

Unitarian Universalists and the Universe

A. Introduction

Obviously I am not a minister, I am an astronomer but there is a connection. We both talk about the heavens but in very different ways. (Actually I believe you had a minister long here that observed the sky with a nice telescope. I like that!) Today I want to talk to you about the current model of the structure, origin and evolution of the universe.

B. Perspective

We live on a beautiful planet which is one of eight planets orbiting our star, the sun. All the stars you see in the night sky (and you have an excellent location to observe from) are part of a system of stars called our galaxy the Milky Way. The Milky Way is a disk-shaped

system of hundreds of billions of stars, gas clouds and exotic objects. Perhaps you have seen the strip of light in the night sky, best seen in the fall, that is the disk of our galaxy seen from the inside out. The Milky Way is huge. It takes light, traveling at 300,000 km/sec, 100,000 years to cross the disk of the Milky Way.

C. Dark Matter

In addition to stars there is a mysterious part of our galaxy that was suspected for a long time but only understood relatively recently. Stars in our galaxy orbit the center of the galaxy like planets orbiting the sun. The sun orbits the galactic center, a point in the sky in the direction of the constellation Sagittarius, at a velocity of about 220 km/sec, taking about 250 million years to circle the galaxy once. (That means that the sun has circled the galaxy 20

times since its birth.) The speed of a star orbiting the galactic center depends on the amount of matter inside its path. But it has long been known that there is not enough visible matter to make stars orbit as fast as they do in our galaxy. This has led to the realization that there is matter in the galaxy that we can't see but that exerts gravitational force. We call this material dark matter. Early in the study of dark matter it was guessed that it consisted of MACHOS, massive compact halo objects like isolated black holes or dark stars. But now we think dark matter is particles of as yet an unknown kind. Dark matter particles are often described as WIMPS, weakly interacting massive particles. Not far from here dark matter particles are being searched for. At the bottom of the Homestake gold mine in Lead, South Dakota an experiment called

LUX, Large Underground Xenon dark matter detector is trying to observe dark matter particles colliding with Xenon atoms. Having the experiment a mile underground helps filter out other particles that might be confused with dark matter. Also, the large hadron collider in France and Switzerland, a particle accelerator which last discovered the Higgs Boson, unfortunately called the god particle, is now been upgraded to try to make dark matter particles. Evidence is overwhelming that a large part of the Milky Way is dark matter and attempts are being made to identify it. More recently images from the Hubble Space telescope have shown wonderful examples of gravitational lensing that demonstrates that dark matter is not just in our galaxy, but is all over the universe. Gravitational lensing is matter bending light like a lens, another

phenomena predicted by Albert Einstein's theory of general relativity.

D. The Big Bang Model

Of course the Milky Way Galaxy isn't the only galaxy. There are billions of them in the observable universe. The nearest large galaxy can actually be seen by eye in the night sky. It is the Andromeda Galaxy which is just visible as a fuzzy patch to the east of the great square of Pegasus in the fall. Where did the galaxies come from and how are they behaving in the universe?

The modern picture of the origin of the universe originated in 1929 when Edwin Hubble presented the results of his studies of many galaxies. Hubble found that almost all galaxies he studied are moving away from the Milky Way galaxy at tremendous velocities. And he found

that the more distant the galaxy the faster it was moving away. This led to a picture of the universe called the big bang model. (Not to be confused with the Big Bang Theory TV show.) In the scientific big bang model the universe is like a loaf of raisin bread dough. The dough is like space. (Space is a real thing.) The raisins are the galaxies, imbedded in the dough which represents space. The raisin bread dough has lots of leavening, (yeast, baking soda etc.) so when you put the dough in a warm place it expands carrying the raisins farther apart. Similarly in the universe space is expanding carrying the galaxies apart. Of course the dough is expanding in your kitchen but the universe isn't expanding into anything because the universe is all there is. This is hard to picture.

Now assume that you have video of the expanding universe and you run it backwards. The universe gets smaller and smaller until all space and matter is concentrated at a point. The point is called the primordial black hole. The beginning of expansion of this black hole is the big bang, the beginning of the universe. It happened 13.8 billions of years ago. The early universe was filled with energetic photons we now call the cosmic background radiation. (Let there be light is a good description of the origin of the universe!) Early in the history of the universe some of these photons transformed themselves into matter and antimatter and ultimately became the matter part of the universe. But many of these photons remain as the cosmic background radiation. Remember Einstein's equation $E = mc^2$ tells us that mass

and energy are just two forms of the same thing. In the very early universe the expansion was more rapid for a short time. We call this rapid expansion inflation.

E. The Accelerating Big Bang and Dark Energy

Until recently it was assumed that the gravitational attraction between all the mass in the universe would slow the expansion. The Hubble space telescope was designed to measure the slowdown of the expansion. But in 1998 astronomers were shocked to discover that the expansion wasn't slowing down it was speeding up! This accelerating big bang model has been verified by mounting evidence. A repulsive force must be acting against gravity causing the expansion to speed up. But what is the source of the repulsion? Strangely many years before Einstein had contemplated an antigravity force called the cosmological

constant but he gave it up. But there is another candidate for a repulsive force something vacuum energy. Quantum mechanics predicts that space is filled by an energy field. This energy field could produce a repulsive force.

Currently the nature of the repulsive force is unknown but we know it is real because the accelerating of the universe is real. We call the cause of the acceleration dark energy.

So we live in an expanding universe which is accelerating. It originated 13.8 billion years ago in the big bang event. An inventory of the universe is revealing. Only 4% of the universe is normal matter, hydrogen, helium and all the other elements that we are familiar with. Not too long ago we thought that the entire universe was normal matter. What a shock!! And 23% of the mass of the universe is dark matter, mysterious particles that exert

gravitational forces but so far can't be detected any other way. But most of the universe is dark energy, 73%, the component that causes the repulsion that makes the expansion accelerate. Both dark matter and dark energy seem so alien they sound like something from Star Wars. But chances are good that there are dark matter particles and a dark energy field within this very room.

F. The Multiverse

The accelerating big bang universe filled with dark matter and dark energy is supported by observational evidence.

But there are many speculative theories about the origin of the universe not supported by evidence. One of the most interesting are the multiverse theories. In one multiverse variation on the big bang many universes perhaps an infinite number of universes were formed during the

inflation phase of the big bang. Each universe would have their own set of physical laws but considering them together anything that could happen will happen in one of these universes. So there is a universe exactly like this one except I weigh 20 pounds less than I do here. And there are universes so alien life can't exist. If you think this sounds silly it has the support of such cosmology luminaries as Stephen Hawking. In one of those other universes my talk goes way long. But fortunately in this one I finish right on time. Thanks