much brighter than two quarter-moons would be). There are two reasons, and they are both related to seeing the Moon from the Sun's position. First, the Sun sees no shadow because every rock, every grain of sand and every mountain (and on Earth, every leaf), hides its shadow from the Sun. When flying in a small plane you may have noticed that when the plane gets high enough above the ground – so that the shadow of the plane is no longer seen – the shadow is replaced with an apparent bright spot that follow you wherever you go. It is simply the spot where you see no shadows because you are looking from the Sun's position. We see the brightness of a full Moon a little to the side of straight down the shadow of the Earth; otherwise it would be darkened in an eclipse. Just before and after Totality it will be partially darkened by the partial shadow of the Earth (the Penumbra).

The other reason the full Moon is so very bright is because one-third of the surface material on the Moon is glass. It is glass beads all over, and the surface beads, which have not yet been dulled by micrometeorite impacts, shine back the sunlight toward the Sun. That is also what makes those brilliant rays from crater Tycho. When the Moon gets hit by a large asteroid at some twenty or thirty miles per second, the asteroid goes several miles into the rocks where the kinetic energy of the impact is converted into a tremendous explosion of vaporized stone. In the absence of an atmosphere this condenses into spherical glass beads. That is why the Moon is all covered with glass. And that is why the brightness of the full Moon is also so enhanced. The bright rays from the crater Tycho, which are so conspicuous when the Moon is full, are simply glass bead streamers, less than a million years old. Incidentally, they are long enough to reach from San Francisco to Denver.

Sometimes people ask us why does the *Moon looks so big on the horizon*? That is because of your genetic expectations. Your genes have it hard-wired so that the things you see at or near the horizon are farther away than the things seen overhead. This is true for the Gulls, the Zeppelins, the Blimps, the planes and the clouds. Similarly, your expectation tells you that it should also be the same for the Moon, but it's not. So when the Moon is seen on the horizon, your expectation tells you that it must have gotten bigger to look so big when it's that much farther away.

A BRIEF HISTORY OF COSMOLOGY (1997 Original)

How scientists, ancient and modern, have viewed the Universe

Newton had a cosmological problem introduced by combining his universal gravitation with his inverse square law. In order to avoid infinite gravitational problems, Newton's Universe had to be finite in an infinite ocean of space. That is, it had to have a center. But that contradicts the cosmological principle that the Universe should look the same from any position.

Then the astronomer Seeliger pointed out that the Universe could still be infinite if we allow that over very large distances the gravitational attraction between bodies falls off more rapidly with distance than with Newton's inverse square law. (This suggestion of Seeliger's is the famous cosmological term that Einstein used and later regretted.)

In order to preserve the notion that "There exists an average density of matter in the whole of space which is everywhere the same and different from zero," and to preserve the notion "That the magnitude of space is independent of time," Einstein introduced Seeliger's cosmological term, "...a term which was not required by the theory as such nor did it seem natural from a theoretical point of view."

Then, in the nineteen twenties, the Russian mathematician Alexander Friedman pointed out that we could still have an infinite Universe, with an average density different from zero, and yet get rid of Seeliger's cosmological term if we allow that the magnitude of space might *not* be independent of time, that is, if we allow that space might expand.

This predicted expansion, which was confirmed observationally by Hubble and others, implied both an "origin" and a "creation" for the Universe, and gave rise to the Big Bang models. But how could the Universe come out of nothing? What drives the expansion? And why should the Universe expand at the escape velocity? And there was even some doubt that the Universe could be older than the stars.

In the nineteen forties Bondi, Gold, and Hoyle, in England, pointed out that we could get rid of the "origin" problem if we allow that creation is continuous, that is, that hydrogen is created throughout the Universe at a rate to match the expansion.

That gave rise to the Steady State models which hold to the perfect cosmological principle, that the Universe should look the same not only from any place but also at any time. But where does the "new hydrogen" come from? And from where do we get the 3^0K microwave background radiation discovered by Penzias and Wilson which the proponents of the Big Bang took as the clinching evidence for *their* model?

Then Dobson, in the United States, pointed out that we can get rid of "creation" altogether if we allow that the material (through Heisenberg's

Uncertainty Principle) must recycle (by "tunneling") from the border of the observable Universe imposed on us by the apparent expansion.

This implied that the Universe is neither infinite nor actual, rather finite and apparitional, and that the apparent cosmological expansion is driven by energy which the radiation loses to redshifting through its long traverse of the vast expanding spaces of the Universe.

This apparent expansion of space imposes a border to the observable Universe at some fifteen billion light years away in all directions simply because at that distance things would be receding at the speed of light. Then, since objects receding from us at or beyond the speed of light cannot be seen by us, nor affect us in any way, we can get no information from beyond that border.

(The sound of the bell of an approaching fire engine is heard at a high pitch because the sound waves are laid down too close together; but the sound of the bell is heard at a lower pitch when the engine has passed, and it slurs in passing because the fire engine missed you. Similarly, the spectral lines of an approaching star are seen blueshifted to higher energy, like higher pitch, while the spectral lines of a receding star are seen redshifted to a lower energy, like lower pitch. And if the speed of the recession is seen to approach the speed of light, then the energy of the radiation is seen to approach zero.)

Actually it is the redshift itself which imposes a border to the observable Universe regardless of the cause of the redshift. And since no messages, either electrical or gravitational, can reach us from there, we get no information from beyond that border.

Now the interesting thing about that border is this: that nothing can be seen to cross it. If the energy of the radiation of a particle approaching the border approaches zero, so must the energy of the particle itself. But we know from Einstein in 1905 that mass and energy are the same thing. So as the energy of the particle approaches zero, its mass approaches zero. And that has two very interesting consequences. First, all radiation going through such a field of low mass particles will be so often picked up and re-radiated that it will be thermalized to 3^0K and appear as the cosmic background radiation discovered by Penzias and Wilson. Second, Heisenberg's Uncertainty Principle requires that these particles recycle from that border.

If the mass of the particles approaches zero, so must their momentum. (You can't have a large uncertainly about a small momentum.) Then, by Heisenberg's Uncertainty Principle, our uncertainty in where they are must approach totality. They simply recycle back in.

Thus, from a consideration of the border conditions imposed on us by the cosmological expansion, we see that we automatically get both the "new hydrogen" predicted by Bondi, Gold, and Hoyle and the cosmic background radiation discovered by Penzias and Wilson. And the amount of 3^0K radiation predicted by this model is closer to what we measure than is the amount predicted by the Big Bang models.

But how do the particles recycle from the border?

They simply "tunnel" back in. Electrons and protons aren't "things", and they do what things cannot do. They're like dollars in the bank. And when an electron goes from one energy level to another in an atom, it does not slide down. It disappears from one energy level and reappears in the other. The physicists have a name for this; it's called tunneling, and there is no "in between". When someone writes a check from a bank in Santa Barbara to a bank in Portland, no one goes down to the bank to get the money. It disappears in Santa Barbara and reappears in Portland, and there is no "in between." Likewise, when the particles recycle from the border, there is no "in between."

But is there any observational evidence that matter is really recycling from the border? Yes, indeed there is. The Hubble Space Telescope sees evidence for unexplained hydrogen clouds between the quasar 3C273 and ourselves, as well as great clouds of hydrogen, big enough to make all the known galaxies, in what were thought to be the great galactic voids.

Thus, without introducing the notion of creation, Dobson's model has a source for the "new hydrogen" predicted by Bondi, Gold, and Hoyle, as well as for the three degree cosmic background radiation which was formerly taken as evidence for the Big Bang. And it also has a driving mechanism for the expansion.

But if, as this model implies, the changing, finite, and divided Universe which we see is apparitional rather than actual, then there must be something behind it. There must be something which we are mistaking for what we see in space and time. As Einstein observed as a child, when someone gave him a magnet, "Something deeply hidden had to be behind things." So what could be deeply hidden behind the Universe which we see?

What James Clerk Maxwell meant by force was "the tendency of a body to move from one place to another." But what Michael Faraday meant by force was "what drives the whole universe." That is our problem. What drives the whole Universe? What could possibly exist in the absence of the Universe and in the absence of space and time? And could what is hidden drive the whole Universe?

In the absence of time, what is hidden could only be changeless. Change takes place only in time. And in the absence of space, it could only be infinite and undivided, since the smallness of the particles and the dividedness of matter are seen only in space. But if we are seeing the underlying existence as if in time and space, then the changelessness, the infinitude, and the undividedness of that underlying existence must show through in our physics, just as the length and diameter of a rope must show through in the snake for which it is mistaken. And that is indeed what we see.

"Space is not that which separates the many, but that which seems to separate the One, and in that space that Oneness shines, therefore falls whatever fall. And space is not that in which we see the small, but that in which the Infinite appears as small, and in that space that vastness shines, therefore bursts whatever bursts, therefore shines whatever shines.

Time is not that in which we see the changing, but that in which the Changeless seems to change, and in that time that Changeless shines, therefore rests whatever rests, therefore coasts whatever coasts."

The Universe is made out of energy. It is not made out of anything else. And since energy appears to be that underlying existence showing as Changeless through changes in time, we have both the Conservation of Energy and its Inertia. Matter (energy) fights every change in its state of motion. The Changeless shows through.

As pointed out by George Gamow long ago, what we see as nuclear energy is related to seeing things in space and time. We know from Heisenberg's Uncertainly Principle that only if our knowledge of where something is in space and time went to zero could its energy go to zero. And since electrical energy appears to be that underlying existence showing as the Infinite in the smallness of the particles in space, we have the self repulsion of electrical charge and the fact that the energy of an electrical particle would go to zero if, and only if, the size of the particle went to Infinity. The Infinite shows through.

Since gravitational energy appears to be that underlying existence showing as undivided in the dispersion of the particles through space, we have the fact that the gravitational energy of the Universe would go to zero if, and only if, the dividedness of the Universe went to zero. The Undivided shows through.

Note that dividedness and smallness are parts of the same thing. You can't break a cookie into larger and larger parts.

When we say that we know where something is, we mean three things. We mean that we know where it is in space and time; that it is small enough so that its position could be accurately designated; and that we know where it is in respect to other things. (The only reason that the distances between large towns can be designated on a highway map to within a mile is because they measure from post office to post office. Otherwise the position of a town cannot be so accurately designated.)

If you can know where a proton is in space and time, it will be wound up against the Uncertainty Principle to five hundred atom bombs per pound. And if it's small enough so that you could designate its position accurately, it will be wound up to the same five hundred atom bombs per pound against electricity. And if you can know where it is with respect to all the other matter in the observable Universe, it will be wound up to the same five hundred atom bombs per pound against gravity. These three windups are all the same thing. They are the two sides and the edge of the same coin. The Changelessness, the Infinitude, and the Undividedness most certainly show in our physics and without alternative explanation.

Now since the notion that the Universe might be apparitional, rather than actual, is certainly counterintuitive, the question that naturally arises is: do the equations of our physics support it? Yes. It was the equations, not something else, that drove Dobson to this model.

Einstein, in 1905, pointed out that what we see as matter is just potential energy, that is energy itself which shows inertia, and time must come into our geometry if we are to understand that the Universe is objective. Now space and time come into that geometry as a pair of opposites - so that if the space and time separations between two events are equal, then the total separation, the space-time separation, between them stands at zero.

Now that puts the separation between the emission and absorption events of the photons at zero and calls into question the separation between the perceiver and the perceived. If we see an event at a distance, we see it also in the past, and in just such a way that the total separation, the space-time separation, between us and what we see stands at zero. And that calls into question the objectivity of the Universe. Special Relativity was invented to save the objectivity of the Universe, and although it calls that objectivity into question, it doe not imply subjectivity.

Also, in 1926, Heisenberg pointed out that there is always a necessary uncertainty in what we see in space and time. If we can know where something is in space, we cannot know its momentum. And similarly, if we can know when something happens in time, we cannot know the energy of the happening. In short, if we see what we see as if in space and time, then we cannot quite tell what it is that we see. It's like trying to identify the snake for which a rope has been mistaken.

Now, taken together, Heisenberg's Uncertainty Principle and Einstein's four-dimensional geometry do indeed suggest that the Universe might be apparitional.

SUMMARY AND CONCLUSION

For years Einstein argued with Neils Bohr and Heisenberg. He didn't like Quantum Mechanics, even though he himself had written the first important paper on it. He felt that there must surely be something real, something "deeply hidden," behind the quantum mechanical Universe which we see. Most quantum theorists disagree with him on that point. But Dobson agrees with him and points out that that which is hidden must be the Changeless, the Infinite, the Undivided, because that's what shows in our physics. And he points out that it shows, not through any actual change, but through apparition. You cannot change the Changeless, nor cut up the Undivided.

All the previous cosmological models, from that of Newton to the Steady State model of Bondi, Gold, and Hoyle, have taken for granted that the Universe is actual. Dobson points out that the Universe which we see could not be actual. Actual means that it arises by action, by a process of physics. But matter does not arise by a process of physics. The Conservation Laws forbid it. The Conservation of Energy law forbids it.

All the Big Bang models, and the old Steady State model, have taken for granted that matter can come out of "nothing". But there is no observational evidence for this.

Newton's laws of motion take inertia for granted. Special Relativity takes space and time for granted. General Relativity takes gravity for granted. Quantum Electrodynamics takes electricity for granted as well as Heisenberg's Uncertainty Principle. Dobson points out that if we allow that the first cause under our physics is apparitional - that we are mistaking the Changeless, the Infinite, and the Undivided for the changing, the finite, and the divided which we see as if in space and time – then we need not take any of this for granted.

This model does not give rise to an arbitrary physics which we do not see. It gives rise to the physics which we do indeed see, and which currently stands in academia without explanation.

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This predicted expansion, which was confirmed observationally by Hubble and others, implied both an "origin" and a "creation" for the Universe, and gave rise to the Big Bang models. But how could the Universe come out of nothing? What drives the expansion? And why should the Universe expand at the escape velocity? And there was even some doubt that the Universe could be older than the stars.

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Penzias and Wilson which the proponents of the Big Bang took as the clinching evidence for *their* model?

Although the Steady State models got rid of the "origin" problem, they did not get rid of the "creation" problem. But we can get rid of the "creation" problem as well as the "origin" problem if we allow that the particles might recycle from the border of the observable Universe imposed by the observed expansion. (Actually, it is the redshift itself that imposes the border, rather than our interpretation that the redshift is due to an expansion.)

Since the spectral lines of the radiation coming from very near that border appear very gravely redshifted, it follows that, as seen by us, the particles giving rise to that radiation are of very low energy and very low mass. And that low mass has two very interesting consequences.

First: Since radiation going through a field of low mass particles will be thermalized to 3^0K by being so often picked up and reradiated, we have a possible alternative explanation for the observed microwave background radiation discovered by Penzias and Wilson, and interpreted by some as the "echo" of the Big Bang.

Second: If the mass of the particles is low, their momentum, and therefore our necessary uncertainty in that momentum, will also be low. But, by Heisenberg's uncertainty principle, if our uncertainty in the momentum approaches zero at that border, our uncertainty in the position of the particles there must approach totality. And that allows the particles to recycle from the border. (Also, as the mass of the particles goes down, their electrical size must increase, rendering the formation of atoms and molecules less likely.)

Now if the particles can recycle, by tunneling, from the border of the observable Universe, we can get rid of the "creation" problem as well as the "origin" problem.

Is there any observational evidence that material is thus recycling from the border? There is. The Hubble Space Telescope supplied evidence that there are some nine or more clouds of hydrogen between the quasar 3C273 and ourselves. And it is difficult to believe that such clouds could have survived for some fifteen thousand million years without condensing into something we could see. Measurements with the Hubble Space Telescope also indicate that there is more than enough hydrogen in the great inter-galactic voids to make all the known galaxies. And, finally, the slowing down of the cosmological expansion rate predicted by the Big Bang has not been confirmed.

Is there anything which this recycling model predicts? There is. It predicts that the Universe must be built on frustration or it couldn't go on like this. (This is a steady state model.)

The poets say that the stream will be happy when it reaches the sea, but the poets are wrong you know. It won't be happy when it reaches the sea. The streams and rivers are trying to get to the center of the Earth, but the rocks are in the way, and the streams get frustrated. The rocks are trying to get to the center of the Earth, but the iron of the Earth's core is in the way, and the rocks get frustrated. The iron is trying to fall into the Sun, but its inertia is in the way, and it coasts around the Sun. The Sun is trying to fall into the center of the Galaxy, but its inertia is in the way, and it coasts. Our Galaxy is trying to merge with all the rest of the matter in the observable Universe, but the cosmological expansion is in the way. And the expansion is trying to reduce the density of the observational Universe, but the recycling is in the way.

If it could be shown that the Universe is not built thus on frustration so that it could go on like this, all steady state models would be dead.

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October 10, 2002

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Of course there is still the question as to why we see hydrogen falling together by gravity to galaxies and stars. Why hydrogen? Where does the gravity come from, and the inertia, and the electrical charge?

That problem was handled by some ancient physicists whose word for the Universe was *Jagat*, the changing. But they were smart enough to see that since change is seen against the changeless, there must be something underlying the changing Universe that is not in space and time, and therefore undivided, infinite and changeless. Their question then was: "How do we see change?" And they said, "It can only be by mistake." So they studied mistakes, and they said that if one mistakes a rope for a snake, the length and diameter of the rope *must* show in the snake. That is, the undivided, the infinite and the changeless *must* show in our physics. That might explain gravity, electricity and inertia. But why, if we see a duality or a plurality, doesn't the undividedness show through and shut it down? Perhaps it is because we see an electrical duality *within* a gravitational plurality, and they keep each other up. This wouldn't be interesting, of course, if it didn't show up this way in our physics, but it does.

The undividedness can close down the duality of the electron and the positron, because neither of them is wound up on the gravitational plurality. But it cannot close down the duality of the electron and the proton in the hydrogen atom, in spite of the enormous electrical attraction between them. That's because the proton is tied into the gravitational plurality whereas the electron is not.

(That's Heisenberg's uncertainty principle.) And particles with a half unit of spin (Fermi particles) cannot occupy the same energy state and collapse the neutron stars. (That's Pauli's Verbot.)

Those ancient physicists saw that this Universe is made out of energy which they saw as the underlying existence showing through. Although they failed to mention nuclear energy, they listed five forms of energy perceivable by our five senses, gravity with the ear (the saccule), kinetic energy with the skin (as temperature), radiation with the eye, and electricity and magnetism with the tongue and the nose (salty and sour are electrical sensations, and the nose reads molecular structures tied together by magnetic bonds). They even saw the identity of mass and energy, which we didn't get from Einstein till 1905. Einstein got it from Mileva, his first wife, who wrote the papers for him in 1905. Mileva Einstein was a close friend of Nikola Tesla who got that idea from Swami Vivekananda, and *he* got it from the Sanskrit language. All this is built into that language, and anyone could have seen it. Why me? I am not a Sanskrit scholar by any stretch of the imagination; however, I have been exposed to Sanskrit over most of the last century.

If the changeless didn't show through in our physics, we wouldn't have inertia. If the infinite didn't show through, we wouldn't have electricity. And if the undivided didn't show through, we wouldn't have gravity and the attraction between opposites. Also, if the duality didn't keep up the plurality, we wouldn't have the atomic table. And if the plurality didn't keep up the duality, we wouldn't have atoms at all. That's how I see it.

John L. Dobson
October 11, 2002

ANCESTORS

Only because our ancestors were swinging in the trees do we have arms that reach from side to side. Only because of that do we have shoulder blades parallel in the planes of our backs. All the rest of the quadrupeds have shoulder blades, one on either side, parallel, but with the body in between, so that they cannot lie down on their backs and gaze into the darkness of the sky at night and wonder in their hearts how deep it is.

And only because our ancestors were marooned on an island, where their body language failed in the sea, do we have words to convey our wonder to each other. There were so many onlys before we knew what we know now.

ASTRONOMY FOR CHILDREN GREAT AND SMALL

by:
John Dobson

INTRODUCTION:

This is not a technical book about stellar evolution or astrophysics; it's a book about us, about people. But we live in this vast Universe and the question is: what is the nature of the world which we see, and why do we see it the way we do? So this book is a portrait of the Universe as seen by me, and it's written for all children great and small. We want to know: Of what is the Universe made? On what kind of energy does it run? And what is the history of our species that allows us to see the world the way we do?

When you go to a theatrical performance there are four things you want to know: Who are the performers? What is the name of the play? Where is the theater? And when should you go? They'll all be written on your ticket. In this case space is the theater and time is the date, but we want to know of what is the Universe made? (Who are the actors?) And on what kind of energy does the Universe run? (What is the name of the play?)

But I should remind you that the performance is like a television show in that we all came in in the middle and no one is staying till the end. And while we're watching the performance we're trying desperately to figure out the plot. But it's not like watching Star Trek. When you watch Star Trek if you see a stranger on the bridge at the beginning of the program you know he won't make it till the end, because you've watched such programs before you have what we can call comparative Star Trek, because you can compare one program with another.

Similarly, since on this planet there is more than one kind of animal, we can have comparative anatomy. We even have comparative religion. But when it comes to figuring out this Universe, since we have no other Universes to compare it to, since we have no previous performance to help us we have no comparative cosmology. So we start with ordinary questions and ordinary answers. By and by the questions and the answers will become quite extraordinary, but we'll start with our feet on the ground. Of what is the Universe made? And on what kind of energy does it run? It's no use thinking that the grown-ups get up early and wind this thing up. They don't. It runs by itself and we want to know how. And we want to know what happened in the development of our own species that allows us to wonder about such problems.

As things go now, near the end of the 20th century, our knowledge of physics (that is the knowledge of how matter behaves) can be roughly divided into four sections: gravitational physics (which takes gravity for granted), Newton's laws of motion (which take inertia for granted), quantum electrodynamics (which takes electricity for granted), and nuclear physics which also takes a great deal for granted. Can we physicists find some other point of view from which we don't have to take these things for granted, from which we can understand why matter shows inertia, why it's made of electricity and why it fails together by gravity? Do we have enough information now to fit this puzzle together? Can we find a point of view from which we can explain both the experiments of the physicists and the experience of the mystics? Because we don't have two Universes, one for the physicists and one for the mystics. We have only one; so if both descriptions are correct, their descriptions have to mesh.

When we look out with our big telescopes, optical telescopes, radio telescopes, etc., what we see is that all the distant galaxies seem to be rushing away from us, and the farther away they are the faster they seem to be rushing away. And the simplest and most straight forward explanation for this behavior is that long ago (about 15 American billion years ago) all the matter of the observable Universe was involved in a single explosion. This alleged explosion has been dubbed the Big Bang. And it has been suggested that although you cannot speak of a time "before" the Big Bang (because time began with the Big Bang) still, in the absence of the Big Bang there was nothing.

Now this model of the Universe has been compared to a raisin pudding in the oven. As the pudding gets bigger and bigger, the raisins get lonelier and lonelier; so if you come too late for dinner, you get only one raisin to a spoon, or you may not get any raisins. But some other cosmologists, called the Steady State bunch, thought it might be more like a pudding in which, as the raisins get lonelier and lonelier, new raisins spring up in between; so "it don't make no never mind" how late you come for dinner, you get three or four raisins to a spoon. Well the Big Bang people didn't like that and demanded "Where did you get those new raisins?" And the Steady State people asked "Where did you get yours?"

So that is another problem in understanding the Universe. It is made of matter or energy, yet no process in physics known to man gives rise to matter or energy. The Universe appears to be a perpetual motion machine but perpetual motion machines are forbidden by our physics, so either there must be something wrong with the Universe or there must be something wrong with our physics. We see a Universe made of matter and wound up tight, yet we have no source for either the matter or the energy. Where is the raisin store and who wound up the clock? Can we find a point of view from which we can understand the existence of matter and energy, and from which we can understand who we (the observers) are?

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B. THE THEATER AND THE DATE

C. WHO ARE WE THE AUDIENCE AND WHY DO WE WATCH THE PLAY?

CHAPTER 1:

So our first question is: Who are the actors and what is the name of our play? Of what is the Universe made, and on what kind of energy does it run?

Right away you might answer that if it's running on energy it must be made out of matter. We're accustomed to thinking of things in this way. Cars (automobiles) which are made mostly out of metal run on gasoline and air (that is, they run on the energy derived from the oxidation of the hydrocarbons in the fuel); so we're accustomed to think that if it runs on energy it must be made out of matter. But how many kinds of matter are there? How many different kinds do we know? There are many kinds of metal, many kinds of rocks, many kinds of gas, etc. Well, long ago the chemists reduced the number of kinds of matter to the 92 chemical elements of the atomic table. Unless you are working with radioactive materials, all the materials you see around you are probably made out of only those 92, and very likely only a few of them.

Reducing it to 92 was an enormous simplification of our understanding. To know that all the multifarious variety of materials which we see around us could be made of only 92 ingredients was an enormous simplification. And the next question is: Which ones of the 92 preponderate in what we see around us, and can we make one of them out of another?

As long ago as 1815 a chemist by the name of William Prout thought that all the other chemical elements were probably made out of hydrogen. What he noticed was that if you take the weight of a hydrogen atom (which is the lightest of them all) as a unit of weight, then helium is 4, carbon is 12, oxygen is 16, etc. It goes something like that; so he thought that that was what might have happened. But in those days no one knew how to do it, nor where it might have been done.

It wasn't till much more recently that Sir Arthur Eddington figured out how to calculate the temperature at the center of a star like our Sun. What he noticed was that since the Sun is packaged by gravity (and not by the Coca-Cola bottling company) if you knew how big it was and how heavy it was, you could calculate the pressure all the way down to the center. And if you knew the pressure you could calculate the temperature. Temperature is a measure of the kinetic energy of the particles, that is, the energy they have because of their motion. And the faster they move the more pressure they exert. So if you know the pressure you can calculate backwards and get the temperature. So Eddington knew how hot it was in the stars and he thought it might be hot enough to make one chemical element into another.

We know now that Prout was right, the other chemical elements are made out of hydrogen, and we know now that Eddington was right, that it happens in the stars. But in Eddington's time that was a very unpopular view; so in a lecture he suggested that those who feel that the centers of the stars are not hot enough for this should find themselves some hotter place.

We also know now that it's hydrogen and helium that preponderate in the Universe. About three fourths of the matter we can see is hydrogen, nearly a quarter is helium, and the rest which is the dust of exploded stars, is only about two percent. Most of what we see at night is stars, and the stars are mostly hydrogen. And even by day the biggest thing you can see is the Sun and it also is mostly hydrogen.

Our Earth is a collector's item; it's made of iron and rock with a thin veneer of water and gas over the surface; and even the ocean is just the oxide of hydrogen. Mostly the Universe is hydrogen. The actors in our play are hydrogen atoms, but what is the action? What is the name of the play? On what kind of energy does the Universe run?

The problem of the energies was pretty well sorted out by the ancients. There are only six kinds of energy, and five of them were known to the ancients. They knew that when you picked something up you put energy into it which came out again when it fell. They called this "potential energy" because it seemed to be in there even when it wasn't doing anything and because it was related to position in space (in the gravitational field).

They also knew that things had energy due to their motion. That's what makes it dangerous to get in front of a pitched baseball or a moving train. This energy of motion they called "kinetic energy", and they knew that its amount depended on the mass of the moving object and on its speed.

The ancients also knew that radiation was a form of energy because sunlight warms things. And they knew a little about electricity and magnetism. Like gravitational energy, electrical energy is referred to as potential because it seems to be in there even when it's not doing anything, and because it also is related to position in space (in the electrical field).

It seems the ancients did not know about what we call "nuclear energy", the energy associated with radioactivity and nuclear power plants, and which is also potential energy because it's related to position in the nucleus of the atom. But long ago, several thousand years ago, some physicists in northern India had the other five kinds of energy associated with our senses of perception: gravity with the ear, kinetic energy with the skin, radiation with the eye, and electricity and magnetism with the tongue and nose. I'll explain.

Our orientation in the gravitational field is perceived through the saccule in the ear. Kinetic energy as temperature, is perceived through the skin. (Temperature is a measure of the mean kinetic energy of the molecules.) Radiation is perceived through the eyes. (But there are many kinds of radiation not perceivable by eye, such as radio waves, microwaves, infrared, ultraviolet, x-rays, and gamma rays.) Finally, electricity and magnetism are perceived through the tongue and nose. (Protons taste sour, and the molecules which we detect by smell are held together by magnetic bonds.)

These five energies, perceivable by our five senses, were referred to by the ancients as five elements out of which the Universe is made. In Sanskrit they are called: Akasha, Vayu, Tejas, Ap, and Prithivi. Akasha means sky, space, and "the first principle of materiality" which we would have to say is hydrogen. But as the first of the five energies it is the one associated with position in space (in the gravitational field.) Vayu means energy or wind (not air.) Tejas means "that which shines" (not necessarily fire.) And Ap and Prithivi mean water and earth.

You might ask: Why should electricity be called the water element? Well, our own word electricity comes from the Greek word for amber; so you must also ask: Why did the Greeks call it the amber element? That's because if you stroke a cat's fur with amber, the amber picks up an electrical charge by which it is able to pick up bits of paper. Try it! But although amber is not itself electrical, the water molecule is. It has an oxygen atom on one side with two extra electrons (negatively charged) and two protons on the other side (positively charged.) That's why it is so good at dissolving electrical molecules like salt, but it's a little hard now to say why the ancients used the term "earth" for magnetism.

Around 600 B. C. this theory of the five elements migrated from India to Greece through some Punjabi traders in Babylonia. At that time Thales of Miletus was a Greek mercenary soldier fighting for Egypt in Babylon. He carried the theory back to Greece. It is through the Greeks that we have our modern translation of Akasha, Vayu, Tejas, Ap, and Prithivi, as ether, air, fire, water, and earth. but the Greeks understood the theory in a very different way than the ancient Indians, and by the time it had fallen into the hands of the alchemists John Dalton said, "They could no longer show their wares." So he took their word elements and applied it to the 92 chemical elements of the atomic table. To the ancients it meant five energies out of which the Universe is made. Now it means ninety-two kinds of matter out of which the Universe is made.

We will postpone the problem of whether the Universe is made out of matter or energy. It would land us too soon in the extraordinary. Right now our problem is: Which kind of energy preponderates in this Universe? On what kind of energy, mostly, does it run?

Since we now live in what we think of as the nuclear age, many think that nuclear energy preponderates in the Universe. In one sense that would be partly true, but from the ordinary point of view that would be wrong. If all the matter in the Universe began as hydrogen, (which has the maximum available nuclear energy) and ended up as iron, (which has none) then the nuclear energy released by that change would be only one percent of what is available by letting the Universe fall together in the gravitational field. (It's an electrical problem which limits the nuclear energy available at iron. Although there are nuclei larger than iron, they contain so much electrical charge that it takes too much energy to push any more charges in.)

But what's the density of the Universe? How much stuff could you expect to find in how much space? Well, I once told a minister that the density of this Universe is only 20 drops of water in a billion cubic miles. I said, "That's all the creation the good lord came up with, and it's no big thing. And I recommend that you be a little careful." I eventually saw what might have been the slowest smile in the world.

The Universe as a whole is very cold, very dark and very lonely. It is only near a star that we have anything that you would think of as "day".

Now if the Universe is made mostly out of hydrogen falling together in the gravitational field, if the name of our play is "Falling", what would you expect to happen if we started with nothing but hydrogen spaced out at a density of a few grams in a billion cubic miles? Would we, if we waited, get school kids chewing gum? In what way would the hydrogen behave?

Probably you would say that it will fall together (clump or curdle) into clouds because wherever there is more stuff there would be a stronger gravitational pull. It would be what we call gravitationally unstable. Wherever there is more, more would go there; and wherever there is less, it would go away to where there is more. "To him that hath it shall be given, and from him that hath not shall be taken away even that which he hath."

But now our question is: Will it fall together to one big cloud or "here a cloud, there a cloud, everywhere a cloud, cloud"? (like Old MacDonald's farm.) Will it be a one cloud Universe or a MacDonald Universe?

With a little care we can answer this. First of all, observationally we see that it has not fallen to one big cloud. We live in a "MacDonald Universe". When we look out with our telescopes we see clusters of galaxies here and there.

But we want to know which size clouds could be expected to fall together faster, big clouds or little clouds. Later we'll want to know what could be expected to happen as such a cloud falls together. But for now let's consider two clouds of the same density, but where one has a diameter twice that of the other.

We'll call the smaller one "cloud A" and the bigger one "cloud B". And we'll call any old place in "cloud A" "point a" and the corresponding place in "cloud B" "point b", and we want to know which gets pulled harder toward the center of its cloud, a hydrogen atom at "a" or one at "b".

Since gravity pulls harder when we're closer (four times as hard if we're twice as close) when we consider only the distances of "a" and "b" from their centers, an atom at "a" should be pulled four times as hard. (If you go twice as close to a lamp, it will look twice as tall and twice as wide, or four times as big and as bright on your side.)

But when we consider how much stuff in the two clouds is doing the pulling we see that there is eight times as much in "B" because it's twice as wide and twice as tall and also twice as deep.

Then, if we consider both problems together, the distance problem and the problem of how much is doing the pulling, we see that the atom at "b" is pulled twice as hard as the atom at "a". (Because the pull of gravity is proportional to the mass of what's pulling and inversely proportional to the square of its distance away.) So the atom at "b" is pulled twice as hard but since it also has twice as far to fall both clouds fall together at the same time (say at 4:35 in the afternoon). We say that the free-fall time for clouds of all sizes is the same if the density is even. And the free-fall time for the Sun at its present density is three quarters of an hour.

BORDERS

If we stick to the observations, the observable Universe would appear to have a border some fifteen billion light years away where the red shift of the receding matter presumably approaches totality, and where the energy of the particles must therefore approach zero. Now if, as seen by us, the energy of the particles approaches zero, so must their mass and, therefore, their momentum. But if, as seen by us, their momentum approaches zero, so must our uncertainty in that momentum. Then, by Heisenberg's uncertainty principle, our uncertainty in the position of those particles must approach totality. That is, they may be found anywhere in the observable Universe. The question then arises: In what form will they be found? And what is the evidence that they are thus recycling?

Now since the mass of these electrical particles is related to their size, it follows that as their mass goes down, their size must go up. And, since that allows the atoms and molecules to disintegrate, we may expect the matter to recycle from the border as electrons and protons, that is, as hydrogen atoms. But I'm not sure that some of it might not recycle as helium since the helium nucleus is rather tightly bound.

Since these considerations argue for a steady state cosmological model rather than for a big bang model, I should perhaps point out how this model accounts for the cosmic background radiation discovered by Penzias and Wilson in 1965, and I should also mention the driving mechanism for the expansion. (The driving mechanism for the big bang expansion does not follow from that model, but was "thrown in by hand.") Also, I should point out the observational evidence that hydrogen is really recycling from the border. Then, too, I should point out what this model predicts.

Penzias and Wilson's background radiation follows naturally from the fact that star light going through a field of low mass particles near the border would be so often picked up and reradiated that it would come in thermalized to 3K, and the amount predicted by this model appears to be closer to the measured amount than is the amount predicted by the big bang.

Also, as I see it, the energy of the radiation that is lost to red shifting (because of the expansion itself) drives the expansion.

There are two observational evidences that hydrogen is recycling from the border. First, two measurements by the Hubble Space Telescope indicate that there are some nine or twelve clouds of hydrogen between the quasar 3C273 and ourselves. And the question is: Where did they come from? According to the big bang model there is no way to put new hydrogen in there, and no way to have clouds of hydrogen hanging around in there for some fifteen billion years without condensing into something we could see. Also, the measurements by the

Hubble Space Telescope indicate that there is more than enough hydrogen in the great intergalactic voids to make all the known galaxies. Where did that come from?

This model predicts that the Universe must be set up in such a way that frustration is inevitable. Otherwise it couldn't go on like this. In this model even the entropy of the Universe at large doesn't go up because the material from the border recycles as hydrogen dispersed in space with all its negative entropy built in. If any one could show that any of these cosmological processes, such as gravitational collapse or cosmological expansion, could succeed, all steady state models would be dead.

A great deal of effort has gone into reinterpreting our physics to support the big bang model. And it may be that the model is right and the physics was wrong, but it seems a bit more likely that the physics was right and the model is wrong.

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