SCORE FOR THE BIG BANG:
The Universe as Voice

Score for the Big Bang: The Universe as Voice

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Fine Art at Virginia Commonwealth University.

by

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Abstract

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The thesis is a multimedia document, including a documentary video and audio
recordings, that catalogues and unpacks the cross-disciplinary project Score for
the Big Bang. On April 13, 2012, thirty-six vocalists sang the sound of the Big
Bang in a historic church in downtown Richmond. For this project I worked with
an astronomer, composer, choral director and organist to translate the
primordial sound into musical notation. This is the universe as voice, through
humans, recreating what we have come to understand was present at its birth.
Documentary Video

In order to view video:

Open the separate video file “Mikalson_Thesis_Documentary.mp4” in the VCU Digital Archive;

Or stream it online at https://vimeo.com/42000402
Artist Statement

I do not have new questions, but I have big questions. Why are we? Where are we? What is it like to be?

I transform abstract concepts into familiar objects and visceral experiences. I convert the digital to analog and back again, translating data through the human body and voice. In a recent performance, Score for a Cyclone, the audience creates live foley sounds to the twister scene from “The Wizard of Oz.” For Dream Assignment I approach lucid dreamers online and ask them to dream my dreams, commissioning them to produce drawings and texts that document their private nocturnal performances. For Score for the Big Bang, I translate the sound produced by the Big Bang into musical notation that is performed live by a chorus of thirty-six vocalists, transforming an impenetrably remote event into an immediate and human experience.

The futility inherent in these projects—attempting to sing the Big Bang, dream someone else’s dream, or spontaneously recreate the sound track of a film—acknowledges the futility of our efforts to know and catalog the universe, while finding significance in that very search for meaning. For me it is the act of
reaching—not necessarily what is reached for—that yields meaning in an indifferent universe.

An essential mode of my artistic practice and production in the past two years has been that of collaboration and participation. I set up a call-and-response with acquaintances across town and strangers across the world; I collaborated with other artists, with a nineteen-year-old boy in Ohio, with a choir, with an astronomer, with my audience. My open-ended way of working challenges the role hierarchical processes play in contemporary art, and shifts the focus to the importance and presence of collective creativity in our time.
Interview with an Astronomer

March 1, 2012

Dr. Mark Whittle, Professor of Astronomy, University of Virginia
Office 216, Astronomy Building, University of Virginia, Charlottesville

How do you know about the sound of the Big Bang?

One may wonder how on earth anyone could know anything about the origin of the Universe—it was a long time ago and so it’s not obvious how you might know anything about it. Astronomers are extremely lucky people because they actually have direct access to history through telescopes. By looking very far away you’re looking back in time, because it takes a long time for the light to get to you. If you’re looking at a star in the sky that is ten light years away, you’re seeing that star as it was ten years ago. You’re actually seeing a piece of history. Ten years is not very long, but if you have a big telescope you can look
much further—you could look a billion light years away and see a galaxy as it was a billion years ago.

It turns out the Universe is about fourteen billion years old, so if you take a telescope and look fourteen billion light years away, you’re seeing the Universe as it was fourteen billion years ago. The Universe back then was the fireball of the Big Bang. It’s a quite staggering fact of Nature that by looking to extreme distances you can see the creation event itself. This is not at all obvious when you first think about it, but when you realize that, you realize what an extraordinary gift Nature has given us. It’s actually shown us its own birth, which is wonderful.

To develop the idea just a little bit more, you might be thinking, “Well in what direction should I point the telescope to see this event?” It turns out if you look in any direction you’re looking back in time. We witness all around us at enormous distance the flash of the fireball of the Big Bang.

At this point in the explanation, you might be puzzled by thinking, “Well if it was a bright flash from the Big Bang why, when I look out at the night sky, is it black and dark? I don’t see the flash you just told me is in every direction, all I see is a black velvet background of sky with foreground stars.” The reason is that in the fourteen billion years since this primordial explosion the Universe has expanded greatly. It’s expanded a factor of one thousand! There are light waves coming from the flash of the Big Bang, and as the waves cross the Universe to us they get caught in that expansion. They are, in a sense, embedded in the space and since the space is expanding, then the light waves are stretched. So they come to us not as visible light waves, but a thousand times longer, because that’s the factor by which the Universe has expanded. They rain down on us, not as light waves, but as microwaves.
Our eyes don’t see microwaves, so when you look at the night sky it looks black to our eyes. But, if you could imagine an odd quirk of evolution which had given us microwave sensitive eyes, then when you looked to the sky you would see a glow in all directions. You would be witnessing the stretched light that was coming from the fireball itself, in addition to stars and galaxies that would be in our foreground. The glow would be the backdrop, the most distant curtain of image that you would see.

So you figured out the sound from light data that was in microwaves?

Yes, that’s right, and I will try and explain that. It’s very important that we’re not listening to the sound, we don’t have the sound waves here. We see them on the Microwave Background.

This microwave glow that comes from, essentially, the Big Bang, was discovered in 1964 by accident. That was almost fifty years ago, and that means it’s been studied very, very carefully. Because it’s the creation of the Universe, scientists have thrown a lot of effort at witnessing this event. One of the most productive satellites that mapped all of this was a satellite called WMAP—Wilkinson Microwave Anisotropy Probe. The WMAP satellite took this picture, a photograph, using microwaves, of the entire dome of the sky.

We’re all familiar with the spherical globe of the Earth. If you think about it, the sky is a spherical dome around us, and can be represented by a similar kind of dome, with the stars and constellations on it. Imagine replacing what we see with our eyes with an equivalent dome, but seen with a microwave telescope. You see a sphere of exceedingly uniform brightness of microwaves.

The great capability of the WMAP satellite was to look beyond that uniformity for very, very slight fluctuations in it—slightly brighter and slightly dimmer patches. The picture that it emerged with shows the full dome of the sky, color-coded for
the brightness of the microwaves. It’s slightly brighter in the red parts and slightly dimmer in the blue parts. You’ll notice is it patchy. There are little patches, medium size patches and great regions. One whole region is a bit dimmer and one is a bit brighter; there’s a whole mottle of patches. These are the seeds of future galaxies.

This is an image of the Universe as it was about half a million years after it was born, fourteen billion years ago. It was a very smooth gas, there were no stars or galaxies; what we’re looking at here are the very beginning of galaxies. It took a long time for them to develop and grow, but the seeds of them are already here.

There is another way of looking at what these patches are. It’s an honest way, it’s just a slightly different way of looking at it. Back then there are no obvious structures like galaxies and stars. The Universe is a thousand times its dimensions smaller, and all the material is spread about uniformly. It’s just a dilute gas, and it’s very hot. Where the region is brighter, not only is it a little denser, it’s also a little hotter, and that means it has a slightly higher pressure in the gas. Where it’s a little darker it’s a little cooler, it’s a little less dense, and the pressure is lower.

When we say that there is a region of slightly higher pressure and a region of lower pressure, what we’re actually saying is these are the peaks and troughs of sound waves, because sound is a pressure wave in gas. If that gas happens to be glowing, which it was back then, then when you have a sound wave and there’s a compression it glows a bit brighter and when you have a rarefaction, a trough of the sound wave that’s a little bit lower pressure, it glows a bit less brightly. So when we look out and see this early universe, we can actually witness, through the glowing gas, the peaks and troughs of sound waves. It’s the brightness of the glowing gas which reveals the sound.

These peaks and troughs of sound waves are going to become the galaxies that fill today’s universe, through a long and arduous process, a bit like how the
growth of our little egg becomes a baby. That synchrony of nine months gestation roughly maps onto the birth of the first stars—the Universe didn’t have stars for 200 million years, which is about nine months on our human scale. Then quickly infant galaxies grow, and by about eight or nine billion years, mature looking galaxies are present.

The universe was born foggy because it was very, very hot, and no atoms could survive. Electrons were moving around and acting like water droplets, scattering the light. The universe was opaque; you couldn’t see through it. It took 400,000 years for the Universe to drop down to the critical temperature, three thousand degrees, at which hydrogen atoms could form. From then on we have a transparent Universe.

We look out through a transparent universe, back in time, out in distance, back to the time that the Universe was three thousand degrees. Beyond that it’s foggy, and earlier, nearer than that, it’s transparent. What we witness is in fact the wall of fog. We see that clearing of the fog. The Microwave Background is this glowing wall of fog, it goes all the way around the sky. We see the sound waves which were moving through the gas on that wall of fog. Where a peak is, the wall glows more brightly, and where a trough is, the wall glows less brightly.

The light that was being emitted then was very, very powerful orange-red light. It was as bright back then as it would be hovering over the surface of the sun, immensely bright. Fortunately for us, the universe is expanding, so that intensity of light is diluted. Otherwise we would be fried by the Microwave Background. Fortunately, that brilliant flash of light has been immensely reduced in its power. So much so that, in fact, your eyes don’t even see it and you have to invest three hundred million dollars in a satellite to witness it. It’s that feeble today, but back then it was very intense light.
We have a way, of not directly hearing the sound of the Big Bang, but of witnessing the sound waves as they move through the glowing gas. It’s that glowing gas that we see, and furthermore it’s not the light that we see, it’s the stretched light that we witness as microwaves. Metaphorically, it’s not terribly different from listening to a live broadcast of a concert that was produced somewhere else. The sound waves move a little microphone which gets sent to a radio antenna, the radio waves come across the country, are picked up by your radio and reproduced as sound. You’re not actually hearing the orchestra, because it’s been mediated through the radio waves. But if you know what you’re doing you can effectively reproduce the sound back there, even though you’re not hearing it because it’s too far away, but the radio waves have crossed the country and reached you. It’s the same with this—the light waves have crossed the universe, they’ve come to us and they reveal the sound waves as they were back then, coursing through the young universe.

So we see the Big Bang and the sound it made in the microwave data?

Let’s be clear about how young the universe was. The Microwave Background is not in fact the Big Bang flash itself, that happened about 400,000 years earlier. We witness the gas in the Microwave Background. We don’t have access to earlier times visually because the gas was foggy, so we can’t see deep into the fog, we only see the wall of fog at 400,000 years.

Four hundred thousand years after the Big Bang sounds like a lot of time for a person, but it’s not for the Universe. If you think of fourteen billion years, the current age of the Universe, as the lifetime of a person—let’s say eighty years—then 400,000 years corresponds to half a day. So we are witnessing the Universe, as if it were a person, half a day after conception. We’re not even yet into gestation, in the human metaphor we would basically have a big molecule, DNA with a cell around it. There’s no arms and no legs, there’s no structure really, and that is just the same in the Universe—no stars, no galaxies.

The information that’s stored in the DNA of a human is equivalent to the information that’s in the sound waves. The sound waves are going to determine where the galaxies form, how they form, when they form. Our own DNA determines how we grow and, to some extent, how we are as adults, but the DNA also tells us about our evolutionary history. An infant’s DNA doesn’t just determine its future, it also contains all our ancestry. The patches, the sound waves, on the Microwave Background have roots that go back to the launching
mechanism of the Big Bang itself. So they have ancestral information, right back into the pre-nanosecond-old universe. They’re an extraordinary resource of information. They tell us how the universe is going to evolve and they tell us how it was created. They’re very interesting things, these sound waves.

Why was there sound at all?

The very quick answer, which is wrong, is that it was a “big bang”. The word “bang” immediately connotes sound, and if you think about the Big Bang in a knee-jerk manner, it’s an explosion, and explosions, as we all know, are loud, they send out sound waves. Unfortunately all of those connotations are actually flawed. That is not how the Big Bang occurred.

The Big Bang was not an explosion into a pre-existing space, with material being shot outwards. There was no atmosphere to make a sound wave. When an explosion goes off, the pressure wave comes out, and bang!—you hear that pressure wave, because there’s an atmosphere outside. In the case of the Universe, space itself was unfolding. In fact, the initial expansion was so smooth and so streamlined that no part was catching up to any other part. It all was just going away—every piece was receding from every other piece. So there were no pressure waves. The Big Bang was, in fact, a silent process. The sound develops later.

A much better way of thinking about all of this is that in the silence of the initial expansion, slight lumpiness was made in the launching mechanism of the Big Bang itself.

The universe was born with a very slight degree of unevenness. By that I mean, this region over here was just a little bit denser than the region next to it, and the region over here was a little bit denser still. This applies on all scales, so there’s a huge region right here that is slightly denser, and a huge region here that is slightly less dense, meaning there’s slightly more stuff and slightly less stuff per cubic meter.

Within this mottled, slightly uneven Universe that is in a state of expansion, there are actually three key players. There’s a hot gas, so we know that there are protons and electrons, the stuff that ultimately becomes us. There’s also light, incredibly bright light. And there’s a substance called dark matter. This is a crucial player. Without it there would be no sound and there would be no galaxies. It’s quite an important ingredient in the universe.
It’s become understood since about the 1970’s that the universe contains a form of matter that is rather unusual, not like protons, electrons or atoms. It’s significantly more abundant than atomic matter, by about a factor of six—there’s six times more stuff called dark matter than there is atomic matter. It’s unusual in the sense that it doesn’t interact with light, so it’s dark, light passes right through it—it’s transparent. It doesn’t form objects, the particles just move through each other. It’s very non-interactive, but it’s present. You can think of it as a cold dilute gas with no pressure. That’s a slightly technical way of describing it but that’s ultimately what it is—it has no pressure.

The lumpiness that emerged from the universe included lumpiness in the dark matter. Because dark matter was the most abundant material back then, it was the primary source of gravity. The lumps of dark matter exert a gravitational tug that causes the surrounding gas to fall in. As the gas falls in it gets compressed and is then pushed back out by that pressure—like a spring. The gas going in and bouncing out is a pressure wave, a spherical sound wave.

The gas is falling and bouncing out of pockets of dark matter of all sizes. In the little ones it is falling in and bouncing out quickly, because they’re small. In the big ones it falls in more majestically and bounces out more slowly. This means we have high pitched sound waves and low pitched sound waves. A sound wave which is oscillating quickly has a high pitch. A sound wave which is oscillating slowly has low pitch.

As the thousands of years pass by, spread throughout the universe is this landscape of dark matter with gas falling in and out of different sized regions, all making sounds of different pitches.

*If we had been back there would we have heard these sound waves?*

The answer is no. If you read this aloud, the waves that are coming out of your voice right now are oscillating about 300 times per second—that’s fast. Whereas the loudest sounds in the early Universe fall in and bounce out every 200,000 years. You can see that they’re very, very deep waves—fifty octaves below the range that we hear. We can hear waves that are somewhere between 20 vibrations every second and 20,000 vibrations every second.
If you go back then, what are the frequencies of the waves?

It depends on the size of the patch into which the gas is falling. Remember we have only had 400,000 years since the Big Bang, so you cannot have a region bigger than 400,000 light years across, for which a sound wave could have moved in and bounced back out again in the time available. You couldn’t have a million light year region do that, because there just hasn’t been the time for the gas to fall in and out—we’ve only had 400,00 years.

The age of the universe at any given moment back then sets the pitch of the deepest tone. So 10,000 years after the Big Bang, regions that are 10,000 light years across are, at that moment, the deepest notes that are sounding. By the time you come to 400,000 years, when we see the Microwave Background, the regions which are undergoing this oscillation are 400,000 light years across. That is one enormous organ pipe. It gives a deep note because it’s so big. The smaller ones might be 10,000 light years across, and they’re oscillating with a higher pitch.

Why do you choose 400,000 light years for a sound wave to cross? Doesn’t sound move much more slowly than light?

Back then, sound waves move at sixty percent of the speed of light. It’s a very, very fast sound wave in the gas. There’s a simple, and rather nice, reason for that. The main ingredient that is giving pressure to the gas is, in fact, light. Light itself is so bright that it is pushing on the electrons, on the gas. It’s the light that’s making the pressure. In this room that is not true. It’s molecules hitting each other that makes the pressure. The light that comes from these overhead lights is very miniscule, only contributing a tiny amount of pressure because the photons are hitting things.

But back then, for every atom there were a billion photons of light, all giving relatively the same amount of pressure. The dominant source of pressure is light. Even though we’re talking about pressure waves and even though we’re talking about sound, what’s pushing the gas is actually light’s pressure. For that reason these sound waves move approximately at the speed of light. Not quite the speed of light, about sixty percent. The gas is very lightweight and this pressure by comparison is very high, so the sound waves move very quickly. But even so, the regions are very big. So it still takes about 400,000 years for the sound wave to cross a 400,000 light year organ pipe.
What did it sound like?

Recognizing, of course, as I’ve just explained, that the sound is too deep for our ears to hear—never mind the fact that you would be killed instantly by the brilliance of light—we can allow for some sort of ear that would be able to hear. To actually be able to experience these sound waves pushing on an ear drum, we would need a very large heat-resistant ear that is expanding with the universe.

We find out what the sound was like by looking at the Microwave Background. I’ve mentioned the small patches creating high pitches, medium size patches creating medium pitches and then huge patches which are creating very deep pitches. The sound is really the sum of all of those. So one really wants to know, how much of each pitch was there? How loud was each pitch? Let’s add all of those together and then we can recreate the sound. And although your eye is not particularly good at doing that, a computer can do it very effectively. It can look at the entire collection of patches and extract what is called a “sound spectrum.” This is a whole range of pitches with the loudness of each pitch generated as a graph. The graph that’s come out of this particular observation, the sound spectrum from the Microwave Background, is very famous and really quite fantastic. There’s not just a smooth range of different pitches, there’s actually a fundamental tone. It’s a lot louder in one particular pitch, and then it drops, then it’s louder at a certain pitch and it drops again.

Table 5: The Observed Sound Spectrum
These are all harmonics. This is quite interesting because there are only a few things in nature that generate harmonics. Musical instruments are one and our voices are another and there are a few other things that do it, but it’s not obvious that you would expect to see harmonics coming out of the early universe. Yet that’s what there is.

And this is what it sounds like*:

| 🎶 |

The harmonics themselves are very broad in frequency. Our ears are not very good at picking out the different tones, so it sounds like a hiss to us. But it actually has more of one pitch present, less of another, more of another, less of another. It has those harmonics present in it. That sound is, of course, at 400,000 years—that is the sound that we witness in the Microwave Background. You cannot recreate sounds from earlier times using telescopes, you have to use a computer to calculate what they were.

*Are those earlier sounds that you calculate using a computer accurate? Do we really understand the properties?*

Without wanting to sound too arrogant here, the answer is, yes we do. After about thirty years of theoretical astrophysicists working very, very hard to reconstruct the equations and follow the properties of the early universe, there’s a very sophisticated understanding now of exactly what was going on back then. It’s checked by matching it to the patches we see on the Microwave Background, and the match is an exquisite one.

The early universe, while it was remote in time and remote in distance, is an exceedingly simple thing compared to today’s complex Universe. Even trying to untangle, for example, what goes on inside the antenna of an ant, is enormously more complicated than the early Universe. It yields to graduate level physics and is tractable. So it is possible to, on a computer, simulate the sound and match it to the data we have for the Universe at 400,000 years.

These very sophisticated computer codes are publicly available. NASA provides them, so I could run a particular code and then extract the information from that.

*Please open the accompanying document “Mikalson_Thesis_with_media.pdf” in the VCU Digital Archive to hear the sound. Audio is not included here in the interest of keeping the file size small.*
That was how I generated the sounds.

*How did the sound evolve?*

Early on the little organ pipes are oscillating and the big ones haven’t got going yet, because there hasn’t been time. There is an entire register of organ pipes present, but we only activate them from the highest ones first. As time passes by, we can activate the bigger and bigger organ pipes.

This is what the sound is like across the first 400,000 years, compressed into ten seconds:

![Sound](image)

It’s like a descending roar. It’s unfortunate, aesthetically, that our ears don’t pick out the harmonics, because there is a musicality to it. It’s just that we’re so used to hearing harmonics that are very narrow in frequency range, very well-defined tones. I’m going to conjecture that is because our voices produce harmonics of that kind. If you had a little sound analyzer and took the spectrum of your voice, you’d find that every time you said anything, there would be narrow spikes for certain pitches coming out, with everything quiet in between. That is certainly true for almost every instrument we ever make, they have narrow harmonics. The cosmic harmonics are very fat, they have a very broad range. It’s like coming up to a piano and instead of playing one note with your finger you press your whole arm down—you don’t hear one note, you hear a

![Graph](image)

**Table 6:** The chord present in the primordial sound
whole lot, and our brains process that as noise.

I wanted to deviate slightly from an overall desire to recreate the sound as accurately as possible by modifying it slightly so the way we respond to harmonics is enhanced – to help us to hear the musicality of the sound.

Here is the true sound:

And this is the true sound with non-acoustic effects removed by using the computer simulation. So this is what it would really sound like:

And this is what it would sound like with narrowed harmonics:

If you musically analyze that tone, it’s actually between a major and a minor third. Which is kind of nice; it has the quality of both the major and minor chords that are present. That of course was just at 400,000 years. Let’s do the same thing from the beginning. So we’re going to narrow the harmonics down and listen to the evolving sound:

That captures something of the descent of the sound. It’s still tricky for your ears to pull out any change in the chord. So I’ve allowed myself two more creative steps, without trying to deviate too much from reality. The first is to remove the downward slide, so now we can listen to the change in harmonics and the change in the chord:
The other step was prompted by working with Ander. I go back to that first version with the descending pitch, keep honest to the descending pitch, but this time recognize that as each note, which is sliding down continuously in pitch, crosses any note on the piano, on our even-tempered scale, I articulate that note and let it hang. It’s a bit like going down a piano. This is what that sounds like:

You might notice that has this rapid change at the beginning. That is characteristic of the Universe, it evolves very rapidly early on and then it slows down. Today we live in a slowly evolving universe, but things happened very fast early on, and this rendering evokes that. Then it does settle down and then, if you listen to that rendering a minute later, those little notes come out in a semi-random way, and there’s a certain charm to it. Though it’s still a little bit sterile.

If one really wants to try and take this notion of the primordial sound and bring it more into a human experiential realm and have it resonate with us as humans, that’s where somebody like Ander and the sound artists come in. They may take this as their starting point, and to some extent, honor its particular form and character but simultaneously modify it in ways which draw upon a more creative spirit. Perhaps they also draw upon an understanding of what’s actually happening out in the Universe, so there’s some attempt to reflect Nature.

*You said that the early universe was like a musical instrument?*

Yes. One of the delightful features of the sound spectrum that emerges from analyzing the patches on the Microwave Background is that it reveals the presence of a fundamental tone and higher harmonics, which are really what you expect from something like a musical instrument. So in quite a real sense, the early phase of the universe’s life was a musical one. Quite apart from that being a rich notion poetically, it’s actually scientifically very interesting as well.

The reason that musical instruments and our voice have a fundamental tone and harmonics—which give them the quality that we associate with notes, with music—is that all of those objects are bounded. They have distinct edges to them. In the case of my voice, there’s my mouth and my larynx. With the flute
it’s bound on one end and then the other. With a guitar string it’s held at the top and the bottom. They all have boundaries, and a certain number of waves can fit between those boundaries. One wave might fit, or two or three waves, but not one-and-a-half waves. Since they’re anchored at either end you can’t have that wiggling. It has to be a node, it has to be a fixed point of the wave. Things with fixed boundaries tend to have only limited ways in which they can wiggle. And those limited ways are, in fact, the fundamental tone plus the higher harmonics.

_That idea doesn’t obviously translate to the early Universe. There were no walls, there were no edges, so what were the boundaries that were responsible for the harmonics?_

The boundary is, in fact, the boundary of time. It’s not a spatial boundary, it’s a temporal boundary. There’s been a fixed interval of time between the Big Bang and the Microwave Background, or any moment in between.

At any given time, there are only particular organ pipes that are at their maximum compression, in which case you will see them as a bright patch on the Microwave Background, or their maximum rarefaction, in which case you will see them as a dim patch. But let’s imagine a patch in between, where the gas has fallen in and bounced only halfway out. There is no compression or rarefaction, so we don’t see it as a bright or dim patch. The intermediate sizes of organ pipes don’t show up on the Microwave Background, and that’s how the harmonics are formed. It’s because of a temporal boundary between the Big Bang, when all the waves began, and then any given moment when you’re looking at it.

So it isn’t quite true to say the harmonics have the exact same quality as in a musical instrument. There are nonetheless aspects of vibration which are present with some pitches and not so present with other pitches, though it comes about in a slightly different way. Personally I feel that it’s nonetheless appropriate to think of them as regular harmonics and recreate them that way. It helps us bridge the gap to Nature.

The church organ is a good metaphor to use because there are many sizes of patches in the early Universe, and there are many pipes in an organ. You have access to all of these and they each play different notes. In the case of the early Universe you’re sounding some of these and not others. As time marches forward which ones you’re sounding are changing. That’s more or less what
you’re doing when you play an organ. You sound some of the organ pipes and then you stop them, and then you sound others and then you stop them. So it’s in that sense that the organ is nice because you can visually witness all of the different pipes. Whereas for something like a guitar it’s one string and then you’re blocking it at different places, but with the organ they’re all there, individually. When you walk around the back there are little pipes which are playing the very high notes, then there are whoppers which you see out in front, thirty feet high. They play notes which you can’t even hear, they’re wiggling your tummy so that you feel the music rather than hear it. The deepest notes on church organs are for atmospheric effect rather than for tonal effect. Needless to say, of course, the early universe pipes were enormously deeper.

You said it was based on time, so if we listen to it a thousand years from now would the harmonics be different?

Yes, though a thousand years would not be enough to change it much.

But a longer time period, maybe?

That’s a fascinating question. Currently, we’re slicing the 400,000 year fog from 13.7 billion light years away. If we go a billion years in the future, we would look back, not through 13.7 billion light years but 14.7, because now the universe is a little bit older. So we would still slice the universe as it was 400,000 years after its creation, but we slice through a different piece of gas. The actual patches will look different, but the sound spectrum will be the same. Where we had sliced a sound peak, we might now slice a trough. And next door, where it had been a trough it might be a peak. The specific patches would change but the statistical nature of the patches would be the same. Meaning the sound would ultimately be the same.

It is as if there’s an orchestra playing in New York and I’m listening on my radio. It’s a live broadcast, and I’m hearing it, say, thirty microseconds after they’re playing. If walk ten miles further away, do I hear the same music? I do, I just hear it a bit later. But it’s the same music. I don’t suddenly catch them playing a different piece of music. It’s just that the whole thing unfolds just a little bit later downstream.
What information did you give to Ander for this project and what form was it in?

There are a couple of ways that I provided Ander with information. One was graphical. On the Y axis is pitch and I plotted a piano keyboard next to it, so you can mark off where all the octaves are and identify the eighty-eight notes. Then on the X axis is time and it very simply starts at the Big Bang, zero, and ends at 400,000 years. On the same graph, on the right hand axis I put loudness

Table 7: Pitch and loudness of the primordial sound, plotted within the human vocal range
in decibels. Then I plot the pitch at any given time and how loud each harmonic is. The odd harmonics—the first, third, fifth and seventh harmonics—grow in strength throughout, but the even harmonics die out a little bit. That’s to do with whether the harmonic is linked to the compression part of the wave or the rarefaction part of the wave. In addition, because to some extent I think Ander also wanted to work in our even-tempered scale, I then made sure that there was a little dot that showed each time a harmonic crossed one of the eighty-eight notes on the piano. I scaled the pitch, recognizing how deep a human voice can go. I made sure that the lowest harmonic at 400,000 years didn’t go below 110 Hz, about the A two octaves below concert A—otherwise it just gets too difficult to sing.

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| Table 8: Partial table of times that particular notes sounded in the early Universe |
I also printed out a table of numbers, which gave the time scaled to the length of the score they were writing, which at that time was about eight minutes. It showed at what second each particular note was sounded. The information that I gave them was just a starting point, a visual and a quantitative description of the nature of the sound, so it helps then in scoring it or in deciding what to bring in when. You can get a sense of what’s happening by listening to the sounds, but these printouts extract the information in a more transparent way to work with.

So the sound lasted for 400,000 years and then it just ended?

At 400,000 years the fog cleared. The sound waves stopped at that moment. Those tones became frozen. But those sound wave patterns were instrumental in crafting the subsequent location of the galaxies.

Recently the location of about a million galaxies have had their positions plotted on maps, out to a distance of about 2 billion light years—a fair chunk of today’s universe. The wonderful pattern of the galaxies—they tend to be clustered with little chains and voids—is called the galaxy web. When you analyze the galaxy web in the same way that you analyze the patchiness of the Microwave Background, you find that there’s an excess of clumping of galaxies at the same fundamental tone that was present back there. In other words, you can see the fundamental tone, and the second and third harmonics, etched in today’s distribution of galaxies.

It’s no longer sound, it is the pattern of the distribution of galaxies. They’re given a rather amusing sounding term—they’re called Baryon Acoustic Oscillations. Baryon means it’s matter, the matter that makes up galaxies, not dark matter. Acoustic is because it has in it the information that came from the Acoustic Era, the first 400,00 years. And Oscillations is because they were oscillating, and then they got frozen and we see them in the pattern of galaxies today. For cosmologists it’s a very useful pattern to recognize, because it allows them to triangulate on the total age and content in the universe, which other methods can’t achieve.

The bottom line is, the harmonics that are coursing through the very young universe leave their imprint on the tapestry of galaxies that permeate today’s universe. They’re written in those patterns and it’s been found. Those galaxy maps are now being worked on quite heavily. They’re trying to map out to 4 billion light years, and to go up from a million galaxies to a billion galaxies. Then
you begin to tease out these residual harmonics that are manifest in the position of galaxies, and use them cosmologically in important ways. It’s good stuff isn’t it?

It’s amazing.

Yes, it’s amazing! I know, it is, it’s just amazing.

So what did the universe, or what did it sound like before the Big Bang?

That is not known, not currently. We do know enough about space and time to at least be cautious about the question. There may not have been such a thing as before—if time was created in the Big Bang, then you can’t really ask about before. I should quickly say that we don’t know whether time was created; there may well have been a prior time.

Our current, best bet theory for the creation process itself involves a realm of quantum foam or entanglement. It’s a realm which is deep, deep in the minutia, the tiny, tiny scales of reality, where gravity and quantum mechanics and space and time are all in a form which we wouldn’t easily recognize here in our large room. It’s down at the tiny, tiny scales, the Planck scales. And somehow, in ways that we don’t understand, maybe this seed – the inflation seed – was created by a quantum process. It’s that seed which inflated, and it’s the quantum fluctuations within that inflation which then created the patches from which the stars and galaxies grew. I want to qualify that this theory is not on nearly as robust a footing as the hot Big Bang story I just described.

So we are not sure about what came before?

Any question about the prior time or the ultimate ancestry of the primordial sound pushes us into a part of the cosmological story which science is much less confident with. It deals with the process that created and launched the expansion of the Universe. The cosmological story is a little bit hesitant on providing the launching mechanism and being confident that it understands it. That’s distinct, incidentally, from our ability to recognize the reality of the hot Big Bang. We’re now talking about what launched its original expansion and created all the material that’s now in the universe.
With that proviso, the most likely theory looks to the creation out of a prior realm whose nature is very poorly understood. But it is thought to do with the quantum nature of reality, the fact that, deep down, the Universe follows a quantum rulebook which is rather different than the rulebook that large objects in our world seem to follow. There’s a different set of rules. These rules are actually capable of creating things out of nothing. The mechanism that created the Universe out of nothing is called inflation.

This particular launching mechanism does an extremely good job at generating the kind of structures that we ultimately see. That was one of the greatest successes of the inflation theory. After it was created it was then realized it could do a very good job at accounting for the structures that are present in the universe. You may not realize that the universe could have been born completely smooth. There’s no way that stars and galaxies would ever form. In a cosmological story with any success, you have to find a way in which structure was created and then amplified, to then make stars and galaxies. It’s not a given that that should happen. So it’s a very, very key part of the story to have that mechanism.

The launching mechanism itself generated the patches, the organ pipe register, in a quantum process. There is this remarkable recognition that phenomena that were occurring on a sub-atomic scale during the launch of the Big Bang are ultimately what spawned the sound waves and the patterns of galaxies. It’s difficult to sort of grasp that gulf, but things happening smaller than a proton are laying the blueprint for billion light year patterns in the galaxies.

There’s ways of analyzing these patches that try and probe the nature of that early mechanism. The data is not solid yet but we keep putting a tick against the quantum origin. There aren’t many options—it’s not easy to think of ways in which structure can be created in the early universe—and that’s the best bet theory at the moment. Part of that mechanism is to seed the expansion with a slight roughness that sets the whole acoustic stage.

You can’t create a whole universe out of nothing, but what you can create is a seed. The word seed is an appropriate one because it’s tiny, it doesn’t contain much, but the stuff it does contain is extraordinary. Within modern physics, there is the concept that certain kinds of quantum fields can exist that act like space itself but they have weight, they have mass. So the content of this seed is a dense form of vacuum called an inflaton field. One of its remarkable properties is that it is unlike normal matter or energy whose gravity makes it get smaller and collapse, like the sun would collapse if you allowed it to. When you
have dense vacuum in a ball, even a tiny ball, it actually falls outwards, not inwards.

As it does so, the gravitational energy that’s released as it falls—when things fall they pick up speed, they release energy—that actually makes more vacuum. So this seed falls outward, making more of itself out of the gravitational energy that it just released by falling, and having made more of itself it does the same thing again and again and again. This tiny seed, therefore, doubles in size and then quadruples and then gets bigger exponentially. At the sort of scales that we’re talking about the density of the material is so great that the falling time is very, very rapid. Much faster than a nanosecond.

The stuff that is falling is a quantum field. And so, in addition to responding to gravity and making more of itself by falling, it also has a roughness, a texture, to it, because it is a quantum substance and all quantum things oscillate and vary in their energy; that’s inherent in their nature. It’s actually true even for things like electrons and protons and atoms, they all wiggle a little bit and fluctuate in their energy. In the normal world, those quantum fluctuations average out, and what goes up comes back down again, and what comes down goes back up again—it always averages out.

But in the context of an expanding realm, a very new and fascinating thing occurs. The quantum fluctuations get frozen as real fluctuations. They don’t have to come back down again. If a region is expanding and it happens to fluctuate and become slightly denser, as it expands that slight higher density gets frozen and locked as a real higher density. And similarly, if, as this region is expanding a little part of it happens to fluctuate down in energy, it gets frozen out as a real lower density region. So as this region keeps doubling and doubling, at every point, roughness is being locked in place. As one piece of roughness is locked in place that piece then expands and becomes a big realm of say, slightly higher or lower density, but within it now, new realms are being created with slightly higher or lower density. So you get this ever-nested structure. Those are the organ pipes. It’s those higher and lower regions which are going to become the framework within which the gas ultimately oscillates and bounces in and out. During the inflationary launch the organ pipes are latent. They’re present but not yet sounding.
But if they were activated what would it sound like?

There hasn’t been time enough for any sound wave to travel. But if we just have a conceit and ask, “what would it sound like?” The remarkable truth is, it sounds with all pitches known; from the highest to the lowest. It actually sounds the highest pitches more loudly than the lowest ones and in a very smooth and interesting way.

Cosmologists give a name to this—they call it the Initial Power Spectrum. In this context we can call it the Initial Sound Spectrum. The key word is initial, because that’s what the universe is born with. If you go back to this realm just after it’s been made and ask what it would sound like, it would be a hiss. And I say hiss because the “S” in hiss, if you sound analyze that it has a lot of high frequency present. In the Initial Sound Spectrum it is true that the highest frequencies are most present—they go right up to the highest notes imaginable. Simultaneously “hiss” has a bit of low notes in it and the spectrum goes right down to the deepest notes you could possibly imagine. The primordial initial sound had all frequencies present, emphasizing the highest notes.

That quantum hiss is ultimately what we are seeing in the Microwave Background. But it’s been modified by certain developmental processes so the hiss is changed slightly. It’s like when you play a violin, the resin on the bow makes the string slip along in a fairly chaotic manner. But because the string and the violin have resonant frequencies they ignore certain pitches that are being struck and they amplify others. In other words, the structure of the system picks up certain sounds and makes them audible and it doesn’t allow others to be audible. And that’s what’s going on with the universe. The quantum origin of this structure had all frequencies present. Then in the ensuing thousands of years only certain frequencies were emerging and others were not.

The quantum process is profoundly random, which in the current context means that the actual location of peaks and troughs of the sound waves, the actual location of where the galaxies will or won’t form, had its roots in a deeply random process.

It might have been nice to have seen a face in the Microwave Background, but there will not be a face in it because the patches are profoundly random in their location. That’s because Nature is drawing upon a deep mode of behavior, which is the randomness associated with the quantum processes. I juxtapose those two ideas to draw out the fact that as humans we might wish for Nature to be a certain way, because it conforms to how perhaps we’ve grown to think
about Nature. I’m suggesting that we anthropomorphize things. So it would have been nice to see a face, perhaps representing a creator figure. Nature isn’t honoring that in the way we might naively wish. Nonetheless, it’s honoring the program of creating a fertile universe which ultimately leads to us.

In fact, if it had had a rather different kind of sound spectrum we might not be here. The ultimate evolution of the stars and galaxies, which then creates the elements which then create planets which then create us—could very well not have happened had this primordial sound had a different sound quality, or had there been a different kind of roughness generating mechanism. These things are very delicately balanced.

My thought about this is, whatever Nature happened to be doing, that’s fine by me. Because A) it’s bound to be amazing and interesting and B) you don’t want to tinker with it—not that we could, of course, that’s just a philosophical conceit—but it’s best not to impose on Nature what you wish it might have been.

How do you feel about your collaboration with Ander and the significance of what you’re doing? Did Ander come to you? Why does this interest you?

I’m always delighted when anybody is interested in the sonification project that I did. It took a lot of effort to do it and I think it’s a nice topic. So I was delighted when Ander emailed me with some interest. She had already done some work on a sonification of the Big Bang sound. She came and we had a nice long chat about the whole project, both the science and the sound and the piece of music.

I thought it was doubly nice because Ander is quite interested in the science behind what’s going on, partly because it is interesting stuff inherently, but also because I think she had a sense of honesty to the Universe. She was wanting to make sure she understood the components of the sound so that she could work with them and use them as this sort of starting point, so that she felt the starting point itself would be authentic to Nature. I have a sympathy to that particular perspective. I wouldn’t be as interested in a piece of music or sound that was very loosely linked. I think it’s nice to stay a little bit close to what we think reality was, and at the same time work hard to create a strong emotional response.

I think one of the limitations of the sounds that I was generating is that they were not emotionally all that powerful. In fact, when I give a public lecture on this it’s
almost a joke that it sounds like a jet plane landing, like something very parochial, prosaic. I also joke that it doesn’t sound like choirs of angels or the mantra “Om” or something like that. But at the same time it is a remarkable thing one is trying to do, to connect with the creation of the whole universe. So it would be nice to have something which was more immediately resonant with our own sensibilities. That’s the place where the sound artist comes in and begins to work. That’s their area of expertise, I suppose, to use that word. They draw on what they either understand or feel.

I’m happy for Ander to do just exactly what she wants. As I say, I’m pleased that she seems to be interested in having the root be in, as best I can provide, a rendering of the primordial sound, but from there I’m just interested to see what she does and how she brings it all about. What I’ve heard so far I think is lovely. I think it’s emotional eeriness and richness has progressed greatly from renderings which sound like a jet plane through others which are interesting but sound a little bit synthetic. You have the human voice and it’s layered and textured. I haven’t heard the final piece yet but I’ve heard preliminary versions. I think it’s really quite an interesting project.

I think we have a yearning to connect with the world around us and beyond that, the Universe around us, and understand it in some way. I think that’s not just a contemporary feeling, it’s probably a more ancient feeling than we might even experience today because we live our lives a little removed from nature. So I think it’s nice to find bridges to that experience. Science does that, but in an intellectually focused way. I suspect that it takes on a different character when you not only have an intellectual appreciation of something but you also have an emotional response to it. So that your intellectual understanding is in a sense resting upon, or grounded in, an emotional response. They probably have to go together at some level— I don’t think that probably you really understand anything unless you have feeling for it.

In astronomy in particular the experience is nearly always a visual one; we see pictures of things. Sometimes those are graphs, like spectra, but usually we see pictures. But in this particular case, sound presented itself as a bridge. I thought that was another nice thing about this, to employ one of our other senses to gain access to Nature. When you see things you respond in certain ways, and when you hear things, there’s a whole other category of response which is brought in.
As I understand it, at the event there will be two performances of the score. One cold, where the audience just hears the piece, then there will be a panel discussion, various people will be talking, of which I’ll be one of those, so a bit of the science will be presented, and then the piece will be performed again. I’d be interested to know how people respond and feel the piece the second time as compared to the first, because then they’ll have some understanding of the science. My hunch is that that will modify the way they process it emotionally. I think it’s an erroneous but often thought idea that scientific knowledge somehow demystifies and sterilizes nature. I actually think that the opposite happens, that the more you know the more amazing it all is.

To some extent a cosmological story is rooted deeply in all cultures. At all times in history and in all cultures—I’m not sure, an anthropologist might correct me there, it might not be all—but in many cultures that we’re aware of, there are cosmological stories. And they weave themselves in one way or another into the fabric of that culture.

Here we are at the end of the twentieth century and we think we have the real deal. It’s tremendously interesting to see whether this current cosmological story, that the scientific method has somehow teased out of our observations of the Universe, stands up to other mythological creation stories and cosmological origin myths. All of which have, to varying degrees, emotional power, and possibly moral and spiritual power as well.

One really doesn’t want to sound too arrogant about one’s confidence in the modern cosmological story, but it’s on a fairly robust footing right now. It’s not about to go away, I don’t think. In the same way that once the recognition that the earth goes around the sun and not vice versa, once that recognition had occurred it wasn’t about to go away. There was increasing data which
supported that the earth went around the sun. I don’t know whether it’s quite as certain as that, but the hot Big Bang origin of the Universe, in broad outline, is probably as robust as the earth going around the sun. That’s quite a strong statement. But I don’t think it’s about to go away. If you’re interested in the cosmological story of how we came to be here, you’re going to work with this story in some way or another.

*Do you feel like these singers recreating the sound are in a way acting like particles vibrating, resonating the sound of the universe?*

I think if one was to take the largest step back that one could possibly make, then I would say that the singers and all of us are part of the universe and we are recreating what we’ve come to understand was present at its birth. So if you’re willing to see us as pieces of the universe, then in a sense the universe is itself now, through this piece, recreating its own birth sounds.

This is one of the things that the modern cosmological story really brings home, is that we were present back then, in atomic form. My brain wasn’t present, and in fact the atoms in my body weren’t present—they’ve been made for the most part in stars later on—but the protons and neutrons and electrons, they were all present. And they were participating in all of this music. They were only a small player—in the big picture of today’s universe, they were four percent of everything. There’s this big chunk that’s dark matter, there’s a big chunk that’s dark energy, and back then there was a lot of light. So we’ve always been a minor player. When I say “we” I’m meaning atomic matter, our heritage, our lineage. But it was us that
was making the sound. We were coupled to the light, but it was us that was bouncing in and out.

So in a sense what I am doing now is invoking the kind of language that creation stories naturally deal with, and that’s lineage. Where have we come from, in the big picture? Who else was there, what other forces, what other gods, what other laws, were present? And can we find our trajectory back in the bustle of all these other forces and players? And we can. We were this lucky minor player—minor only in terms of the amount of stuff. But we can do things that the other guys can’t do. Like dark matter cannot form dense structures or complex structure. Dark energy is utterly unable to form any structures. Light—light doesn’t form complex things, it’s a medium, it zooms around as individual particles. But protons, neutrons and electrons—they can make atoms, which can stick, which can stick, which can stick, and here we are: big blobs of that kind of stuff. And remarkably—and one can try to answer how this has come about—here we are, able to actually internalize and understand this whole cosmological story. And so what you have is a piece of that stuff back there, fourteen billion years later, figuring it all out, understanding it intellectually and then feeling it emotionally.

So yes, I do actually see a cycle in it in a way. I mean this is the universe as voice, through humans, recreating some aspect of how it was back at the beginning. Yes, we’re integral, we’re part of it all, we’re cosmic beings.

*But we’re very small.*

It’s a nice topic to reflect on our place in the universe. We’re small in many contexts, so first of all, atomic matter is only four percent of the total content of the universe. Four percent isn’t that small but it’s not major. But in terms of dimension, the earth is famously minute compared to any cosmic scale. The earth, just to give you a quick scale, the earth is the size of a virus and the galaxy is the size of the United States. That’s one galaxy. And if the galaxy is the size of this room the visible universe spans the United States. I just did two nested scales there, each of which is mind blowing, incomprehensible. So yes, we’re very, very tiny. But, but—if you don’t put on the spectacles which see size, but you put on another pair of spectacles which see complexity, then our galaxy is essentially invisible. The sun is just so simple compared to a bug, never mind a person. So if you had objects in the universe shine in proportion to their complexity, we would be beacons visible across the whole universe and
the galaxies would be just incredibly dim light bulbs every once in a while. With that perspective we are extraordinarily unusual.
March 19, 2012

James Elliott Shelton, Composer and VCU Music Alum

Practice Room, James Black Music Center, Virginia Commonwealth University, Richmond

What is your role in Score for the Big Bang?

I have been working with artist Ander Mikalson for a while now. For this project I am translating data from the WMAP satellite, given to Ander by astronomer Mark Whittle, into a score. I am taking the pitch information for the composition from the data, using both direct translation and interpretive means. This work will culminate in a performance at St. James’s Church.
How has it been taking that data and translating it into musical form? Were you just crunching numbers?

It’s a blend of crunching the numbers and also taking the data and fitting it to the capabilities of our singers. I figured out which pitches are present in the data and the rate at which they move. All of the pitches are sliding down to lower and lower tones, and the rate at which that happens becomes slower and slower. The last four minutes of the piece are basically a direct translation of the data.

I wrote the middle two or three minutes of the score interpretively, based on discussions I had with Ander about the kinds of sounds and movement she wanted and the feelings she wished to evoke. Ander decided to scrap the first middle section that I wrote and I started again from scratch. We talked a lot about how to approach it the second time. We decided to use modules or fragments that get expanded upon and repeated, taking Terry Riley and Morton Feldman’s use of modules as a starting point. I composed many different one-, two-, three- and four-measure modules with contrasting ideas and material. I took much of that material from the data, abstracting it so that it related to the other part of the score but was not a direct repetition. I sent the modules to Ander and she chose the ones she wanted me to use. I composed the new middle section from there, layering different modules on top of each other and seeing what dovetailed. That is my most intuitive writing in the score.

What is the germ of the piece? What type of sounds are you dealing with?
The score mostly deals with chromatic sounds, all twelve pitches. The piece is almost entirely based on minor seconds and major seconds, and that’s what I explore in the middle section where we move away from the data. The data is entirely chromatic but the pitches aren’t broken up like on a keyboard. Instead, they slide, like in the human voice. Embedded in the chromatic scale is most everything else, so other things have developed out of that material, like exploring microtonal singing—the pitches between notes.

Have you ever done anything like this before?

I’ve composed before but I’ve never composed for this large of an ensemble. Most of my recent compositions are for soloists or quartets, so doing something with a thirty-six person ensemble with organ is a big departure for me. The way I approach composition for the smaller groups of instruments carries over to the large group, though there are some different considerations with a large ensemble. The space the work will be performed in is also something I have to consider. I made many changes based on Rebecca Tyree’s input. She is used to dealing with thirty-six singers and the kinds of

Table 12: Composer’s notes on graph showing pitches present in the early universe
pieces they work with. Ander’s input is helpful as well. Michael, the organist, has helped me better understand the instrument, because I had never written for the organ before or even had the opportunity to play one. It is a collaborative effort. Working this way is a new thing for me, I’m excited about it.

**What is significant about this piece for organ?**

The organ part for the piece is very minimal. It is able to supply some of the information from the data that is outside of the range of the singers. I try to use the organ in a different way than it is usually used, especially in a church setting with a vocal ensemble. The organ can carry itself; it doesn’t need an ensemble with it, but I’m making it secondary to the singers.

**You helped Ander with the previous version with the string instruments. Could you describe how you progressed into voices, what differences there were?**

Working on the string piece was much different than writing for the large ensemble. I wrote it for violin, cello and bass. We were dealing with different data and a different audio file at that point. I used graphic notation and improvisation in that score, but for the large ensemble I’ve needed to make things more clear and precise for the singers. The string composition was more static, while this one has more variation, conventional notation and conventional material. There is a big gap between the two projects. I am really interested to hear the singers and organ complete their rendition of it and compare it to the string version to see the changes that happened between the two pieces.

**How has it been to compose this piece?**

It’s been great, I’ve really enjoyed writing it and I really appreciate Ander giving me the opportunity to do it. It’s also been very stressful and it’s occupied a lot of my time. I’ve had to change the piece a lot. Going from hand writing the score to entering it into the Finale software added another layer of difficulty.

At first I was approaching the score in a mental way, just writing music—I wasn’t even sitting down at the piano hearing it out. Later on I started to work at the piano, scrapping entire sections that I’d written and remaking them. Finally I
started entering the score into Finale which meant I could hear the computer play the music as I wrote it, which is both helpful and horrible.

*Were you influenced by any other composers in writing this score?*

When Ander and I began discussing this piece we talked about a lot of different approaches to vocalization and the ways different composers have written for the voice. We looked at Xenakis, especially *Nuits*, and Morton Feldman’s pieces for voice. Ander asked me to keep in mind Meredith Monk, how she works with improvisation with her vocal ensembles. We talked a lot about Cage. We used those composers as a stepping stone to share ideas and find common ground to build from.

*You just finished the score last night, is that right?*

The piece has been mostly done for a while. But as they rehearse the piece and I get feedback from the singers and Tyree, we see changes that need to be made. When you make changes to one section, oftentimes other things need to be changed as well, to make sure the transitions work and the piece still functions as a whole.

*How was it to hear the piece in rehearsal today?*

It was great. Given that the singers just got back from spring break and it’s a Monday and they’re sight-reading the piece, I thought it sounded really good. I could see the potential today, for the singers and for the piece, and I look forward to hearing it develop. Today I got the sense that the singers felt the score was hard and really weird. I understand it’s a different kind of work than anything they’ve taken on before. I heard some of them say it was difficult, but I think that is good. I want to push the singers.
Interview with a Conductor

April 6, 2012
Rebecca Tyree, Interim Director of Choral Activities, Virginia Commonwealth University
Office 1005, James Black Music Center, Virginia Commonwealth University, Richmond

How did you come to start working with Ander Mikalson?

Ander approached me last fall and it sounded like an intriguing project to express the Big Bang event with the human voice. Ander and I collaborate and work through ideas. Ander and Elliott worked carefully on the score and I bring the choral perspective, determining what can realistically be asked of the vocalists.
I am an editor of the score. My primary concern is to achieve the results that Ander wants, but Ander and Elliott are not as familiar with the capabilities of the human voice. The voice can do a great deal, but there were places in the composition that were unreasonable—out of range or too long. I work to help the singers comprehend and perform a very different type of score. They look at it as music, and it really isn’t music in the traditional sense.

Can you tell us about your job and your background in music?

I’m Assistant Professor of Choral Music Education and direct many of the choirs here at VCU, including the Commonwealth Singers. I teach the choral education majors who will become public school directors and I spent the first twenty-five years of my career in public schools. I taught middle school and high school and worked in choral education and music education. I’ve also directed a semi-professional community choir for ten years: the Fredericksburg Chamber Choral.

Tell us about the Commonwealth Singers.

The Commonwealth Singers are the top vocal group in the Music Department. It is not made up entirely of music majors or voice majors; it is auditioned from the entire university. Of thirty-six singers I think we have eight non-majors. The group is made up primarily of vocal majors, so there are a lot of trained voices and some of our non-majors take private voice lessons as well. They’ve all come from a rigorous background, they read the music and are vocally trained enough to perform at the level that we expect from that group.

This year the Commonwealth Singers is a young group. We had a very large incoming freshman class this year, 2011-12. There are many who are in the group for the first time this year and they have grown by leaps and bounds. They did the Mozart Requiem in the fall and its been a good year of real growth.

What type of music do they usually work with?

We perform music of many styles and genres, from pre-Renaissance up through contemporary writing, classical choral and folk music from all over the world. There are great resources of folk music now. Composers go to very remote places, research, codify, publish, and make available music from all over the
world, such as Finnish and Latvian folk music. There is much really good music available.

How do you choose the material that the Commonwealth Singers will perform?

The most important thing I do is research and find new music, which could be a sixteenth-century piece I’ve never seen before or a score by a contemporary composer. Right now, as we finish up with the Big Bang, I’m already researching the music for next year. That’s an exciting time, finding the right combination of new music to expose the students to. I would like them to have experience in early music, baroque music, classical music—composers such as Haydn—as well as music through the romantic and contemporary periods. In a given year I try to include many different genres, and if they’re in the choir for a couple of years they will have even more exposure.

Is this piece, Score for the Big Bang, different from what you usually work on with your students?

We performed a piece for the ACDA Conference earlier this semester by Karel Husa which had microtonal singing in it. With microtonal singing you’re trying to find all of the tones between a semi-tone, between a half-step. That was perfect preparation for this piece because they were already working on bending notes and really listening to some very different, worldly sounding sonorities—not traditional harmonies at all. There was one movement in particular where they were creating an atmospheric sound, bending the pitches and trying to sustain them a long time. Though not quite as long as the Big Bang [laughs]. When choosing music I do look for the avant-garde, something that’s totally new, not just something that’s harmonious and beautiful. That’s part of stretching the musical mind to be open to different experiences.

I really appreciate this project for these undergraduate students, because they’re seeing that one can have an idea that is ‘out of the box’, and all one has to do is work at it. Ander has collected many people in different areas to help her to make this project. It’s great exposure for everyone to see that, yes, we can all be creative beings.

Working on this piece has been hard for them. Some of them still can’t wrap their minds around it. They want it to sound normal. One student came up and
said, “but these notes have to be held for ten notes and I am used to four or six.” I feel that is growth, the singers articulating why they get lost in the last twenty-four measures of the piece. The creativity of this project is so wonderful, every time Ander talks about the project I get more brought into it.

How did the singers respond to the score?

They were overwhelmed. They were questioning why. When they initially got the scores, some of them thought the patterns were neat, but others were overwhelmed by the unknown. The original score that Elliott hand wrote didn’t even have all of the right beats in it, because of the way he was writing glissandi, so it was really out-of-the-box for many of them. To see so many staves was overwhelming. And we couldn’t say to them “this is what you’re supposed to sound like,” because there is no pre-existing recording. But at the college level I don’t like to provide them with a recording anyway, because I want them to be able to read the score and approach it as a musician. This score was tough. There were extremes in range and in trying to hear the vertical sonorities. Sometimes they were just singing half-step sequences, but it was what they had to hear their note against that was difficult. It was a new experience in training their ears, which we’re still in the process of.

This has been a difficult project for the singers. Some have articulated it to me, and I have sensed it in others. When you are a group leader part of your job is to sense; every second that I’m in front of a choir I’m asking for a response. I’m
constantly scanning to see that they’re hearing what I’m asking them to do, that they’re absorbing it. When we’re in the middle of rehearsals I can sense when they are exhausted, when they’re detached and when they’re confused.

Ander has been at every rehearsal and that’s been very helpful. At times that we needed a little ‘oomph’ I would always solicit a response from Ander, and ask her, “well, what do you think?” because they would forget for a moment. When you’re in a rehearsal for seventy-five minutes sometimes you forget the purpose. And I wanted to remind them that this was a creation, this was something new, this was an opportunity to participate and collaborate with the composer, with the idea-person. That usually would re-engage them.

*Is the score difficult for them philosophically or technically?*

The hardest part physically is the section of sustained notes, which is the last twenty-four bars, about the last four minutes. One singer, a non-major, asked me how to start on the high C, so I had a collaborative discussion with all of the sopranos about how each of them would approach it. Voice is such a difficult instrument and it’s going to be different for everyone. I can tell you to try a certain technique and you will perceive it differently from everyone else in the room, you will do what you think I intended for you to do, and it may work and it may not. I could say it slightly differently and it may suddenly make perfect sense and enable you to sing a high C with ease. So I have brought in a lot of different techniques to try and help them with the difficult technical aspects of the piece.

I was problem-solving all the time. On my way to work I would be thinking, “OK, this is what needs to be fixed next, and how can I come up with other ways of approaching this that will make it easier for the singers?” The writing is a little treble-heavy. The

![Image 14: Rebecca Tyree (behind piano), Elliott Shelton and Ander Mikalson edit the score](image)
basses don’t come in for the first thirty measures. They get to make white noise at the beginning and that’s fun, but they want to sing. And they’re just sustaining notes for most of the score.

Last week there was such fatigue I had to stop. They were so spent when they got halfway through the last twenty-four measures. I heard it in their voices and saw it in their faces, and I stopped because I wasn’t going to hurt them. I felt it from everybody in that room. But there was not any whining about the long, sustained notes today. You still hear the fatigue when they’re winding down. It’s not necessarily correct, but it’s normal for singers to get softer when they get lower. It’s much harder to be loud on a low note than it is to be loud on a high note, that’s just an acoustical phenomenon.

Did you encounter any ideological resistance?

I made a disclaimer early on about the type of project this is, because I know there is a very diverse sense of values, religious and spiritual, in that group. I tried to talk about the cross-disciplinary aspect of it. I sensed a little bit of resistance before I made that statement. Some of the older students and some of our non-majors, interestingly, have been really engaged in the intellectual aspects of it, and that helped those who didn’t understand.

I love the fact that when Ander presents to them and makes her statements she says clearly to them: we have the science now. That’s just where we leave it. That’s just where we leave it. And that’s what Mark Whittle said in his interview.

What is the rehearsal process like?

When I teach a new piece I pick it apart. If you’re doing, say, a Mozart mass, with a group of this caliber you can read straight through it and they get a gist for the whole piece. The Big Bang score is overwhelming and was constantly being rewritten, so I chose to teach it in three sections—the beginning, middle and end. I planned the first rehearsals so that at the end of each one they would have a sense of what was going on in each section.

Usually when I start a piece of music I know what I am going to have it sound like, and that was not the case with the Big Bang. This was a creative process
where they helped create and rewrite this score. Sometimes we would say, “OK, that didn’t work and you’re going to get something new on Monday.”

When you’re rehearsing something of this difficulty and using creative rehearsal techniques, one can hope that the singers will then apply those techniques in the practice room. Ander wanted them to memorize the score because originally we had talked about doing a lot of staging and movement, but it just got to be too difficult for them. The only staging we are going to do is the movement between groups—I’ve grouped them for each section of the score so that they can best hear their part, that’s how difficult this music is. So the staging was arrived at through the process of learning and rehearsing the music.

We had less than twelve rehearsals over five weeks. When you consider it’s only a ten minute piece that sounds like enough time, but not when you consider how difficult it is and that we made constant revisions. If we’d had it in its current form from the very start, with the most recent revision that we made on Monday, rehearsals would have been much different.

*What were the little pieces of paper that we saw in rehearsal today?*

The students did not want to memorize this piece. I told them Ander doesn’t want a folder of music between you and the audience—we’re trying to create an experience. So I came up with a compromise, that they could have an index card, and they could write anything on it that would help them memorize it. Today they were using those in rehearsal.

It’s interesting how the singers analyze the score. I keep telling them, you need to think about this analytically, scientifically and mathematically. I made a chart of the last section in an Excel spreadsheet, that showed the notes and the parts, so you could read it across and see it more clearly. This helped me conduct it and memorize it.
It’s interesting what they chose to put on the index cards—they are all vastly different. Which goes back to what I was saying about how I can say the same thing to a class of thirty-six and each one of them is going to hear it differently, because of the way we learn and process. That’s human nature, and that’s the lot of a teacher, to have to be so clear and describe the same thing in many different ways so that the thing you have in your own mind can actually be received by your students. That was a good process for them because it made them codify and analyze. I find it fascinating to see how they learn and process.

*Has working on this project caused you to reflect?*

I am fascinated by the science behind it too and I look forward to meeting Dr. Whittle and following up with the documentary and his lecture at the Science Museum. It makes me want to do some reading and know more.

Today in rehearsal I started to hear some if the atmospheric sounds that I know Ander wants and that intrigue me tremendously. I would like the entire thing to be atmospheric. The youth of their voices is a factor—if we had thirty-six professional singers it would be different and we could play more. I’m looking for the sounds that take us away. I’ve had the pleasure of directing a classical Haydn performance, where I was taken out of my body when I was in the middle of conducting (luckily I brought myself back). I’ve had incredible experiences with contemporary performances where it was more of a soundscape, where there weren’t words, where we were creating sound. That’s what this piece is,
that’s what I’m looking for, that’s what I’ve been imagining as I approach each day in rehearsal.

*What was it like for the singers to be collaborators and have input in the process of writing the score? Was that a challenge for them?*

There was a good attitude and atmosphere with them in that regard. I never sensed when we revised something that there was any resistance. The singers have been open to the process. I think they understood because of the way Ander and I presented it to them—that this was a process that they all got to be a part of. Some contributed more than others. They love being a part of that group. They have a sense of camaraderie.

I tend to run rehearsals a little more collaboratively than other choral directors. I want the singers to feel like they have ownership. I do usually know what I want with a piece of music. But take a very simple piece of music, which is absolutely beautiful: *If Ye Love Me*, by Thomas Tallis. It’s a renaissance piece, a capella, absolutely gorgeous, defined, very simple. I’ve done it with large groups, I’ve done it with four voices, and every time, even though I know the phrasing, it changes—because of the sound of the group, because of the degree of flexibility of the phrase.

That’s what is so neat about creating sounds with choirs. It’s good for them to be open and see that things can be flexible and shift. I want to make music. It ceases to be art if you do it the same way each time. If that’s what you want, press “play” on a CD player and hear it the same way over and over again. This piece has shown them flexibility and led to growth. It makes them take a
different approach. We still have a ways to go, but they’re getting more comfortable in their own skin.
Ander Mikalson:

The first time I came to class you all had just finished your concert at the American Choral Directors Association Conference and were reflecting about that experience as a group. I was moved by hearing your thoughts and would love to hear how *Score for the Big Bang* was for you.

Rebecca Tyree:

I could start out by sharing comments that were shared with me by audience members who enjoyed the cross-disciplinary aspect of the work, the mixture of science and sound. Sound *is* science if you look at it from an acoustical perspective.

I was personally moved by how you became absorbed into the sound you were making—that’s what changed. All of a sudden you were a part of it and it became a part of you.

It was a huge challenge, to sit there for over an hour without any warm-up, and all of a sudden to perform it again, especially with the demands of that piece. I was amazed by the effects that it had on your audience, and how moved they
were. Dr. Whitmire [Music Director at St. James’s Church] thought it was phenomenal, he was so impressed that even when you were down in the sanctuary, when the organ came in you were perfectly in tune. You had all types of ears listening and all types of beings receiving what this project was.

I applaud you for persevering and making it happen. I remember when I taught high school and middle school, and maybe you can think back that far, to when you got a piece of music that you didn’t like. And your teacher dug in because he or she believed in that piece of music or had chosen it for a specific reason, which is what happened here. And at the end, at the district concert or assembly for the whole school, it was so well received. You never know until you just go after it.

Morgan Britt:

I personally found it difficult when I approached this piece like I would any other piece of music, where you sit down and learn it. I found it was a lot easier when I stopped thinking of it as a choral piece and I started thinking of it as sounds, and assigned different sounds to different mental images. I loved the lecture in the middle of our performances. I was sitting there with rapt attention. That’s not something we think about a lot as musicians, this crazy astro-physics stuff, where we come from. I liked being exposed to that.

Gianna Barone:

At first it was really hard because we were coming off of this high from our ACDA concert. We felt like, “We’re singers! We sing music!” [laughter] And then we get this piece and we’re saying, “I don’t
know what this is. I’ve never done anything like this. It’s scary. I can’t look it up on youtube.” [laughter] We really could only do it together, which was really cool.

I got a lot of feedback from people in the audience who were saying it was one of the most meditative experiences of their life. The second time, after hearing all these things and seeing the circle that represented the universe, I realized, we’re just a little tiny thing that doesn’t matter, but we really do.

Vanessa Naghdi:

Going off of what you were saying about how you can’t listen to it on youtube—I thought it was really cool being part of something that had never been done before. This was a premier. Now we have this recording and maybe other people will want to do this, as a choral work, as something to show. I also got a lot of great feedback about how amazing the atmosphere was, which is what it is. It’s not like a song or a musical work. It’s really about the ambience or the atmosphere that it creates for the people who are experiencing it. I got a lot of great feedback on how it made people feel.

Jesse Horton:

I was surprised by how emotional it ended up being. When I first approached it, the concept was very scientific and very artistic. The way the concert was set up, having us first perform it and then talk about it and then perform it again, it was kind of like putting the audience through the same experience that we went through. Because when
we first got the music we thought, “What is this? I don’t know how to even deal with this right now.” You hated it some days and you loved it other days. Going through it, learning more about it, seeing all of the research and work that went into it, you get so emotionally invested. By the time we performed it that last time in the balcony, I’d never heard it that way. It was a completely different experience from any other time we performed it. I’d like to think that was what the audience went through as well.

Lydia Fisher-Lasky:

The first time that I genuinely enjoyed singing the piece at all was the second time we did it at the concert. [laughter] I mean, I understood it and I appreciated, but it wasn’t until then that I suddenly thought, “I really like singing this!”

I wasn’t expecting to feel that. It was especially weird since I had been sitting there for so long and I wasn’t warmed up, and I was thinking, “this is going to be a disaster.” And then, for some reason, the performance that I was most worried about and thought was going to go badly was the best time that we sang it. I don’t think that usually happens in choral music. Usually if you sit there for an hour and then you sing it is not going to come out well. Yet that was the best time for us. I thought that was really cool.

Malcolm Jones:

I’m not going to lie, when I first heard we were doing something about the Big Bang I was skeptical. I had the same response as everyone else: “What is this?” I found it difficult to sing with it, but when I sat out once and listened to it I realized, “Wow, this is really good.” It finally clicked in my mind and I knew what I was doing.
Caitlin Costello:

I agree. I didn’t really appreciate it until I sat out and didn’t have to think about my part and was able to listen to it as a whole. I thought, “Wow, this is what we’re doing and the sound we’re making, and this is what it’s supposed to sound like.”

When we first got the music and hadn’t yet done any collaborative work on it, I came at it as a musician. I thought, “OK, 10/4 time, I’m not going to be able to breathe, but that’s OK, a lot of times I can’t, I’ll figure it out…” [laughter] But after the collaboration it was different. Ander talked a lot about collaboration. It was important for Ms. Tyree to be able to show her the musical perspective. We were able to adapt it, and we started to appreciate it more as it got easier for us to do because we understood it more. Maybe the situation wasn’t easier but for you, Ander, since it would have been something that you didn’t really understand in a musical sense, but after putting it musically, we understood it more. Everybody understands in a different way.

Alex Harper:

We were approaching this piece like it was music, and it is music, but I think it has a lot more in common with art, specifically with visual art in the last fifty years. Music gives you a clear-cut definition about how you should feel about something. It tends to evoke certain emotions, based on whether it’s minor or major. But this was more like art, in that you can stare at it for hours and get nothing but mixed feelings. There were also mixed emotions in learning it, as Jesse said, some days you hated it, some days you loved it. I
learned so much from constantly dealing with these textures that are unlike anything that we've ever sung before.

Josh Lambert:

I really like it from a scientific perspective. I am not a music major, this is my only music class and everything else is science. I go into physics and chemistry, and we talk about things like the Big Bang in class. My professors explain, this is the calculated, mathematical way the universe evolved—but we experienced it. My boring biology professor will drone on in a monotone for three hours about how the universe came along. But singing it for ten minutes created a deeper understanding than the whole last semester of sleeping through biology class. [laughter]

Some of my family members came to the performance. Both of my grandparents are Presbyterian ministers. I told them, this is what we're singing, and Pops went on this whole schpiel about how he completely disagrees with the Big Bang, which we’ll not get into. [laughter] When we finished singing it I went downstairs and he looked at me and said, “Even if I think the science of it isn’t accurate, that was an awesome experience.” My grandmother called it celestial, which I thought was a great way of putting it.

Sara Tyer:

The thing that most surprised me about the performance was how I got into character for it. For most choral performances you have a character behind it, like for our piece Didn’t my Lord Deliver Daniel you’re a spiritual singer. But with this piece I didn’t have a way to connect with it as a character, I was just singing notes. But
then the performance started and I was sitting next to my boyfriend and I started blowing air and he was shocked. [laughter] You could tell everyone was thinking, what is that? All of a sudden I felt like I was a neutron or something. It was like I was taking people into this experience and it was really exciting because I was a character, I was like an element. It was really exciting to experience the piece that way.

Michelle Nuckols:

It really was an experience, it wasn’t just a song. Like Sarah said, you have a character, or a story behind a song or a specific emotion you’re supposed to convey. Singing those kinds of songs is an entirely different kind of experience. It was harder to connect with this piece because there’s no obvious melody and no words really, but that’s part of the character. It was harder to invest emotionally, but you still managed to all do it, especially by the second performance.

I’ve always liked the concept of this song because I’m a science major as well as a music major. I thought the idea was cool but when I actually saw the song I was stubbornly trying to still like it even though it was really hard and frustrating to practice. In the church I could feel the reverb kicking in and the whole place was vibrating like the beginning of the universe.

Kelsey Snyder:

Getting introduced to this piece as the Big Bang created a lot of different emotions, because a lot of people have different views about the theory and the science behind it. I know that I personally went into it
with a hard attitude, like I wouldn’t let it in. It was so scientific, and we as singers and as musicians rely so much on an emotional connection to music. We just want to have something to connect with what we do. This was different because it happened millions of years ago and it was more scientific than emotional. On Wednesday of last week was when it first clicked for me that we were painting a picture with sound. When we all got comfortable with our notes and we knew where we were going with the music, that’s when it came alive as more than just a scientific idea.

Michael Marino:

I was always kind of skeptical about how we were going to begin the piece by sitting in the audience, but that worked out way better than I anticipated. It created the atmosphere for the beginning of the piece. It was quiet in the hall and there was that anticipation of, when is the piece going to start? And then everyone realized it had already started.

There was only so much work you could do on this piece as an individual. That was one of the things that made this piece much harder as an ensemble, because we only have an allotted amount of time per week. There was a period when people mostly knew their parts but we hadn’t had the time to put it together. I was frustrated with how it sounded as a group. I was thinking, what am I doing, what are other people doing, what isn’t working?

Then Ander spoke in class about some of her philosophy behind the piece. That yes, it is very hard, and might be impossible, and maybe that’s kind of the point. It is a representation of us trying to know everything and gain all of the knowledge about the universe, but maybe that’s impossible. That’s when it clicked for me and that’s when I stopped singing the piece as an attempt to make it perfect and more as just adding my part, and that’s what makes it what it is. That’s what made the piece for me.
William Conn:

I want to share two contrasting perspectives from audience members that really come to the same viewpoint. One is from one of my housemates, who is a huge science geek and a psych major. He came into the event knowing a little bit of what it was about, but he didn’t quite understand the first performance. He was enraptured by the lecture and the entire dialogue that we shared and when it came to the second performance he was completely overtaken by its meaning and by the sound of the choir. He told me that he had a new appreciation for choral music because of this performance.

The other is a member of my church choir at St. James’s. She is ordained in the Episcopal Church and she went to college at the Washington National Cathedral. She sent me an email shortly after the performance thanking me and us for the opportunity to hear this. She said it was a fantastic evening, the music was beautiful and inspiring. She’ll never hear choir the same way again. She loved the presentation and though the event was on the cutting edge of theological exploration. She wrote, “thank you for a deeply moving evening.”

Gianna Barone:

Everyone keeps using the word “scientific” and that cuts emotion out of it. But to me it was extremely spiritual. It was about where we all come from. It was the basis of all of the songs that we sing that have emotions in them. We wouldn’t have emotions without the Big Bang and we couldn’t do this by ourselves.
Jesse Horton:

I approach choral music completely differently than I approach the art I make in my other classes. I look at a piece of music as an instruction booklet, like a blueprint for the art that has already been created. But this piece has been constantly changing and going through the process taps me into the artist’s mind. It’s a completely different experience. The process, for me, is almost everything. To be a part of the labor, research, and emotional ups and downs, brings together what I most enjoy about art and music. It really was a phenomenal experience. We’re probably not going to experience that kind of process again for a very long time, if ever.

Rebecca Tyree:

I would hope that the process of collaboration, realization and adaptation that we went through could be transferred into your approach to all types of music. From the beginning this brilliant young woman got me because of her creativity and how she was thinking out-of-the-box. This was a chance for all of us to engage. Know that every experience that you have in life is built on previous experiences. I'm hoping that this can open up a more creative spirit as we approach your classical pieces so that we can be more open, and we can realize that as singers we are artists. You do the research, understand stylistically how it was written, how it was performed, but then you become an artist by putting your own edge
on that. Then we are artists, we’re not just repeating the dots on the page. Thank you for that. Any creativity that you allow into your being will open doors for you and open your mind to the possibilities.

Lauren Swisher

I knew that I would eventually enjoy it and would get into it, but I was worried about how the audience would take it. I had a friend there who hasn’t been to one of our choral concerts and I was nervous for him and for my parents that they would say “that was cool” but wouldn’t really be able to enjoy it or get into it. But it surprised me that they really did get into and enjoy the whole meditative process. I think we need to continue to broaden horizons.

Mara Smith:

I liked this piece from a conceptual place. We were all excited by the ambition of the project. It seemed lofty, like something we needed to go after.

This piece made me think about the universe and all of these things that have been surfacing in me, with where I am in my life right now. Being able to express that with my own voice made me feel not only like part of the choir but also part of the universe. Sometimes when you’re just going about your life you forget your time and place and everything that’s come before. This was a way of being in the present, looking back and looking forward at the same time.
Alden Bean:

For me as a musician this piece was like a palette cleanser. You couldn’t approach it using the predictable nature of music, the patterns that you can rely on to learn your music. This piece washed out your ears and made you listen for things that you wouldn’t normally be listening for.

Lydia Fisher-Lasky:

Relating this concert to choral experiences that I’ve had before, one thing that was really interesting to me was how the audience connected much more to the performance because of the presentation in the middle. We usually spend this huge amount of time in rehearsal having this incredible process and for that reason the performance resonates more for us than for the audience. They get just the surface of what the choir felt emotionally in their performance. I’ll go through a really emotional performance and my parents will say, “that was pretty good.” And I’m like, but that was everything! [laughter]

With this piece the audience got insight from having the presentation show how we collaborated and turned the score into something else. It was really cool to me that the audience could get almost the same experience that we did just from this one concert.
Savannah Berry:

When I first heard the concept I was fascinated by it. I love science. I’m not a science major but it’s a hobby of mine.

What really surprised me more than anything, especially the second time we sang it at the concert, was how something so scientific became so spiritual. It was probably one of the most spiritual things I’ve ever experienced. No matter what anyone’s beliefs are they could still feel the spirituality of it.

Josh Lambert:

We’ve talked a lot about how this is not traditionally musical. But one thing that I did really enjoy about this from a musical standpoint was the process of creation. I’m used to being given a final piece of work with the message, here, this is what the composer intended, you just have to interpret this and possibly do things minutely different from what they wrote. But with this piece, we showed up to the dress rehearsal and Ander said, “oh, here’s a couple of pages that we’re changing.” [laughter]

I liked being part of the creation of this piece of music. This isn’t just a
traditional song written in four parts where we get up on stage and sing and everyone says, “wow, that sounded great, you guys are an awesome choir.” This is innovative musically and scientifically.

Caitlin Costello:

Everyone is saying, “this experience was…” But this experience is still going on right now. I mean, I’m still confused about whether I really liked it or not. [Laughter] Like Josh said we’ll be part of the experience for the rest of the time that people recognize it.

I don’t think that I would have been as involved in the piece as I was if it wasn’t for the amount of passion that Ander had for it. Her being here for rehearsal and us being able to watch her and Ms. Tyree say, “Do you want to do this? Well do you want to do this? Well I’m not sure.” We saw that she could be just as confused and taken aback as we were. It’s relatable and it’s great to be able to relate emotions towards a song.

I don’t stop to think about the universe very often. I’m not very scientific, I don’t really understand a lot of it. But now I think I will. I mean, if Ander can sit down and research it for two years there must be something interesting about it. [laughter]

Kelsey Snyder:

The ending, I’m pretty sure, every time we did it, was different. [Agreement, laughter.] That’s really what made it so alive. We don’t know exactly what it sounded like back then, nobody does.

Gianna Barone:

We don’t know what it sounded like on Friday night! [laughter]
Ander Mikalson:

This work wouldn’t have been anything without you all. Thank you for your investment, your energy, your insight and your emotional connection to it. You made it what it was. It wasn’t me, I handed it over to you.

When I used to make paintings, it was just me and the painting and I could step back from the work and look at it. But this work I didn’t make by myself. Yesterday I was depressed because it was over and I didn’t know if it had been something valuable. Now I feel like I understand it, I can know it because you know it. I couldn’t make it alone and I can’t see it alone. I have to look at it with you all.

Michael Marino:

You said that you handed the piece over to us, but I think most people would agree that there is no way we would have been nearly as invested in this piece if we’d just been handed a final score and told, here, sing this. You being here really added to the entire process, your drive gave us our drive.

Ander Mikalson:

Thank you for collaborating with me
Interview with an Artist

March 18, 2012
Ander Mikalson
Studio 310, Fine Arts Building, Virginia Commonwealth University, Richmond

Can you talk about yourself as an artist and what you try to accomplish?

I work in sound, drawing, sculpture and performance. I work in the medium that best conveys my idea; no way of working is off limits to me. Most of my works deal with some kind of translation, like in *Score for the Big Bang* I’m translating data through the human body and the human voice. It could also be that I’m translating my dream into someone else’s dream, as in a recent project called *Dream Assignment*, or translating the soundtrack of a film into a score that is performed live, as I did in *Score for a Cyclone*. 
So you wouldn’t call yourself just a painter, or just a sculptor or just a sound artist—you like to make work that is specific to an idea.

Yes. I come from painting. I’m in the Painting program here at VCU currently because the work that I applied with was all drawing. But I’m dealing with ideas that I can get at more directly with other mediums.

Where did the Big Bang project originate?

It depends on how far back you want to go. The idea for this project originated about three years ago, but I’d been working with ideas from physics since high school, over ten years ago. My first oil paintings were these shaped canvases where I was trying to express the idea of extra spatial dimensions. So this is something I’ve been trying to get to for a really long time, and I feel like I’m only just now starting to get somewhere.

The idea for this specific project began about three years ago when I was reading Brian Greene’s book Fabric of the Cosmos. I was reading about this concept that space is expanding faster than the speed of light. There’s this idea of a horizon of light, beyond which there is a vast space that has never seen light before, where the first light from the Big Bang is just
I wondered if there was also such a thing as a horizon of sound, where the first sound is just now reaching. Of course there is no such thing, since there is no medium in space for the sound to travel through. But that question led me to physicist John Cramer’s and astronomer Mark Whittle’s research on Big Bang Acoustics. I learned that the Big Bang did actually produce a sound.

How did your previous projects relate to this one?

When I first came across this idea of the sound of the Big Bang I knew I wanted to make a work with it somehow. Researching the first sound led me to the first sound recording device, the *phonograph*, which was invented in 1857 by Leon Scott. It predates Edison’s phonograph, so it couldn’t play sound back, but it could record sound as image. It was the first time that sound had been

*Image 19: Score for a Cyclone (Musical Accompaniment), 2011, Component of live performance, Graphite and colored pencil on paper, 11 x 17 inches. In collaboration with Alex Hayden*
made tangible in any way. Now we look at wave forms all the time, but this was the first time that sound was plucked from the air and made visible.

I was interested in trying to conflate human history with the history of the universe, to put these things on top of each other. So I set out to recreate my own phonograph. I worked from the original 1850’s patent manuscripts translated from the French. Eventually I built a functioning device on which I could record the sound of the Big Bang—the first sound on the first sound recording device.

Those recordings were really beautiful, these intricate smoky drawings. I was really fascinated by the content in them, that these were actually recordings of the primordial sound—but that wasn’t necessarily apparent to the viewer. So I was still determined to work with the sound

Image 20: *Phonograph*, 2010-11, steel, plaster, wood, sheepskin and paint, 62.5 x 30 x 60 inches

Image 21, left: *Phonograph sound recording in progress*, 2011

Image 22, right: *Phonogram, Sound of the Big Bang*, 2011, smoke on paper, 26 x 11.75 inches
That’s what led me to approach a composer and talk about translating the sound into a performable score. I wanted it to be a score for voice from the very beginning, but the composer that I hired, James Elliott Shelton, told me that the translation would not be very accurate that way, because human voices can’t do those long, sustained, precise descents in pitch. String instruments are best suited for that kind of thing, so we ended up writing the score for violin, bass and cello. That score was performed at my candidacy exhibition about a year ago.

With that work I was really pleased with the act of translation. The idea of the primordial sound is so amazing but the computer renderings of it aren’t really. I felt they didn’t live up to the potential emotional qualities of the sound of creation—they’re generated by computer and they sound that way. By contrast, the sound of the string instruments was much more warm and complex. But I still didn’t feel like the work was finished. For one thing, it was a rather polite performance. We have three
musicians sitting in chairs and even when they are all playing at full volume it is
still not an imposing presence. Whereas the actual sound of the Big Bang was
120 decibels, as loud as a rock concert. Also the sound was still being
mediated, not by computer but by these Western musical instruments that had
all of these connotations that I didn’t want to be part of the content of the work.
I wanted to deal with the sound more directly, to have it processed through the
human body and performed with the voice.

I started doing vocal tests with a couple of singers and realizing that those
problems—that they can’t do these long descents in pitch, that they can’t be
super precise, that they have to take breaths—that they were actually very
interesting and part of the content of the work. Most of my work deals in some
way with futility, attempting to sing the sound of the Big Bang—it’s impossible.
Attempting to understand the idea of the Big Bang—it’s inconceivable. So I felt
it was actually good that the singers can’t do it.

How did you first start working with Dr. Mark Wnittle?

I had been working with Mark’s research for a couple of years before I finally got
up the nerve to contact him. He is a professor at the University of Virginia in
Charlottesville, which is just an hour away, which seemed like just too lucky of a
coincidence. Here I was, working with this person’s research and totally
obsessed with his work and he was so close. So I put together an email
explaining the work with the phonautograph and string performance and telling
him that I’d just really like to meet him and talk with

How has it been working with him? I’ve heard you say that he is very much a
collaborator.

I think of myself as a realist, so I’m not a plein air painter sitting in front of the
landscape painting the mountainside but my subject is Nature. I’m not
depicting Nature in image I’m depicting it in sound, and it’s not a sound that can
be easily comprehended simply by listening to it. So in order to understand my
subject, in order to render it, I need an expert to tell me where the sound comes
from, what it means, how it originated, why it sounds the way it does, how we know about it. That’s where Mark comes in.

Did you just use his research or is there something more active going on?

We’ve had many conversations, I’ve visited him in Charlottesville for meetings and to attend some of his cosmology lectures, and I’ve shown the score to him as it’s developed. The wonderful thing about working with him is that I think he understands that I am trying to be accurate to the sound, trying to be accurate to Nature. But not only in terms of scientifically, technically or empirically accurate, but that I am interested in an emotional or poetic accuracy of meaning.

I say that he is a collaborator because he hasn’t just explained the science to me but he has actually made new sound renderings for me according to the parameters of my project. He uses a computer to generate a rendering of the sound based on the data, and he can set the parameters to be within the human vocal range. We’re already raising the sound up by several octaves so that it can be audible to the human ear. So he is then tweaking that slightly so that it is also within human vocal range.

He has also done some more creative things like narrowed the harmonics and made this rendering where, as the pitch descends past each note on the Westerns musical scale he’s articulated the note so it kind of sings out at that moment. That was the most beautiful rendering of the sound that I’d ever heard and he was pleased with it as well. And that idea has found its way directly into the score—we have solo voices articulating those notes as the rest of the singers are glissing past them. So he has been as much of a collaborator as Elliott, Becky or any of the performers.

So there is the Big Bang, this thing that actually happened, and then there is Mark’s research, then there is this translation of his research, then your translation—how does the sound of the Big Bang change throughout, to this realization in your project?

The sound of the Big Bang that we can hear in a rendering on Mark’s website or in podcasts and articles about the acoustic period is already removed from what the actual sound sounded like. One of the reasons why working with Mark was
so important to me is that I wanted to have a really clear understanding of how closely related my piece is to its source. The event wasn’t only comprised of the performance but also included a lecture and discussion with Mark, so that my audience also had a clear understanding of where the sound is departing from its source.

Mark talks about his rendering as being analogous to listening to a concert on the radio that is happening across the country. We’re not hearing the concert itself, rather the sound from the concert is being transmitted through the air as radio waves and then picked up by our antenna and re-rendered as sound on the other end. The process of listening to the sound of the Big Bang is similar in that we are not listening to it directly or holding a microphone up to the sound—we are seeing the sound waves in the Cosmic Microwave Background Radiation and then using a sophisticated computer program to render the data as sound. It’s a 400,000 year long sound that we listen to compressed into a few minutes. It has also been brought up by fifty octaves to be in our audible hearing range.

The various sections of my score adhere more or less to the actual sound. The piece includes more interpretive passages, but there are other parts that are closely matched to the true tones and dynamics of the primordial sound. The performance starts with a wind-like hissing which is inspired by the quantum noise active during inflation that was ultimately responsible for creating the primordial sound.

*Why do you want to have the work performed in a church?*

The decision to have the performance in a church is one of both content and form. Formally, it is really important that there is a church organ. As Mark has told us, the organ is the best metaphor, the best instrument to represent the kind of structures that were
producing the sound in the early universe. The organ pipes can represent those denser patches of dark matter that the pressure waves were falling into and bouncing out of again. Also, the church has amazing acoustics.

There is a recital hall on campus that also has great acoustics that was available to me, and would have been a lot easier to rehearse in and procure for the performance. It was an intuitive decision, imagining coming into the space as an audience member and coming into a concert hall. The kind of expectations and associations one has with that kind of space didn’t seem as right for this piece as coming into a church. I looked at a lot of different churches and synagogues. I was looking for that feeling of contemplation, of connecting with something larger than oneself.

*Could you talk about science and religion—you seem to see them in one way as together and in another way as apart?*

Some people have asked if I am having the Big Bang sung in a church as some kind of political statement, pointing to an animosity or adversarial relationship between science and religion, especially surrounding creation. That wasn’t my thinking or my approach. Rather I am thinking about these basic, fundamental questions: Why are we? Where are we? What is it like to be? Science is one way of answering those questions and art is another and religion is another. I see them as all coming from the same place and having very much to do with one another.

This last summer I visited the Teotihuacan pyramids in Mexico. I thought it was going to be this cheesy tourist thing but I ended up having a profound experience there. These pyramids are incredible sculptures. They’re all built around the system of the calendar, which was the science of the day, their understanding of the way that nature was structured and the way things work. And they were also where everyone would go to worship. I saw all of these elements conflated or connected in one place. In our culture they’re more separated out. Of course science, art and religion are very distinct ways of investigating and answering questions but they’re also fundamentally connected by a human yearning to understand the world and our place in it.

*Does working on this project empower you? Have you had empowering moments while working on the project?*
This is the largest scale project I’ve ever attempted. The last time I counted there were fifty-three people involved. The thirty-six performers, the composer, the conductor, the scientist, the organist, the audio engineer, everybody. I feel like I’m the hub of a wheel with all of these spokes coming out. Now that the score is almost finished and we’re coming to the point of rehearsing and performing, it feels like my job as the artist is now to let go a little bit and become a creator of a culture and of an environment, rather than a creator of anything material.

I’ve created this structure. I’ve chosen the people that I am working with and I trust in those people. I know that there is a wealth of intelligence there and I just have to encourage it to flourish. I’m going to be at all of the rehearsals to encourage the performers and director to share ideas and make changes as we go. I’m leaving room for everyone to have a voice and for things to happen.

This dialogue that has developed with Mark has been incredibly empowering because I had felt timid about this material. I felt like maybe I didn’t have a right to it. I was worried coming to him that he would think it was uninteresting, unimportant, frivolous or, worse, disrespectful. His valuing of my work, his interest in it, has made me feel confident about going forward and making it a large scale, full-force effort.

*Can you talk about the lyrics?*

Some of the points of reference for this work are the conception of cosmic sound throughout human history. For example, Pythagorus’ notion of a “music of the spheres.” Or in the new testament the creator of the Universe is conceived of as an utterance: “In the beginning was the Word, and the Word was with God, and the Word was God.” In Indian musical theory they conceive of two kinds of sound: *Ahata Nada*, the struck sound, that is the sound that we can hear and feel manifest physically; and *Anahata Nada*, the unstruck sound, which is the Pythagorean equivalent of the music of the spheres. We’re told that *Anahata Nada*, the unstruck sound, is actually a concept in the mind of God, that these unstruck vibrations are like an abstract mathematical concept in the mind of the creator of the universe. In Hinduism, in the Vedic tradition there is the conception of *shabda*, which is the omnipresent sound from which all the universe originates. *Shabda* also refers to the spoken words, the “ohm,” as mantras. Their scriptures say ‘only sound qualifies space’. In the Torah the creator of the universe is described as ‘a still small voice.’
Some of these references found their way into the score as lyrics. I wanted the score to contain all of the different kinds of sound that I imagine are innate to human beings: the lullaby, the prayer, the song, sounds of joy and pain, and sounds of communication. It was important to have very specific word-like sounds in the piece but I didn’t want them to necessarily be discernible or recognizable. So even when we are including phrases in English I asked Elliott to make them fragmented in parts. In breaking up the sounds I was thinking about Morton Feldman and Meredith Monk.

“A still small voice” is perhaps the most recognizable phrase in the piece. This phrase served as a point of departure for Elliott and I in composing the score. Despite its name, the Big Bang wasn’t a loud cacophonous explosion. It began as this very high and quiet sound and then gradually got louder and more intense. “A still small voice” seemed so apt and profound, both accurately describing what is happening scientifically and expressing the awesome, quiet, infinite feeling we have when we contemplate the origin of the universe. That is how I conceived of rendering the Big Bang as a single solo soprano voice doing a kind of siren wail. I was also thinking of the Doppler effect, the way a sound is heard by someone stationery as it moves through space. I tried to achieve that kind of sound with the solo soprano part to create a sense of space expanding.

Is this your way of trying to understand the Big Bang or quantum physics or is it just an experiment?

This is my way of getting to know the Universe. Perhaps the function of human beings is to wonder and marvel at the Universe. Without us here, all of this beauty and logic would go unwitnessed. We are pieces of the Universe who
I do try to understand quantum physics but I don’t feel like I have a grasp on it. I think it was physicist Richard Feynman who famously said “no one understands quantum mechanics.” Quantum physics is so counter intuitive. The nature of reality is much different than what my senses can tell me about it.

To use the metaphor of Plato’s cave, in the last fifty years physicists and cosmologists have turned from watching the shadows on the cave wall to beginning to actually turn around and glimpse the flames themselves. We are starting to understand the nature of reality, and it is bizarre and astounding, so different from the reality we perceive in our everyday lives. The abstract concepts found in the new physics live easily in the abstract language of mathematics. But to understand what they feel like, what they mean to us, we turn to other means of abstract communication. We turn to music, dance and art. The task of describing the indescribable and expressing the ineffable falls to poets and artists. I hope that I am taking up some small part of that task with this work.
Appendix 1: Event Program

Program for April 13, 2012

SCORE FOR THE BIG BANG
THE UNIVERSE AS VOICE
BY ANDER MIKALSON

COLLABORATORS
James Elliott Shelton, Composer
Dr. Mark Whitte, Astronomer
Rebecca Tyree, Conductor
Michael Simpson, Organist
VCU Commonwealth Singers
Adam Bailey
Gianna Barone
Aiden Bean
Savannah Berry
Ryan Blessing
Morgan Britt
William Conn
Riley Cooke
Caitlin Costello
Ashleigh Dickerson
Megan Elberberger
Lydia Fisher-Leaky
Hillary Frame
Alex Harper
Jesse Horton
Aaron Jones
Malcolm Jones
Joshua Lambert
Chappell Lee

ORDER OF EVENTS
Performance
Conversation
William Conn
Vocalist
Commonwealth Singers
Ander Mikalson
Artist, MFA Candidate
VCU Painting + Printmaking
James Elliott Shelton
Composer
VCU Music Alum
Rebecca Tyree
Director of Choral Activities
VCU Department of Music
Dr. Mark Whitte
Professor of Astronomy
University of Virginia
Question & Answer
Tour Through the Early Universe
Dr. Mark Whitte
Acousmatic Performance
Reception

MADE POSSIBLE BY THE GENEROUS SUPPORT OF
College Art Association | Professional-Development Fellowship in the Visual Arts
UNA Department of Astronomy
VCU Department of Kinetic Imaging
VCU Department of Music
VCU Department of Painting + Printmaking
VCU Graduate School | Theses/Dissertation Assistantship
VCU School of the Arts | Graduate Research Grant
Virginia Museum of Fine Art | Graduate Fellowship

DEEPEST THANKS TO
Andrea Almeida
Pete Badics
Curt Blankenship
Melanie Christian
John Dombraski
Evelyn Fisher
Hope Ginsburg
Christine Gray
Alex Hayder
Carlo Hines
Georg Ivanov
Emily Kasey
Ariela Lieb
Melanie McLain
Holly Morrison
Ryan Mozowiecki
PAPRI Grads
P.E.O. Chapter Y
Julie Rashkin
St. James' Church
Laura Schubert
Tom Simon
Stephen Vitollo
Gregory Volk
Dr. Mark Whitte
Hillary Wilder
Appendix 2: Tour Through the Cosmos

Commissioned text for the performance event

Written and read by Dr. Mark Whittle

Score for the Big Bang

Notes for the tour through the cosmos:

My aim is to take you on a journey from here and now back across 14 billion years of cosmic history to the infant Universe, to really see and feel and hear what it was like back then. It may help for you to close your eyes; that’s up to you.

LEAVING THE EARTH

So let’s just recreate the scene around us – the people sitting next to you, the walls all around, and the beautiful organ behind you.
OK, off we go..... let’s move up through the ceiling, above the church, and quickly Richmond shrinks beneath you. Soon the whole earth is hanging in front of you, with the bright sun off to your left.

Moving away from the solar system – the sun recedes to become just another star, one of hundreds dotted about here and there.

Picking up speed, we rise up out of the pale white disk of our Milky Way galaxy – and pause for a moment to look down and admire the majesty of this great spiral galaxy.

THE WEB OF GALAXIES AND DARK MATTER

Continuing our journey, let’s move out until our galaxy becomes just one of many. Pausing for a moment to look around, you see thousands upon thousands of galaxies stretching off into the invisible distance. Here and there are denser concentrations of galaxies, but elsewhere there are huge spaces with almost no galaxies. These two extremes are bridged by an intricate pattern of filaments and sheets made up of galaxies, like a 3-dimensional spiders web. This is the great cosmic web – a tapestry of sorts, woven out of galaxies.

Now let’s turn on a special kind of sight that allows us to see that rather unusual cosmic substance – dark matter – think of it as a transparent gravitating gas. You notice that every galaxy sits at the center of a large fuzzy ball of dark matter, and the entire cosmic web becomes much more clearly defined.

Anticipating our primary theme this evening, try to sense how this web-like pattern of galaxies is in fact a relic crafted by primordial sound waves – they were frozen in place long ago, and over time their peaks and troughs slowly turned into the clusters and voids we now see in the patterns of galaxies.

BACK IN TIME: 4.5 BILLION YEARS AGO

So let’s now pursue this notion of change, by moving back in time. Starting slowly, turn the clock back four or five billion years. Immediately, you notice all the galaxies move about 30% closer. In general, because the Universe is expanding, as we go back in time everything gets closer and closer together, so the young Universe is a much busier, denser place.

Also, the web-like pattern becomes less clearly defined – at earlier and earlier times the Universe is a smoother and smoother place.
Finally, find the Milky Way galaxy again – one of those many tiny pretty patches of light – and try to sense that in one of its spiral arms, the sun and Earth are just being born.

BILLION YEAR-OLD UNIVERSE & FIRST STARS

OK – now lets push further back – by another 8 billion years – to the one billion year-old Universe. The web-like pattern is now much less clear – with a much more uniform scattering of infant galaxies. These infant galaxies are smaller and more numerous than today’s galaxies – little chaotic blobs of a few thousand stars. Many of them are colliding and merging in the busy scene.

Pushing further back to 200 million years after the Big Bang, your view is filled with a dense sprinkling of brilliant blue-white beacons – these are the Universe’s first stars – each a million times brighter than our sun.

THE DARK AGE & GETTING HOTTER

Going earlier, before the first stars, we enter a 200 million year period of utter darkness – called the Dark Age. It is freezing cold – almost two hundred degrees below freezing.

But going earlier, it gets warmer – near 15 million years the Universe is roughly human body temperature. But by 10 million years, it’s now near water’s boiling point!

What’s the source of the heat? It is not the gas – that’s too thin to burn you. It is, in fact, a pervasive bath of infra-red radiation – you are under an all-sky heat lamp – invisible to your eyes, but hot nevertheless!

Going a little earlier, we begin to see everywhere, in all directions, a deep crimson color – it’s 2 ½ million years and the Universe – at a thousand degrees – is beginning to glow “red hot”.

At these early times it’s also important to realize that everything is spread about almost completely smoothly – there are no obvious structures—no stars or planets or galaxies – the entire Universe is basically a uniform hot dilute atmosphere of hydrogen and helium gas, permeated by a uniform transparent gas of dark matter, all bathed in a uniform glow of cosmic light. It couldn’t be more different from today’s Universe.

PRE-RECOMBINATION LIGHT
OK, let’s now get ready to enter the acoustic era. You need to brace yourself for
the transition because the conditions get very intense very quickly as the Universe
gets denser and denser and hotter and hotter.

So, as we slip back through the first million years, the sky color changes from
deep crimson to brilliant red, to orange, to yellow, to green, to blue – a spectacular
sequence of rainbow colors, with a matching increase in temperature from 1
thousand to 10 thousand degrees centigrade.

Let’s pause at 100,000 years when the sky color is yellow – the same color as
our sun. To feel the intensity of this light, you need to imagine looking out not at one
noon-day sun, but you must cover the sky with suns – 210,000 of them – with no
gaps between. This is the intensity of the 100,000 year-old Universe – it is a
staggering (and utterly lethal) brilliance.

FOG & THE MICROWORLD.

Returning briefly to 400,000 years, when the Universe was brilliant orange: As
you go backwards in time, quite suddenly, the gas turns from being transparent to
foggy – suddenly you can’t see very far because of the fog.

To explore the cause of the fogginess, we need to dive down into the micro-
world and become a single electron – perhaps one of the electrons that right now
lives in an atom of your brain, helping you to listen to this very sentence. Back in
the young Universe, before 400,000 years, it’s simply too hot for atoms to survive –
they’re too fragile and they shatter in the violence of all the collisions. So all protons
and electrons just zoom around alone and unattached.

From your electron’s eye-view, you notice that the micro-world is absolutely
awash with photons of light – roughly a billion for every proton or electron. You can
imagine them as wiggly tadpoles, zooming by at light speed. As an electron you are
constantly being smacked by these photons – it’s quite a jolt, and both you and the
photon ricochet off in changed directions. It is these collisions that are the source of
the fogginess – electrons are scattering photons just like raindrops in a morning
mist. Of course, once it’s cool enough for electrons to become attached within
atoms – after 400,000 years – then the photon’s pass by unhindered, and the gas is
transparent.

SOUND

Coming back from the micro-world to our place floating within the glowing fog,
we now become aware of another quality – deep, loud, semi-musical sound. The
gas is alive with motion as sound waves pulsate everywhere. We can even see these waves pass by because the gas is glowing, and the wave crests glow a little brighter while the wave troughs glow a little dimmer.

Let’s join the gas in this wave motion. Start by feeling the gentle pull of gravity towards a nearby region that contains slightly more than average dark matter – now respond to gravity's pull and gently fall into this region, only to meet gas that’s falling in from the far side, and in the squeeze we both get pushed back out again, only to fall in again. The falling and bouncing together make the sound wave.

These pulsations are occurring everywhere, and involve both large and small dark matter regions – a whole register of organ pipes, if you like, sprinkled everywhere, sounding all at once.

Ultimately, then, dark matter is the framework of the musical instrument; gravity is the player that plays the instrument; and we – our matter, back in its youth – is the air that sings. It’s a wonderful collaboration that ensures the young Universe was born singing.

If we now move through the realm, we notice that some wave sizes – some particular tones – are louder than others; there is harmony in the sound, with intervals and chords.

As time passes the Universe expands, and with it the entire musical instrument. So, as the dark matter organ pipes get larger their pitch drops – giving one long downward glissando.

BACK TO INFLATION: QUANTUM HISS

Finally, one may still ask: what process made the musical instrument – why was the young Universe born very slightly lumpy? The answer is much less certain, and requires us to visit the Universe’s actual creation process itself – a process called inflation.

During inflation, a small region of an extraordinary kind of substance fell outwards exceedingly rapidly and as it did so the gravitational energy released made a huge expanding realm. We must dive deep into this expanding medium, to sub-atomic scales, and focus on the inherent quantum dynamism of nature – it’s a ceaseless random tangled fluctuation of energy and density. It’s these tiny quantum fluctuations that lace the newly minted expanding Universe with slight roughness – and it’s this roughness that ultimately leads to primordial sound and the web-like patterns of galaxies.
In terms of sound, these quantum fluctuations are the irreducible hiss of reality. The sound of this quantum hiss then stimulates the various cosmic components – and it’s their response to this hiss that ultimately brings the Universe to life – it changes it from being utterly smooth and sterile to being wonderfully structured and fertile – so fertile, that in time it yields galaxies, stars and planets, and you and me, sitting here in the church, celebrating how it all began.
Appendix 3: Score for the Big Bang

Score for the Big Bang

Music by: James Elliott Shenton
Commissioned by: Ander Mikalson

Soprano 1
Soprano 2
Soprano 3
Tutti ad lib. wind sounds (breathing, air, blowing)
S & A gradually shift to (Sh-) sound

Soprano
Alto
Tenor
Bass

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Note: Improvise freely with 'Shabda' using different lengths of enunciation of Sh- sound. Spoken, not sung.

*Begin to incorporate
and ad lib other white noise
(Ts, Sh, Fh, Ah)
*All parts sing on (Ah) unless/until indicated otherwise.
Organ doubles all vocal parts

16

S

A1

A2

T

B

f

Ah

f

Ah

a tempo

Ah

Ah

All
organ continues to double all vocal parts

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