



Iowa Research Online
The University of Iowa's Institutional Repository

University of Iowa Honors Theses

University of Iowa Honors Program

Spring 2017

Quanta

Miranda Pederson

Follow this and additional works at: http://ir.uiowa.edu/honors_theses

 Part of the [Other English Language and Literature Commons](#)

Copyright © 2017 Miranda Pederson

Hosted by [Iowa Research Online](#). For more information please contact: lib-ir@uiowa.edu.

QUANTA

by

Miranda Pederson

A thesis submitted in partial fulfillment of the requirements
for graduation with Honors in the English

Ryan Tucker
Thesis Mentor

Spring 2017

All requirements for graduation with Honors in the
English have been completed.

Marie Kruger
English Honors Advisor

QUANTA

By Miranda Pederson

A thesis submitted in partial fulfillment of the requirements
for graduation with Honors in the Department of English

Ryan Tucker
Thesis Mentor from the Department of English

Spring 2017

All requirements for graduation with Honors in the
Department of English have been completed.

Marie Kruger
Department of English Honors Advisor

QUANTA

By

Miranda Pederson
Spring 2017Ryan Tucker
Thesis Mentor from the Department of English

This creative thesis titled *Quanta* is a series of non-fiction essays constructed to explore the human condition through the perspective of astronomy and physics. This thesis strives to balance the condition of personal human existence with the logic of physics and astronomy – a marriage between sound science and subjective emotion that attempts to find meaning in the existence of humanity and explore the varying types and degrees of love within the universe. This balance is an attempt to understand the universe, both the macro- and microscopic, and parse through the underlying theme of how the universe loves each and every person and thing differently, sometimes unrecognizably.

I drew my fundamental inspiration for this thesis from many different sources, but three are of the greatest significance. Amy Leach's *Things That Are* is a series of nonfiction essays that move freely between a personal narrative and scientific spheres, conflating them to make a cohesive whole. Marilynne Robinson also had great influence on my thesis, particularly for her lyric prose style, particularly in her nonfiction *Absence of Mind* and *Givenness of Things*. In these, cosmological notions surface to imply there are things beyond the grasp of human understanding, and understanding our incapability to understand is an act greater than itself, manifested as faith or love. Lee Smolin's *Quantum Gravity* also influenced these essays, mainly due to my personal obsession with physics and astronomy. Smolin's concise yet lyric descriptions and explanations of physics and astronomical phenomena approach human understanding in ways my essays attempt to emulate, providing tightly knit illustrations that create a narrative of the cosmos. However, each of these sources try to explain the universe to humanity, but I strive to let the universe explain itself from within us.

In creating this thesis, I have intentionally broken rules of creative writing that I have been taught in favor of emulating an incomprehensible universe. First, this thesis is written in a fragmentary style depicting the limited scope of human knowledge compared to the vastness of the universe. Second, the inconsistent narrator acts as a fluid catalyst to emulate the ever-shifting and changing universe. Third, some explanations and language regarding astronomy are meant to be incomprehensible as a means of portraying the impossibility of wholly understanding a universe larger than our own existence, the impossibility of understanding how it loves us, and the notion that we don't need to comprehend the universe's love in order to accept and acknowledge it.

Table of Contents

Observatory: An Introduction	4
Park Benches	9
Music Theory of Strings	16
The Entropy of Black Holes	26
Gravity Non-zero	37
Shifting Winter Cemeteries	45
The Nth Dimension	57
Time.	63
Critical Essay: Love's Cosmic Structures	68
Annotated Bibliography	77

Observatory: An Introduction

When I was a child, my mother and I would sometimes sit out on a green plastic loveseat on our deck and look up at the stars with nothing but ourselves and the warm summer nights to keep us company. The Iowa heat and bugs never seemed to bother us as long as there were dainty golden glimmers, that seemed to us both proud and elusive, to crane our necks up to - mothers of mothers to whom we young children gaze upward to find an answer to a question we haven't asked yet and don't know how to. And my own mother and I would sit there tirelessly, pulling at the elegant black skirt of Mother Universe as if we were small and fragile, wanting to be picked up, embraced, and loved again.

I can't recall very many specific things we talked about during our midnight stargazings, but I can say they left no small impression on me growing up. I still feel the weight of these conversations years after they have happened, and they feel as pertinent and urgent as they did on the nights where the stars were the only witnesses to our ponderings. Hours would pass, but they seemed to us mere moments that somehow transcended our daily lives, and we figured time was not measured by the stars – a quality we admired because my siblings and I were growing up too fast in a world too small – who winked at us with quiet cosmic wisdom. We could never hear what they whispered though.

Once, we were trying to remember what it meant if a star appeared a little bit blue or a little bit red or white – dying? exploding? moving toward us? away? around? Neither of us wanted to spoil our innocent wonder, so we sat in silence, imagining all the possibilities until submitting to the resolution that the stars didn't care if we knew what they were because they were beautiful anyway. It might be a bit odd that I remember this single conversation snippet, particularly because of my current obsession with physics and astronomy. I know the real answer

to those questions now, and could also tell her how each star formed and what will likely happen to it during the course of its life. However, I will likely never tell her these things – because for her, I know she finds beauty in some things being left a mystery.

This is the farthest back I can trace my obsession, and I don't know when I started to catalogue life into compartments shared with astronomical phenomena. An event might exist as a black hole – the occurrence itself can't be seen nor accessed because it lies beyond the event horizon, but everything surrounding the event (causes, effects, reactions, emotions) are scattered around it in the form of light particles. I don't want to remember it at its core, but I still remain aware of its existence. Others function as red giants - assortments of overwhelming gratitude and fondness that I can't stop gazing at – that glow long, slow, and low-temperated, and stranger events are placed in relation to magnetars because though their memory dismantles my being completely, I am helplessly drawn to them.

As my mother and I used to sit next to each other under a sea of stars, I used to think we were so separate from these celestial bodies and that we had nothing in common with their twinkling brilliance, but I know now that we have more in common with the billions of stars than not. The best way I can possibly explain this feeling is in the phrase “life happens once, forever.” Though this was uttered by photographer Henri Cartier-Bresson, he touched on something universally specific, but maybe I'm interpreting it strangely because of the copious amounts of time I spend checking NASA's website, looking at photographs of cosmic phenomena, scouring journals for any new research. I think he meant not only a single “life,” but life in a large context regarding everything that ever existed and will eternally exist forever because this “once” is the perpetual oneness of time and space and packed dimension(s) – every one of our lives looped

together through ancestry, tracing our origins to the very beginning of the universe, to the single mother particle that bore us all.

Of course, we may be born of one mother, but we must acknowledge our father too, though really there's likely more than one because we have founding fathers that laid the groundwork for us in astronomy. Galileo, Copernicus, Kepler, Brahe, you know the names, all of them largely responsible for revolutionizing astronomical phenomena. And modern scientists like Carl Sagan, Neil DeGrasse Tyson, and Stephen Hawking popularized astronomy and cosmic ideas using the omnipresent media that saturates society. Our Founding Fathers determined the locations of stars, came up with planetary models, and devised the laws of the miraculously functional universe. But we forget that these laws were written by humans, by mere portions of the universe instead of the universe itself – and who is there to challenge these laws besides us? Surely there is more we don't understand, laws unwritten because the universe itself isn't equipped with ink and pens, nor does it have the slightest slice of extra time to write its meaning out for our trite minds. This notion is enough to make a person uncomfortable – that the universe needs not to explain itself to the things created within it, and really, our sad credentials are no match for the universe that governs us.

I have also always had a hard time reconciling religion with cosmic phenomena. They seem incompatible, and it seems society makes them out to be that way. Except I remember wondering why we talked about the big bang but not the phrase “let there be light” when they essentially mean the same thing. I wondered why we talked about omnipotence, omniscience, and omnipresence as if the simultaneous existence of those qualities in a single entity was impossible, particularly when we start talking about the problem of evil or free will. And really, that simultaneity should be impossible, but then I started wondering what would happen if we

looked at religion through the lens of physics instead of the other way around. The universe – our universe – could likely be a closed system, a single unit born of a mother or a father and we only breathe because eternity has told us to, because our ancestors did, and we must honor that. We are just stuck trying to figure out how and why, and in the process, physics has become a religion to me.

So our Founding Fathers are also born of our single mother who breathed a sharp sigh one empty night, ending the infinite void of black, creating the swirling hot mass of energy that exploded across the universe (and probably farther). And our biological father came from a human mother all through the complex line of ancestry until we reach the one true mother adorned in glittering jewels which she has bestowed upon us and within us because we are not just stardust. We are born of Mother Universe and carry her blood, wrought with iron and light and love and strife, and to understand Her we must first understand ourselves. However, to understand ourselves is a perpetual understatement since we can only truly understand the small lives we experience and are privy to, and every story is an incomplete biography that falls sorely short of completion.

However, I've come to a point in my life where it seems to me that a white-haired astronomer has been observing me from a large telescope in an obscure location, mathematically deciphering the strange matters I've encountered in my young life. She has probably pegged me as a low-mass ball of gas in the early stages of its evolution, a formation only beginning to develop in the molecular core of a vast cloud of vapor and dust, cooling in its density. I should become a pretty standard ball of hydrogen and helium, no more significant than other bodies though each one has a unique story all its own. And I sometimes imagine myself gazing back at this astronomer through her own telescope and thinking how strange her life must be to know

how to breathe oxygen and move freely, to have opinions and thoughts and a history to be studied and remembered.

Truthfully, she won't remember me being young at all. She won't even know I exist until I am old and collapsing, when any matters of my existence will likely not have mattered at all, and she and her astronomer friends might marvel at this lightness filling what they once believed to be a blackened void before they realize we are actually the same age and it just took too long for us to meet because this void is too large and the relativity of time is unforgiving.

But really, right now, I am me and I am here. Somewhere across the void there might be a proto-star inhaling dense clumps of gas and dust, creating itself in the center of smaller clumps, both solid and not, spinning amidst them as inspiration for their own twirls and circular dances, until its excited gases ignite to shine on the dance that is forming planetary systems. This light will illuminate its colorful and diverse comrades, proudly displaying its place in the universe while not giving a fathom about anywhere else. No, there is humility in its glow because it simply exists and knows nothing more than the love of that. So despite my astronomic interest in this star, it will never have an interest in me. It will see my life as it is, and it will see it without sorrow or remorse, wonder or joy, malice or envy. Or it will not see my life at all because it can only understand its own fundamental existence, its own laws. But I think it must know exactly what it's made of, to be so boldly emblazoned, so sure that it matters in the universe. It doesn't care where it came from, but it unashamedly knows its place, its purpose, its substance, its beauty.

And I'm still trying to figure out my own.

Park Benches

Our acquaintance seems to be a mere coincidence because I wasn't even supposed to be there, and you weren't even planning on going, so our meeting seems a miraculous anomaly to me. My friend had invited me to go the night before, and you mentioned later that you didn't want to go in the first place but felt obligated to since you were invited by a friend of yours. I remember thinking *I don't want to go tubing down the river, especially this nasty one*, but after glimpsing your face from the backseat of the car, it suddenly seemed like the best idea in the world as long as you would be there. I didn't know you, you didn't know me. But apparently we shared the same sentiment about each other moments after meeting.

The pocket dictionary definition of quantum entanglement is that two or more separate quantum particles can be inherently linked together in such a way that a change made to one particle instantly affects the other particle no matter the distance between them. This was initially thought impossible because these changes would have to cross unfathomable distances faster than the speed of light, but John Bell claimed the existence of "hidden variables" to account for the instantaneous link between particles. I often wonder if these "hidden variables" are synonymous with whatever seems to be missing in our search for a unified theory of the universe. I wonder if these "hidden variables" are really the complex singular thing we call love and if I'm somehow linked to you.

For those that know us well, they would assert that we are essentially the same person, of one being. We noticed this too, but it started out as trivial things such as you like ice cream, I like ice cream, you like cheesecake, I like cheesecake, you like to eat ranch on corn, I like to eat ranch on corn, you enjoy nature hikes, I enjoy nature hikes. Whatever differences we had dissolved quickly, and our narrative became more complex as our lives became enmeshed into

each other – we dislike the societal and cultural construct of certain holidays, we find similar faults in authority, we have the same sarcastic humor and have no hesitations in teasing each other, we both find great value in spiritual exploration and empathy, we both glorify nature and get as much of it as we can. Now our friends only refer to us as a single unit, and you and I remind each other of this fact frequently. To talk about one of us is to talk about both.

There is a park bench somewhere that we once sat on, you and I, where we counted the number of times a young man looked at the backside of a passing woman, and we laughed because such a thing seemed ridiculous to us. You mentioned how inappropriate it was for him to ogle as he was because it seemed misogynistic, and you've always hated objectifications of both men and women. I remember watching your eyes as each widely curved woman walked by, watching to catch you glimpsing her backside. You never did. But you did watch my eyes too, as if I might do the same to the men playing frisbee in the grass a short distance from us. We eventually caught each other's eyes simultaneously and realized what we both were doing. We laughed and kissed.

Even before the moment Einstein's lips parted to say "God does not play dice" the universe has seemed to wrap itself in its own webbing, invisible threads crossing each other every which way, explaining why all the park benches in the county look the same to me as they do in London, Paris, or New York because they are all the park benches on which we sat, my small fingers webbed into your long and elegant ones. I would caress your hand, examining every vein, counting the number of spaces between the lines of your fingerprint, gauging the temperature of your palm, turning it over and back as if doing so would create a larger gravitational force between us, pulling us closer even though fundamentally I was most concerned with the tugging quantum forces between our hearts.

In quantum mechanics, particle wave behavior gets overshadowed by its environment, and the particle is no longer one of its kind, instead being inherently dependent on and influenced by its surroundings. This becomes extremely significant when we talk about quantum entanglement when two particles (likely created from a single particle) are placed in two distinctly different systems. In this case, the two separate systems in which the particles exist become impossibly entangled with each other because of a fundamental connection. But what happens when a person becomes the environment of another person or their environments bleed into and influence each other? If they become entangled, there must be some sort of dependency of spirit present, always recognizable yet barely comprehensible, hidden variables that bear no definition despite their presence.

Quantum rules govern the world of the microscopic - atoms and particles on the most fundamental planes of existence. We too live in our own little world, like the bubbles we blew one summer day on the wide steps of the city's capitol building, each separate bubble floating upwards and around of its own volition. The syrupy mixture we concocted was hardly conducive for bubble blowing, but we cheered each time one of us managed to produce a couple small silvery spheres, as if their tangible translucence was the most spectacular thing we'd ever seen. The sun illuminated shy oily pinks and purples before they unpredictably popped. I remember feeling shy that day too, my cheeks also colored pink by the notion that I ended up in the same universe as you, the same translucent space around you illuminated by the sun, illuminated by you.

One autumn day we sat on a cemetery bench, and you squawked and howled at the birds flitting overhead. Despite the tranquility of the cemetery, the birds seemed restless that day, perhaps agitated by your shrieks or my laughter. You asked me to join you, but for some reason I

was embarrassed at the idea that somebody would pass by and hear me, or maybe I was afraid to let you hear me. However, we agreed to kiss each time a stranger passed in an attempt to make them uncomfortable, and eventually I agreed to holler at nature with you. I think it was that day we developed a language of our own comprised of grumbles, incomprehensible howls, and calculated gibberish, intelligible to only us in the same way distinct particles carrying encrypted data are only intelligible to each other. Quantum encryption extends great distances too, and I like to think that even in moments when we are far apart, you can still detect and decipher my internal howls and whispers. Or even the beat of my heart.

Ever since that day on the cemetery bench, we agreed to name all animals Charles. The first Charles lives at that park with the gazebo, up the hill a short distance from your house. We encountered the second Charles on an early morning walk. The third Charles passed by us near the skate park by the river, and the fourth, fifth, and sixth Charles might actually all be just the fourth Charles. But I know that Charles number seven (or rather five) is the yellow tabby we often stop by to meow at. At some point we stopped counting the number of Charleses we knew and resolved that all Charles are essentially the same, aside from the yellow tabby because he let me pet him once.

I'm actually convinced that Tabby Charles is really Schrodinger's cat since all Charles are one and the same, and they all may or may not be dead. We don't ever talk about this though because neither one of us likes to imagine the world being overrun by Charleses, regardless of their existing state. If each Charles is linked inextricably to the whole, then what happens to one Charles effects all others. Except we cannot monitor all of them, especially since entanglement can occur with many particles instead of merely two, so we become unsettled by the fact that the world may be filled with dead Charleses, which disheartens us both. I rub my thumb along your

thumb and wonder if there are multiple versions of us somewhere and if we are either dead or dreaming, entangled with the masses of ourselves. But holding your hand, I hold on to my belief that two specific particles can be more closely connected than the rest of their kind – so close that they are more readily perceived as a single object, a single system, a single particle, undivided despite any apparent distance between them.

I once read an article about an elderly couple who died within minutes of each other. The nurses had been kind enough to place them in the same room upon their admittance, with the beds close enough together, allowing the couple to intertwine their fingers in the space between them. I don't remember what ailments they each had, but I do remember the wife died first and that within minutes the husband breathed his last as well. This isn't an uncommon occurrence, apparently, which shouldn't surprise me since entanglement has evidentiary support. We have often talked about death, and we still have friendly quarrels about who will die first, but we both know these are also very serious quarrels because I've grown too close to you to think about you dying. So I tell you that you can die first because I don't want you to suffer the bite of loneliness. You always got upset when I said this for the same reasons I said it.

We seemed so young then, even though temporally it wasn't that long ago, but our relationship feels much older than it is, like we've been taken from the same universe thread, unraveled, and then spooled back together except the thread has grown thicker because we had to travel across space and time to become alive, already older than we think we should be. And perhaps we ill age further to sometimes still sit on various benches, pointing in random directions to passers-by, shouting "it's that way" without them prompting us for direction. But it might as well be the direction they're going because the best destination is home, and I now know that home can be a person, and the places called home are carried with us since the unit system was

never divided to begin with. Or, if it was, it remains intact because its fragments were once one whole. No matter which direction we go, we are home.

I used to believe that the shortest distance from one point to another was a straight line, but I feel this can't be true because string theory postulates the quickest way to get from one point to another is a curved line, one end touching the other, bent to transport matter from point here to point there instantaneously. I'll stand here, and you stand there, and if we fold space-time over itself, our positions will meet without us having to move at all. However, I don't think this is entirely accurate either because when I stand here and you stand there, your there-ness is present in my here-ness, a part of you not implanted within me but intrinsically fixed to my soul.

And maybe this is why I am so terrified of losing you. Maybe this is why I am so terrified that all the words we exchange and experiences we share are simply reruns of bad soap operas I've lived in real life because I once believed the lie "I love you" and don't want to make that mistake again. I wonder too if this fear stems from my past selves, selves that I am glad you will never meet even though they are still part of me – but if entanglement is true, then they are also part of you, and that is a part of you I would be heartbroken to find. But if I hold onto these small, sweet memories, they can't possibly be spoiled as long as they are small and sweet, and through entanglement I can convince myself that the whole is not small but is indeed very sweet. And I will always believe you when you tell me you love me because I will always love you, and in this you have my solemn vow.

If we were trying to marry human existence and the scientific modes of the universe, then we might safely assume that this union was a form of love in the same way that marriage is a union saturated in a lifetime commitment of it. I feel this is at least partially wrong, mostly because I believe experience and logic were already "married," but also because physics tells us

that everything was once compressed into a single, solitary particle (though this theory is still being contested), so if there was at one time any love in the universe, then it must still be everywhere, distributed perhaps unequally and in various degrees of potency. Additionally, and though this might seem unrelated, the term “’til death do us part” replays dejectedly in my mind frequently, reinforcing this idea that there could be no “marriage” when we and the universe are essentially one. Death cannot separate a thing from itself, and, as any good physics student would know, Einstein’s equation $E=MC^2$ applies to everything – including us – implying that even in our own brutal deaths, we do not simply vanish from the universe unloved.

In the beginning, there was the word, and the word inflated to make the whole universe – an explosion of sorts more akin to blowing up a latex balloon, its pink edges becoming more translucent the farther it stretched. This single word expanded as an undivided unit system, and the illusion of new words emerged because of the vast distance the balloon covered, each new system illuminated by a different sun and teasing us with barely enough light to decrypt secrets with. I believe we are all still pink inside from the inflation of the universe and that there’s some significance in the commonality of our origins, that one’s pain is another’s pain along with joy, sorrow, remorse, and everything in between. Somewhere, you and I must have gotten stretched just far enough apart to touch fingertips in this lifetime, still part of the same system, still the same inflation, still the same singular unit except existing in what others see as a different word or world, pink and illuminated before we vanish. And I wonder if universe balloons have any relation to bubbles. Or park benches.

Music Theory of Strings

I was told in high school physics that the shortest distance from one point to another is a straight line, but this can't be true because string theory postulates the quickest way to get from one point to another is a curved line, one end touching the other, bent to transport matter from point here to point there instantaneously. I'll stand here, and you stand there, and if we fold space-time over itself, our positions will meet without us having to move at all, companions forever, instantaneous.

I began piano lessons at the age of six, but really I fell in love with the piano at the age of three – plinking out by ear whatever tunes my sister played. The first piano teacher I went to wasn't interested in taking me at first since she had a strict rule of only teaching students ten years and older. However, my mother pleaded with her to let me come for one single, half-hour lesson, then she could determine if I was ready to begin lessons. Of course, I had no idea of this arrangement because I was too excited at the prospect of having formal piano lessons and thrilled by the opportunity to play on the teacher's baby grand Yamaha. I remember we sang at that first lesson too – the teacher poking my belly and saying, “No, no. We breathe deep and low, not high and tight,” and eager to please, I obeyed the best I could. When my mother came to pick me up afterwards, the teacher chatted with her in the entryway for a while. I guess she decided she wanted me to come back the next week.

Today, the upstairs piano is storming, a ragged, angry groan emerging from its insides as it voluntarily plays itself. Nobody else can hear it, but I can hear it from where I sit at the bottom of the basement steps as I rub the fleshy webbing between my twenty-two year old fingers. This rumble becomes louder as it sonically stumbles through the upper floor hallway and trips down the stairs, gaining momentum until it no longer resembles a thunderstorm but instead rusty nails

and gravel rattling in a tin can. This could be a sign that the hammers need to be replaced or something's come loose or it needs to be tuned, but I pretend not to hear. I pretend that the sound doesn't feel like the rusty nails are being driven into my back either.

It's funny how hammering something into place binds two distinct objects together, as if attempting to coerce them into occupying the same space at the same time – two points drummed into one by an oscillating hammer, its deliberate sine and cosine motion akin to curved frequencies of music bearing a melody as they pulsate to a rhythm and vibrate with every strike until suddenly the curves overlap, transferring notes and melodies across a resonant soundboard until I am as deaf and dissonant as a hammered Beethoven. I drum my fingers on the wooden steps, remembering that a colony of Beethoven's Sonatas remains scattered on the floor next to the piano. I should pick them up, cradle their curled and torn edges in my fingers as an apology for wrenching them out of their binding in the first place in a frustrated state caused by my artistic incompetency, an apology for my non-existent response to the piano's attempts to grasp my attention.

I bought my upright baby grand Steinway, a studio model 1098 clocking in at a light 480 pounds, for two thousand dollars on eBay from an elderly man. He was a retired professor from the University of Missouri in Kansas City and had no choice but to sell the piano since he was moving to California. He had originally bought the piano on a whim from the university, but I was surprised he listed the price so low since these musician's Cadillacs are bought new for over 15 times that amount – and that's for the inexpensive models, for the models like the one this man was selling – models like mine. I should have asked him if the low price was because the piano had a sour temperament due to loneliness and neglect. I should have asked if it had the tendency to throw an internal, rusty-nail wailing fit when it felt dejected. I guess his answers

wouldn't have persuaded me either way though, as it turns out my piano and I are more alike in these ways than I care to admit.

I was almost disappointed to see it when I picked it up – this piano had not been loved well. It might have been well-loved, but it had not been loved well since it existed mostly as university property. Its ebony finish had been repainted dozens of times with sticky, tar-like paint unsuitable for Steinways, suffocating the Sitka Spruce soundboard within, and the piano was attempting to vomit this black substance out. This gurgling grime resisted my fingernail when I tried to peel it back, and though the European spruce keys were still beautifully intact and pristine, when I caressed one with my finger a layer of dust clumped together and clung in a crescent shape to my fingertip. I rolled the dust clump into a ball and let it drift to the floor as I reached to touch one of the many water rings across the top, each looping over another.

I had watched my father nail down the two by fours that would become the skeleton of the room that would house the piano. First came the concrete, the grey bricks for a foundation, studs and scaffolds for bones rising, beams and rafters forming overhead, arches, insulation, dry wall, shingles, all held together by many hammer oscillations that echo in the history of every house. My father wiped his brow as he turned to me and said *this is how you make a home*. I still wonder if the same concept applies to me railing my fingers into the keys of the piano with the top open to glimpse the hammers striking the strings. First comes the A theme, pianissimo, andante, building and shifting into the B theme, scales, arpeggios, augmented chords, a new key, a new key signature, accidentals, caesura, forte, fortissimo, rage, loneliness, neglect, isolation, crying myself to sleep, counting bruised heartbeats and praying they're loud enough for God to hear. I wipe my brow and think, *this is how you forge a soul*.

I once watched a documentary about how Steinways are made – the hammers, strings, panels, tuning pins, iron plate, soundboard. I think it was shown mainly as a long advertisement for Steinways, or perhaps a promotion of a famous pianist who was playing at Carnegie whose name I cannot remember. I do, however, remember watching him float from Steinway to Steinway in a piano store as large as a football field, testing each piano individually to find one with the perfect sound quality for the Beethoven pieces he was to perform. The piano he was searching for turned out to be a freshly arrived specimen in the back, still half-packaged in saran, bubble wrap, and soft plywood, its strings and keys still cold from winter transport, with an especially strong reverberating tone. I remember thinking he had basically found a companion, a soulmate. I remember thinking I wanted a soulmate too.

I like to imagine Einstein sitting at a Steinway, conspiring with Beethoven's ghost about how to hide a unified theory of the universe within the impossibly large chords of a Sonata or a Fantasia or even Bagatelle number 25 in A minor, widely identified as Für Elise. These chords would make a song that sounds a lot like a melody remembered from childhood without our ability to recall the exact name of it, as if being stretched over a lifetime has tightened it more than piano strings, pulled it so thin the tune itself is weak and whispered. We have somehow forgotten how to listen for this melody from the first moment we left the warmth of our mother and her voice now sounds old, feeble, and unlike our memory of it, of her, though our memories are often wrong. We want to remember her heartbeat, her pulse, her touch, her gentle eyes before she kisses our foreheads and tucks us in, her hummed lullabies folding us into sleep, her voice in the background of our dreams like the cosmic background radiation of the universe we can't hear unless it's put to music – a theory of the universe where the throbbings within us and without us bear symphonic chords, vibrating piano strings of the soul that fold into a Master Equation

devised by Einstein's own imagination, conceived by our mother, bearing us unto the world and the world unto us until we are one and the same.

But we remember – I remember – loneliness and cold, empty and dark, friendlessness and silence, and the hope that string theory is accurate, that my soul isn't frozen. That the universe will fold space-time and I will unite with a soulmate.

The main premise behind string theory is that strings are the smallest components of matter in the universe instead of the beyond-microscopic quarks made of hadrons. Point particles and lines are not fundamental components of matter because tiny, vibrating, one-dimensional strings are what the universe is comprised of. They can be open-looped, close-looped, folded around each other, vibrating in a twisted Calabi-Yau, even oscillating in and out of each other. Variations in their structure, size, and vibration give matter specific properties such as density and mass in the same way that Beethoven's many Variations give music properties such as harmony and key. I like to think that these strings aren't necessarily the smallest components of matter but rather the smallest composition of matter, unpredictably formulated music. I'm still parsing through this idea, but each time I try to fully understand how strings and piano strings are the same, I come to a half-acceptance that I might never.

Bill the Piano Tuner came about six months after the Steinway's settlement into the guest bedroom. He checked the soundboard, the strings, the hammers, the keys, the pedals, he even played his usual recital for me – Beethoven's Für Elise on a continuous loop. Everything was, surprisingly, just fine. He said the strings had a few more years left on them and the bowels of the piano were healthier than expected, given where the piano came from. I still thought it sounded funny and tart, but I paid him and he left.

I've always had this theory that a piano begins to sound like the person who plays it the most, adopting characteristics of an individual's personality and soul. My Steinway's voice was revolting to me when I first started playing it – nasal with an unrefined twang that seemed to be a sonic representation of exhaustion and dust. I only hoped my theory was right and it would start to sound more like me and less like an amalgam of stressed, hormonal college students the more I played it. And I used to stretch my fingers religiously every day, loosening the taut tendons, pulling my fingers farther apart and massaging the webbing between them so that I could play Beethoven's octaves with ease. So that I could play distant notes with one confident strike.

Beethoven has always been my favorite composer, even at the age of six, and as I grew older I had strong opinions about other composers despite my appreciation for them. Mozart was cute, Brahms was predictable, Bach was sweet and sensitive, Chopin, Schumann, Scarlotti, Mendelssohn, all of them seemed too refined for me. But there was a ferocity in Beethoven, a largeness that swelled out of the reaching octaves, full chords, passionate fortissimos, and haunting melodies. There was a darkness that I recognized as depth drawn from loneliness and near-insanity, solemn but fierce, calm but intense. I memorized Für Elise before the age of ten despite my piano teacher telling me I was too young to perform such a piece, a discouragement I thought was ridiculous then and now *know* was ridiculous due to the rigor of competitive piano studios. Even so, I manipulated my small hands to work the chords that were much too large by many years, and I practiced religiously until every piano lesson became to me a concert of my favorite piano piece on my teacher's baby grand. I craved immersion in Beethoven's sonic loneliness, an attempt to give voice to my own without doing so explicitly.

I keep meaning to refurbish and refinish my Steinway. Every time I pass by its melancholy gathering of dust in the guest room, I feel the impulse to immediately peel away the

grime, re-polish the ebony panels with a fresh coat of glossy, black satin lacquer, reach inside its heart and pluck the Swedish steel strings with my fingers, heartstrings, one by one, before releasing them, all 36,900 pounds worth of tension, just to tighten new ones in their place. I want to examine how the copper is wound around the bass strings, how the treble strings bend and oscillate with the slightest touch, trace them with my eyes, fingers, mind, heart, soul. I want to smell the aged Sitka Spruce soundboard and rub my knuckles on it to see if it's still smooth.

I'm convinced string theory will one day prove the existence of other universes. Not the kind of universes that house "alternate realities" that play out all the potential decisions of a person's life in so many acts, variations upon variations of overlapping variations of the universe we perceive. No, I'm talking actual other universes that have their own substance, simply overlooked by us because they are so discreetly folded within our own universe or vice versa. And by universes I really mean dimensions. And by dimensions I really mean all the things beyond our meager mind's comprehension like cosmic background radiation, quantum chromodynamics, the essence of existence, and strings. I think music counts too.

Pythagoras has close ties to music as well, and though he is well known for his theorem, he also discovered that the planets had spaced themselves out the same way musical triads are spaced out. During the inflation of the universe, moments after what we call the Big Bang, fiery debris and loose matter strung themselves as lights across the universe in perfect harmony with each other, a symphony of creation that unfolded itself around fresh frequencies. I think their oscillations are still waiting to be refolded into each other. Or at least understood.

I remember when I pounded my fingers into the keys so hard I had to wear a splint for three weeks. Or when I couldn't get the trills in one of Beethoven's Sonatas so I bit my own ivory teeth into my hand until I broke the skin. Or the time I punched the piano panels over and

over, feeling shamefully empowered by each choral whimper that echoed within it until I thought the piano was as wounded as I was about my incompetent existence. I punched until my fist went limp. The bones in my knuckles never did heal right. The piano's bones didn't either.

If you hold down a note, any note on the piano, soundlessly, gently, and strike the third or the fifth in the triad, the first note will ring in harmony with the struck one simply because it is not being choked by the premium wool-top felt hammer anymore. They oscillate, these separate strings, quaking with curved vibration until they fold together sonically. I've noticed my piano has started to do the same thing when I sing. If I sing close enough, it will sing back. In triads.

There's a thick white binder full of Italian Arias for the soprano that I haven't touched in months, maybe years. German, French, Latin, even Swahili are in there too, but my favorites were always in Italian. They still are – Porgi Amor, Le Violette, Sebben Crudele, Alma del Core, Bel Piachere. I would play and sing these on the days I became frustrated with Beethoven, the days when I got tired of the voice in my head saying *curve your fingers more, not so hard, don't jab the delicate moments, lean into it, you miss that fucking A sharp every time, this isn't the right tone, stop stop stop stop fighting it stop fighting the piano, the music, you're not connecting, connect with it, breathe, connect.*

My hands used to shake ever so slightly before a performance, but maybe it was more of an internal shaking – a spidery ball of anxiety roiling in my gut, wriggling up through my esophagus and spewing out my mouth, down my arms and elbows, past my wrists, and crawling back in through my fingers. Their journey felt too circular, and that's probably why I was most discomforted by this path because I thrived on oscillatory patterns, and the only circle I was really comfortable with was the Circle of Fifths.

The last time I ever performed for an audience was in high school at a piano festival. I used to thrive on IMTA and Guild auditions, playing occasionally for church and cherishing piano recitals and competitions. But this one final time, I realize now, was a last ditch effort to express, to those who misunderstood my sour temperament as behavioral issues and a bad attitude, that I was terribly lonesome. That I knew too well what it was like to be friendless, to cry myself to sleep every night believing there was something disgustingly wrong with the strings and loops of which my soul was comprised and composed. My hands shook at the realization of how vulnerable I was making my emotions, and a photo somewhere has captured the furrowed brow of concentrated pain on my face as I played a few pieces, Sonatas maybe, that I hadn't forgotten. I remember the single spotlight on me and the piano as if we were on a medical examination table, under strict scrutiny for our fundamental existence. I remember this unfamiliar piano made me feel lonely too, its cold, sterile-looking keys judging me up close while judges assessed me from afar. I think it was then that I knew my loneliness was entirely mine, eliminated only by a strange sort of love between my Steinway and me. I now only play piano when I am alone, when I am at my loneliest.

The quickest way to get from one point to another is a quantum loop, tiny strings folded over and around each other, lively vibrating inside their specific oscillations. They sometimes entangle themselves with one another, overlapping their frequencies and exchanging melodies, but their overlap is brief and barely detectable. I try to imagine how here and there could become this one place with everything fitting inside each dimension tightly, tighter than Swedish steel strings. I try to imagine how I might fit inside a new frequency, and I want to know what Beethoven was trying to say. I want to know what Einstein didn't say about the universe and his

theories. I want to know how I ended up loved by a Steinway that fired its soul-shaking frustrations at me, even after I struck it. I want my here to be there.

But today I am still sitting on the bottom step of the stairs, and I can now only imagine my Steinway's ragged whimpers and sobs because it has finally quieted. Its silent pleas hurt more than the hammer driven nails, and I desire to run my fingers up and down its keys again or press my cheek against the soundboard while I hum an old Beethoven Sonata, feel the vibration through my skull until it oscillates down into my heart and pulse.

But someone has closed its lid, and a laptop sits on it in a layer of dust along with some storage boxes filled with junk my mother is trying to sell on eBay – shoes, dolls, and ceramic jars along with other miscellaneous items in hopes to ship them off to distant places, an attempt to make them go anywhere besides here. Anywhere so far away that it will be like their existence never happened and there will be no strings or curves or loops left to connect our distances together. I only pray this fate will never be my piano's. Or mine.

The Entropy of Black Holes

For me, the new house never even began to feel like home. The day we moved in, I realized how large my room was compared to the closet-sized living space I had grown accustomed to. I also realized that my room would never look full because I didn't own many things. This extended into the larger realization that the house itself only looked bigger because it was emptier. Kira's closet, though, was large enough to be a room on its own and was often my hiding place whenever people's voices got too loud. "You can't stay in there forever, you have to eat sometime," she used to say.

So she would lure me out with the promise that I could watch MTV with her and not get upset about me doing flips off the basement sofa. She used to play videogames with me, and I used to hide chocolate in her nightstand drawer. She used to be funnier and tickle me until my face turned purple and give me cheesies, which were basically special noogies for cheeks. But she gradually stopped talking to me, and she became quieter, and then angrier, and then altogether absent from my life. By the time she was a senior in high school, I didn't recognize her at all. I didn't recognize myself either.

At least that's how I say it happened. That is how I tell myself that nothing was my fault in this story. I tell myself that it was her who ruined me, that her attitude was the reason I turned out the way that I am. It was not.

I didn't mention all the times I slammed my door in her face for reasons I can't even remember. I didn't mention when I punched the basement wall and blamed the dent on a rogue billiard ball or a party she had thrown. Or the time I wasted trying to figure out how to put a sliding patio door back in place without anyone noticing the damage from it being yanked out in a fit of rage. Or the relief I felt when nobody noticed it had ever been out of place. I didn't

mention sitting on the floor staring endlessly out that door in the dark until I thought my reflection was something else. Or my horrifying realization that I was scarier than my reflection. I was made aware of this fact by the constant distance she and everyone else kept from me. Distance I acknowledged with indifference. Indifference because I actually wanted to be isolated and cold and angry and we all knew that.

“Let me take you to get your hair done,” Kira had once entreated. I pointed out to her that I only liked my hair slicked back into a tight ponytail. “I know, but people think you look mean.” I shrugged and walked away.

After she went off to college I used to sit in the middle of the empty bedroom she left behind. It was a lot colder in there than I remembered, but that could have been because the walls were still painted a cool indigo, sponge-painted so they looked like mini stars that forgot how to be stars because they were all the wrong color. We had once stuck yellow glow-in-the-dark stars to the walls, making the room resemble a splotchy galaxy. We even tried to get the constellations right, attempting to create the obvious ones – Big Dipper, Little Dipper, Orion, Leo, Cancer – and we would pretend the Solar System was as close as the walls and ceiling. I gave her a pink star from my bedroom, and she stuck it right in the middle of the Big Dipper above her bed. I believe we are all still pink inside from the inflation of the universe and that there’s some significance in the commonality of our origins, that one’s pain is another’s pain along with joy, sorrow, remorse, and everything in between. There’s still a small clump of putty where that star used to be.

I like to imagine that little putty-clump watching her from behind the star, past the hazy pink glowing in the dark, and her gazing up at it, pretending the star pressed past the ceiling and into my room above hers, linking our respective galaxies. I like to imagine that my galaxy

pressed back through the little star, squeezing itself down to embrace her before she fell asleep. I like to imagine that putty-clump doesn't mark the spot she fell into that severe, unconscious drunken state. I like to imagine that it didn't witness the boy who intruded into her room to unbuckle her belt, pull down her pants, her panties, rub his greedy, offending hands on her legs and up her stomach, taking off her shirt with one motion. I like to imagine my 12 year-old self, sensing something wrong instead of hating her disobedient and reckless party-throwing persona, and bounding down the basement steps with a baseball bat or an iron fist fit for people who really deserved to have to make up excuses like rogue billiard balls.

I like to imagine now that the small putty-clump is actually debris from a supernova, that the little pink star imploded because the degeneracy pressure of the room got screwy at some point in time by hot, inward falling gases until finally they violently rebounded off the surface of its too-massive iron and nickel core. Supernova. Little putty-clump debris. I never knew she kept the little pink star.

I saw her again years after she graduated college at a family holiday get-together, Christmas or Easter or something, maybe Thanksgiving, I don't remember because the seasons all look the same – brown and lifeless – at our parents' house because everyone there was and is chronically unhappy. She was standing next to the kitchen island, scooping some potato salad onto a square paper plate. She had a new boyfriend with large bicep tattoos and a past everyone whispered about, and I caught Dad shooting a cold glance at him from across the room. I never introduced myself to this new boyfriend, and she never introduced him to me. I just sidled past them both, past the potato salad, past the tension of unspoken years between us and into the insulation of my own hot hatred near the stove.

Nobody talks about the temperature of black holes. Any conversation about them is typically saturated in the fascination of what would happen should we encounter one or the theoretical outcomes of falling into one. Many people think that the gravitational power of a black hole would crush a person, but it would actually do the opposite and tear a person apart, wrenching each finger, elbow, shoulder joint, vertebra, artery, the palpitating heart, the skull and its teeth away from the body – human silly-putty pulled apart, and I wonder how much heat would be produced in this situation, how much light. But even an experiment emulating this would be too calculated, too predictable, compared to that of a black hole. Entropy is not kind.

Except entropy is at the core of the entire equation. It is as inescapable as the black hole itself. Information goes in and becomes entirely inaccessible to the rest of the universe, and we can only hypothesize the increasing amount of chaos beyond the event horizon, the photons drunkenly dizzying themselves, falling downward, upward, all-ward, every-which-wayward, depending on where they tripped past the threshold, on a hot disk.

But is the disk hot? For all we know it could be cold and empty like newly built houses during winter or rooms we forgot to fill with things like sofas, potato salads, and sisters. Rooms that felt larger because they were empty, and temperature is inversely proportional to largeness of mass, not size, in a black hole. The larger the black hole's mass, the colder the temperature.

But even this is more complicated than it sounds because temperature and entropy are measured by the acceleration of an observer. Motionless, the observer's calculations come out to equal zero. They would see only empty and cold and no hot photons flailing about. They would measure no temperature, no matter the size of the black hole. The information lost past the threshold of the event horizon would be perceived only as empty space. And always cold.

But I can only feel the hot disk of a stovetop burner near my hand and understand my own relation to it according to my own perspective and motion. If I stay still enough, all my calculations will too equal zero as it would be impossible to process the hot photons vibrating around and around in the small red space or the differentiation between the burner and the air surrounding it. All would be still enough that the only thing I could feel is what the burner gave off, which would soon feel like nothing. If I stay still enough, all memory of her will freeze, her existence in relation to me will be gone beyond the event horizon. There will be no photons to detect, no way to find them again.

I remember peering through Mom and Dad's dining room window, watching bright ember debris fall from Kira's cigarette as her slender fingers gave it a light, practiced tap. Then she brought it to her mouth and inhaled for what seemed like a long time. This seemed unusual to me because it's hard to imagine her tiny lungs sucking in anything as visible as smoke. But I watched her as her cheeks receded even further beneath her cheekbones, small holes accentuating the canyons of scars across her face, which grew more prominent with each passing year. I remember thinking she looked much older than 25, and I felt much older than 19, and I wondered if those scars had anything to do with the fact that our childish cheesies had turned into bruised cheeks or if those scars cracked a bit deeper each time my hand slammed a door in her face. I remember thinking this didn't matter much to me and fascinatedly watched the smoke swirl out of her mouth as it rose toward the watery winter sun, and this sun-smoke looked like the result of a Supernova, only darker. It looked like it was still warm.

I imagined this dark smoke transforming itself into the colorfully hot red, purple, and orange embers of a supernova, being seemingly exhaled from an overwhelmed star that had just undergone a massive core collapse. The sun made the smoke look like it was shimmering, and

the swirling mass seemed to be spreading itself out into the empty space of the sky, appearing as a semi-gelatinous substance waiting to be inhaled again to create another star or putty-clump or black hole, a freshly spread contusion congealing, clumping, clotting to make something darker.

When a star undergoes a core collapse, it implodes into itself instead of actually exploding. It's the inward falling gases that cause the explosion - they screw up the degeneracy pressure surrounding the too-massive core and end up violently rebounding off the surface of the imploding mosh pit of iron and nickel. Supernova.

The result of a supernova is the thing most people talk about. We talk about the colorful smokiness that the star has seemed to exhale, the hot reds and oranges that shimmer like cigarette embers. They appear to be in motion, swelling into the large empty space beyond what's left of the core. They are unsure of where to go next and frenzied by this new freedom of being unbound to an iron fist that might as well have punched the now bruised face of the universe or even the basement wall, blaming the mass of a billiard ball because that's the easiest thing to do.

The best case scenario would be that the core, now neutralized after having such a temper tantrum, will become a neutron star, which is only about as large as a city and has a mass about 1.4 times that of our sun. The typical speed of rotation for a neutron star is 43,000 rotations per minute. This can be best visualized by simply turning a common kitchen blender on the highest setting and watching the blades spin.

But I've learned temperature is inversely proportional to mass. If the heat of the raging core collapse was too great, there's a good chance that there is too much material hanging around what's left of the core. This weight overwhelms the degeneracy pressure again, and the clouds are sucked back in, cosmic cigarettes, still visible but more vaporous now, to a small and circular

dent beneath where a cheekbone was struck by a fist. The ball slowly becomes more massive, accumulating the weight of chaotic supernova debris around it, everything falling back into it, yet it remains incomprehensibly small for its density. So no, sometimes this stable bundle of atoms doesn't turn into a neutron star.

Sometimes it turns into a black hole.

My brother Jason once told me that Kira thought I was delusional and lived in my own fantasy world. They had been sitting at a bar when she said this. She was still sober then.

About a year afterwards she drunkenly found her way to Mom and Dad's house and pounded on the front door until Dad finally let her in so she could stumble down the basement stairs to collapse on the sofa. I, still in high school at the time and holding onto a disdain for her that even I misunderstood, peered out of my room to look at her, slumped over the armrest, before determining it was safe to make a dash across the hall to the bathroom to take a shower. After closing the door behind me, I silently stared at my unscathed face in the mirror, imagining the twitch her cheek still makes when she gets tired or upset. She was sobbing.

I eventually did creep out of the bathroom, approach her, and hug her slender shoulders. I gave her a glass of water along with a tissue, gave her another tissue when that one became tear-sopped, and finally gave her the entire box of tissues – my last box. Holding her hand, I hugged her again. And I told her I loved her.

I didn't know if I meant it.

When Mom came downstairs, I retreated back into the bathroom and turned on the shower to pretend that I had an actual reason to stay in there for as long as I did when really I sat at the base of the door with my ear pressed against it, listening to her sobs and thinking about

how her tears pooled funny near the dents in her face. I thought about how those dents looked when she sucked in the smoke from a cigarette and how sometimes clouds of hazy debris after a Supernova hover too close to what's left of the collapsed star core, and they start to get sucked back in too, still visible in their swirls but more vaporous, into the small dent where a universe cheekbone was struck, and the core gradually becomes more massive, accumulating the weight of hatred and chaotic supernova debris but remaining incredibly dense and small until finally there is enough compressed and repressed matter to make a black hole, hiding everything it knows and feels beyond the threshold of its gravity.

I couldn't hear much of their conversation through the threshold either, but I stayed and listened until they both went back upstairs and she left to go home. I emerged from the haze of the bathroom to where she had been sitting and rested my hand on the spot still warm from her body. There was still a small dent in it, despite her fragile frame. She had left the tissue box behind. It was empty now, and I turned it over in my hands, peering inside it. I don't know what I was looking for inside that box, but I know I thought it was funny how I never needed to use tissues for tears, and I wondered why I didn't cry. I wondered why I didn't feel anything.

If a magnetar passes too close to Earth, it will completely disrupt everyone's nervous systems – we won't be able to feel a thing. What's worse is that we won't even notice that we can't feel a thing. Because we will all be dead. If a magnetar comes close enough to destroy all human feeling, it will likely come closer still, destroying the forces within the very atoms the universe is made of, counteracting covalent bonds, dissolving everything in its path. This is because, as the name suggests, magnetars have a magnetic field powerful enough to scare a black hole. To put this further into context, Earth's magnetic field measures at about one gauss.

Multiply that by a quadrillion. Now we have a magnetar. Except a magnetar is only about as large as a small city, and a mere teaspoon of it would weigh one billion tons.

A magnetar is forged from the same iron-fisted supernova as neutron stars, caught amidst the swirling embers of red and orange debris, hoping that it doesn't become a black hole. Except it never expected to become something just as terrifying (if not more) than a black hole. And while black holes are abundant throughout the universe, there have only been 15 magnetars detected, and they are only detectable when they flare up. I won't mention that there's one just barely across our own galaxy.

Magnetars can be simultaneously hot and cold with a crust that has a temperature substantially higher than its core. I often find it difficult to wrap my mind around this notion because temperature is supposed to be inversely proportional to mass. But magnetars have a superfluid layer beneath their crusts that disrupt their blender-like rotation. Sometimes an anti-glitch effect occurs, and the magnetar's rotational velocity slows a great deal. However, this doesn't affect its magnetic power, and it still undergoes starquakes, crumbling its own crust into shifting fragments, a strange self-inflicted punishment for its inescapable rage.

Astronomers have now proposed that magnetars could have also been formed from two extremely massive stars orbiting each other in close proximity, companions in a binary system, spinning around each other amidst a large backdrop. Spinning so fast that the backdrop would appear empty because the blur of all the other stars would dissolve around them. I sometimes wonder if a magnetar's guilty starquake rage detonates because it swallowed its sister.

Dad once asked me if I smoked too as I walked through the back door, returning home from my first year at college. Confused, I told him no and asked why he had said *too*. I didn't

know she had started smoking, and I was surprised Mom and Dad found out before I did. I wondered if they knew about the time I dragged her nearly limp, drunken body, a mere paperweight to me even back then, to her room, pulling her up onto her bed and tucking her in before cleaning the entire basement, hiding liquor bottles, beer cans, articles of clothing left behind, scrubbing vomit from the floor, scraping food and cheese off the wall, unclogging the bathtub drain that was gurgling up something black and grimy. I wondered if she knew I did this. I wondered if she cared.

Whenever I'm back in that basement, I still sometimes sit in the dark in front of the patio door, staring at my reflection and wondering how much she actually knows – about me, about us, about then. People say we look so much alike, that we are visibly sisters. I either don't see this or choose not to. But I look closely into my own eyes and think about how each pair of eyes resembles a different nebula leftover from a supernova. There's the Orion Nebula, Cat's Eye Nebula, Lagoon Nebula, Rosette, Horsehead, Eagle, Crab. Mine look like the Helix Nebula with its distinct aqua blue and small speckles of lighter blue interspersed throughout. Hers are no longer as blue as they are in old photographs. Instead they are gray, smoky and swirling with small flecks of black ember embedded in them.

There is a photograph somewhere of her and me when we were still little enough to play dress up. We are standing in the kitchen of the old house in front of the peely cream wallpaper, spotted with little blue diamond shapes. She's making a quirky pose mid-laugh, bent half at the tummy with her arms flung outward, like a smooth doll in her frilly skirt and feather boa. Her enormous blue eyes and open smile, her mousy brown hair frizzled around her face. And me to her right. I'm standing stiff against the wall, leaning slightly out of indifference, trying to appear cool in front of the camera, or maybe just in front of her. A loose smile on my face looks more

like a snarl, my head tilted slightly upwards, chin jutted in pride that is poorly disguised as defiance of the pink Barbie dress I'm wearing. False pride that says I absolutely can't be wearing the pink Barbie dress my cool big sister is too old for. I feel it is still photos like these that characterize us best.

I have since shoved these photos in a box somewhere, information lost beyond their event horizons. I'm starting to feel their weight now. I now hate the color pink. I hate closets big enough for sisters to share. I hate rooms that are too large, and I hate how small and helpless I feel in them. I think I have forgotten how to laugh. I think I have forgotten how to cry and give out tissues and hugs. But I remember what color the basement sofa was and how Kira looks when her slender cheeks exhale heat and smoke. I remember that temperature is inversely proportional to mass.

It wasn't always like this. When we were little and still lived in the old house, in the warmer hours of sunset, we used to dart around the old front yard catching fireflies. We would stand still for moments, glancing smiles at each other before lunging after a firefly until one of us caught one. We would watch it walk from finger to finger, holding our breaths as we marveled at how it lit up and dimmed lit up and dimmed, a golden ember in our hands until it flew away into the chaotic cluster of other fireflies that were only visible if we stood still enough, if we could be motionless observers in black space. We would hold hands and spin among them until we fell down to gaze at the constellations, pointing out the ones we knew and making up the ones we didn't, pretending we knew so much about space and galaxies beyond our own threshold, pretending we knew so much about entropy and its relation to heat and mass. You squeezed my hand and told me to never grow up. I squeezed back and told you I love you.

Gravity Non-zero

When I was a child, I once took a red wood-handled broom outside and stood in the middle of the long gravel driveway, the broom between my legs, willing myself to fly. I made sure to give myself plenty of space because I'd probably have trouble steering at first. But the more I ran, jumped, fell, ran jumped, fell, the more I realized my broom was broken – it couldn't lift me off the ground. I tried sitting on it sideways, backwards, even standing on it, and eventually I went to get a different broom only to discover the same problem I encountered with the first. With splinters in my hands, legs, and knees along with gravel embedded into my palms, I resolved to go back inside and surrender the thought of flight for the day.

There was nothing sudden about my realization that I was in love with physics and astronomy. It was more like a faint birthmark on my arm that I was always conscious of but ignored until I eventually grew to love and embrace it. It seemed the most rational of the maths and sciences while simultaneously being the most irrational and imaginative. It took care to acknowledge the infinite as well as the small and seemingly insignificant, taking extra pains to make everything feel included, to make everything belong in the complex, multi-variable universe in a unified theory. Everything except gravity, that is.

Because gravity is a lie.

Gravity and I spend our days obsessively dropping things. The best spot is the mint green bridge crossing the Iowa River, right in the corner next to the stairs because there's a buildup of frothy river grime there, and rocks, pennies, acorns all make a satisfying plup when they hit the water and disappear beneath the foam. I've developed an irrational fear that I will someday drop something important, like my phone or wallet, into the river just to watch it careen through the air, turning uncontrollably on its axis, pulling back on the Earth as the Earth pulls back until they

finally collide. It's not the collision that fascinates me but rather the suspension before it. Freefall is a form of suspension, but to me, the pennies I drop are moving towards the water at a rate of 9.81 meters per second squared. I can calculate this simply with a timer and the height of the bridge, but I know there are two problems with this. First, gravity on Earth's surface is not a constant value, nor is it constant anywhere else in the universe. Second, I only witness this particular gravity because gravity is relational. It all depends where stand.

I've always had a funny relationship with gravity. As a dancer and tumbler, it always felt like I was fighting against it. The day I learned how to do an aerial – a cartwheel without hands – the moment before planting my foot proved crucial because I could either pitch my face into the blue fabric mat or push hard enough to launch my other leg over the top of my head, arms spread, upside-down helicopter. The fear of face-planting overwhelmed the fear of landing wrong, and I always jammed my foot into the ground a little too hard each time I landed. By the end of practice, my ankle was extremely sore and a little blue. For the next month I wore an ankle brace, and even though I had overcome gravity to do an aerial, my fight with gravity to obtain that skill caused me more trouble than I imagined. Even though I overcame gravity for that short time, gravity still somehow got the best of me. It was months before I could confidently do another aerial.

My older brother Jason and I used to jump on the trampoline, and we would sync our jumps to launch me into the air. Of course everyone else saw the danger in this because of our weight difference and how high my small body flew, but I only saw it as great fun. The ground shrinking fast, the suspended gut drop at apex, wide smiling and hair rising on end as I try to permanently capture a picture of the world from up high. But flying was easy – it was the landing that had reason for concern. Suspended, nothing could hurt me, but gravity was always

attempting to force me back into the ground. Our fun ended one day when I fell backwards off the trampoline, my forehead smacking the trampoline's steel supporting leg so hard that even my eye turned purple and black. Jason says it was one of the grossest things he's ever heard.

I really started to love math and science around the time we moved into the new house. Nothing made sense to me at that point in my life – my older brother was leaving, my sister felt distant, my parents seemed to argue more often than not, and I didn't have any friends that I could turn to. So the only thing that made sense to me were the cold hard numbers who couldn't hit back when I pounded my fists into them. There was right, and there was wrong, and there was hardly any wiggle room between them. This distinction, this solid law was what I needed at that time, and math became the only problem I could solve that had a definite, final, correct answer. Math and physics, in the end, were the things that taught me I could punch and punch and flail and kick until I'm too exhausted to be angry anymore, but the problem would still not be solved. In fact, the problem was usually made worse.

My dad and I used to play chess frequently. In fact, he taught me at such a young age that I actually don't remember when or why I learned to play chess at all – it feels like something that's forever been floating around the open space of my mind. He always started by moving his right Knight, and I always started by moving a pawn out of the way for access to my left Bishop. Sometimes we talked a lot during our matches, sometimes we talked very little, but his kind patience, no matter how long it took me to decide on a move, was an unquestionable constant in the formula. I remember distinctly one night when my sister was at prom, my dad suggested that we also stay up super late to play chess until she got home. I guess this was his way of making sure I didn't feel left out of the fun, even though I wasn't even in middle school yet. We played until she came back from the dance, and we continued to play long after she had left for the after-

prom party. Years later, I still sometimes open the game closet doors just to peek at the chess board and roll between my fingers the delicately carved ebony and ivory pieces, always a Knight and a Bishop. I'm still convinced that he let me win most of those matches.

Chess has been his and my game since I was little because nobody else seemed interested in learning its rules and developing the skills to play it. My dad once mentioned that he and I shared a similar intellect, and I think there's a lot of truth to that since we both gravitate toward numbers and puzzles. To us, chess was a strategic puzzle made more complex by the participation of an independent thinking mind – it was a puzzle with constants as well as ever-changing variables, rules and boundaries affected by a near infinite number of potential moves and strategies. Chess is a lot like gravity. Both depend on many variables, both seem to have certain rules, and neither one is an actual force in physics. But chess doesn't claim to be one, so I guess that makes gravity a liar.

Most of my life feels like it's been spent trying to figure out why gravity lies. Though gravity is likely what brought physics and me together, the fact that it's not technically a "force" is still hard to wrap my mind around. I can calculate the "force" of gravity between two objects with a simple formula, but the two objects have to have mass, so I still don't know how the math would function if one of us had mass and the other was massless. Gravity brought me to physics and astronomy, but this force is incalculable because I am the only body with mass in the equation. I can't gravitate toward something that has no mass unless some other physical concept applies or gravity is not truly the force it pretends to be.

There was one time my best friend and I were simply walking around downtown, and for some reason I thought it would be funny to try to trip him. Walking alongside each other, I kept sticking my foot out in front of him while nudging his shoulder saying "don't fall! don't fall!"

Except within moments my knee was in the sidewalk, my hands futilely splayed out to catch me, and I somehow ended up on my back staring up at him, dumbfounded. Another time I was jogging from one side of my apartment to the other, which mysteriously resulted my face smashing into a wall because I fell mid-jog. I probably shouldn't even mention the time I was simply standing in a doorway one moment only to find myself collapsed onto the floor the next for no logical reason. We all like to joke around and conclude that I'm just bad at fundamental things like walking or standing, but clearly gravity has it in for me. I just wish I knew why.

The Des Moines Skydivers used to come to an airport near my hometown Labor Day weekend each year to host a skydiving extravaganza, and willing patrons could opt to tandem skydive for a fee. I paid some amount over two hundred dollars to find out that I have exactly zero qualms or anxieties about leaping out of a mid-flight helicopter. They assigned me to tandem jump with an insanely tall man who asked as the helicopter ascended if I felt nervous at all, but nervousness hadn't even crossed my mind or crept into my gut because the rising altitude numbers on his watch held my whole attention. Three thousand, five thousand, eight thousand, ten thousand, twelve thousand, what does Earth look like from up here when I'm unrestrained and unsupported? When I fall freely into it? I didn't hesitate to jump to find out, and I remember watching the ground expand towards me, my arms and legs splayed wide in an X pattern, feeling the pressure of the strikingly cold air stretch my cheeks backwards into an involuntary smile that allowed more air to force itself into my mouth. I couldn't have screamed or cried or laughed even if I wanted to. The endless crystal sky was filled with air no human had likely breathed yet, and I swallowed as much of it as possible while the ground became larger and larger until the parachute jerked awake to slow the fall. The sky was saturated with a smooth, gliding silence

that permeated into my mind, allowing no thoughts to form or distract from this seeming freedom from gravity.

Falling from a cliff or jumping out of a helicopter would be exactly the same as floating in space if we could eliminate the upward force of air drag or atmosphere. So falling from a cliff is actually floating from a cliff, and floating in space would feel the same as being in a windowless room as it fell towards Earth. Ever since I realized this, the extended moments of skydiving have replayed themselves over and over in my mind, reminding me that gravity is relational to objects near enough to be affected by it. I never free-fell to Earth, the Earth and I drifted towards each other. Black holes don't "suck" things up, black holes and smaller massed objects fall into each other, but I only think things are sucked up by them because that's how it looks to me relationally.

I once sat in my freshman year dorm room and read over half of the astronomy textbook in a single day. Something kept me grounded to the text, and my orange highlighter was running dry by the end after marking everything that was either interesting, important, or odd. The same thing happened with my physics textbook, and even though every physics or astronomy book I have ever read have their own reserved, special stack in my room, I still have hundreds of notes and pictures from them saved on my phone in case the urge to re-read them becomes overpowering whenever I am dropping things into the river or am away from home. Whenever I need to be reminded that mathematically it is possible to drive a race car on the ceiling. That there are stars that are cool enough to touch. That it would only take a week for the moon to finally collide with earth after its accelerated orbit was disrupted. That without black holes and gravity we couldn't exist.

What I've always thought fascinating about gravity is that it distorts time. Larger massed objects have a higher gravitational force, causing time to pass seemingly slower than – than what? The speed of light has been surpassed by gravity from a black hole despite gravity being labeled as the weakest force in physics compared to other forces such as electromagnetism or nuclear forces. The graviton doesn't even have mass even though the more mass an object has, the more gravity it has. The weakness of gravity demotes it from any prestige it could have in comparison to other forces because it is so different. It's so different that gravity technically isn't even a force. It doesn't seem to really belong at all. Maybe that's why I love it so much.

In the seventh grade, there was a window I used to sit next to in science class. This window wasn't particularly significant, but I do remember staring out of it one particular day, inwardly pleading to become as invisible and transparent as the glass. The instructor had been talking about how technology and robots have become crucial to society, that they do exactly what they are programmed to do and the only reason they fail is due to human error in programming, that robots are predictable and reliable. They do as they are told and nothing more, they don't make mistakes. They aren't humans.

This lecture seemed fine to me as I doodled in my notebook. Until somebody from the back of the room blurted out “Miranda's a robot.”

I remember feeling every eye burning on me after that moment, and disappearing altogether suddenly seemed like the best idea in the world. They might not have meant it as an insult, but no matter how I interpret that remark, it still fundamentally stands as my demotion from humanity. Too different. Don't belong. Inhuman. Nothing.

My face felt hot with shame, but no tears welled in my eyes despite how much I wanted to cry. My hands were shaking, the room was shaking, and the world had turned itself inside out

into a horrible black void that I was frozen in. Nobody said a word, and no sound was made except the sound of every mean thing, every name, every belittling remark resounding in my skull. And the skull dark numbness somehow hurt because nobody came to my defense – not even me. Even now, sometimes it feels like I'm clawing at the inside of my brain, but no matter how hard I try, I can't escape my mind and all that's in it. That person still has no idea the gravity of that single remark.

I hate to admit it, but this feeling of differentiation, a puzzle piece that couldn't fit or an equation with no answer, further qualified every reason I had to dwell on my insignificance. But gravity was different too, lying about its place in physics because it wanted to be as important and as captivating as the other forces. Except it didn't realize it already was significant because it's what keeps the moon in orbit, keeps the Earth dancing around the sun, keeps our solar system from flying uncontrollably through space by its continuous balance with the black hole at the center of our galaxy. But I really think I understand why gravity lies, and I think that's why I've always had such a strange relationship with it.

Even now gravity remains a favorite of mine in physics. The only difference is I just know better than to let lies deceive me like they did in my childhood. But gravity distorts time, and certain times feel farther in the past than they probably are. This is one deceit I can forgive gravity for, I think, as I stand on a bridge and drop pennies into a foamy river. I have started a new habit of assigning a negative thought or feeling to each penny, rolling the dirty copper between my fingers before dropping them. And I let gravity take the weight of these burdens, freeing me from pains that still sometimes hold me down, because gravity knows I too was once made to feel different, insignificant, and laughable. And you know what? I was.

Because I almost believed it.

Shifting Winter Cemeteries

Someone once told me that Africa gets in your blood, and you can't get it out. I didn't think much about this then because I was convinced I wouldn't even be able to get the red-orange dirt out from inside my ears, under my fingernails, scrubbed out of my skin, rinsed out of my hair. But I now know what they meant – it's soaked through my every pore and throbs with my every heartbeat. It's pooled warmly where my hugs are, and it's congealed itself to my sorrow. In some places it's grit dry – an eternal internal itch, and elsewhere it's drowned and frozen smooth. In other places I think it's just dead, or maybe it's killed me – a rank fermented venom spread deep like dark matter and close as my own shadow. I let Africa get in my blood. And though there's a lot of Africa I want to keep loving in there, there's a lot I want out.

I also know that while I was there a lot of the people wanted me out too, wanted us out. This was a consciousness I felt strongly in the cold stares from people I passed on the street, the children running after our bus, and I understood why we weren't wanted there walking in the same streets sweaty white travelers like us had walked before, preaching deliverance who-knows-what with a white-savior complex and pretending to save complex lives they know nothing about. After decades of being treated like un-tamed animals ogled at on a safari, I wouldn't have wanted me there either, and this weighed heavily on my mind even as our brothers and sisters at the synod office smiled and hugged us in welcome. Our goal wasn't to convert anyone to anything or sermon anybody to salvation – we were there to see family, our companion synod, and strengthen our relationships through celebration, conversation, exploration, and many hugs and tears. And though we were invited to come to Africa, I still felt like a walking germ amidst the clean. And I can't forgive myself for what harm I might have left behind.

I have this filthy red journal I keep wedged underneath a stack of books, AFRICA written emphatically on its cover in sharpie. Its jagged jaws grin within the crumpled pages, and its red predatory eyes seem set on me with feral frayed stitching stained a little orange from the African dust as if ready to unhinge itself and everything written in it. And that stack of books is my personal way of chaining it down, hoping to crush its spine so it might not torment me anymore. So the words I wrote in it won't torment me anymore.

I feel incredibly pathetic as a person because I am wealthy in material ways but poor in the heart whereas these people are steeped in riches of the heart, where it matters most, even though they have so little. And what little they do have they are so proud of (an empty plastic bottle for a toy? Seriously? Any American child would throw a fit).

But Pastor Fraley made a good point – our interactions are showing love which makes us not so pathetic. And whenever you open your heart to love, you're guaranteed to have pain with it. But I guess I'd rather take both than have neither.

On a side note, I'm finally getting used to being always covered in orange dirt here. However, I will NEVER get used to the cold.

For some reason, my hands are chronically cold, and I can't remember a time they weren't. Nor can I remember a time when I wasn't trying to understand why my hands were so cold. In elementary school, I once convinced a friend that I was a vampire because of this frigidness. My deathly pallor, insomniac qualities, and strange like of the taste of blood helped make this diagnosis feel accurate. She went home in fearful tears to her mother who then called my mother to notify her of what I had convinced my friend. I lied and told my mother that I didn't think my friend would actually believe me, and in reality I didn't think she actually would – I just wanted her to. I was more or less trying to convince myself the coldness existed for more

imaginative reasons, and if other people believed my story, then it must be true. I wanted to make myself believe I had a sort of mythical disease that could be cured with wooden stakes, garlic, or holy water, that any story could be true except for the true one. Which was that I was parasitically diseased. And any mythical story at all was more comforting than the reality that I had tried to sell my soul to something I no longer wanted to believe existed.

I've always held a strange fascination for this complex stuff called dark matter, and more is unknown than is known about it. We know that about 27 percent of the universe is made up of dark matter, another 68 percent is dark energy, and not even 5 percent is whatever we call "normal" matter, the stuff we can see and understand and interact with, though I'm not sure why we call it normal matter since it appears to be in the minority, an anomaly in the universe. And to us, space appears to be mostly empty when really it's the opposite, but I remember lying on a dark rock in the middle of a Tanzanian night and thinking the sky never looked so full of life and light, and vibrant were the empty spaces between the stars and I wondered what actually passed between them. I remember thinking the sky must never end and that it won't because dark matter matters less to me than dark energy which perpetually sprawls itself across the cosmos, an anti-gravitational ancestor claiming space, space, and more space until I can't tell the difference between alive and deceased or alive and diseased.

When I think about exorcisms, I try not to think about them. Somehow, though, I end up returning to one moment of spiritual ruin, and I think about darkness, about the eternal, frigid winter nightness, the single streetlight illuminating a solemn concrete stage. I think about the cringing bloodscream, darkened pools in the red dirt creeping their wet shadows, the night seeping through the window, the stained yellow curtains flailing against it, my right shoulder jamming itself against a wall while I choked on a stone in my throat, unable to explain to my

fellow missionaries that *I think I had something to do with it*, and repeating prayers in my head to take up the space of dark things I didn't want to remember. I think of people hugging their knees on the ground, ashen faces buried from the grim news that weighed thick in the air, helplessly shaken and shaking helplessly as their eyes jumped from one another asking, "Why?" but I did not ask why. I knew why. And I died a little bit that night.

It's been winter ever since then, and I am still always cold.

Ugh, feeling cold and gross today and ready to go home.

Listened to a Peace Corps guy talk about how the doctor here tried to tell him he had some broken vertebrae. I think he was on drugs. Super funny guy though – nice Zanzibar jersey he was wearing too. He seemed rather interesting with a colorful background. His idea about death here was interesting too. I think he said "die" about thirty times in the same paragraph. "People just...die here. You know they just... die. They die and – well, they die. Sometimes they even get sick and die. It's not a huge deal because people die. Just die."

I like to believe that when we pass away we aren't just wiped out. I think it's more like our energy shifts into a different dimension, but traces of us can occasionally remain here in this one but are much harder to find. I used to think what was left of us would be dark matter since matter can be neither created nor destroyed, but now I'm convinced that dark energy is truly the energy of the dead - trees, plants, animals, more specifically humans. $E=MC^2$ has to apply to everything, including us, otherwise it wouldn't hold true. So we can't simply vanish - our energy must be dispersed somewhere, somehow, someday, and in some form, and that form must be dark energy, so the reason dark energy has anti-gravitational tendencies is because of this continual death accumulation, pushing the universe outwards on itself like air being blown into a

multi-dimensional pink latex balloon. But I think instead of pink mine is red, and I'm still trying to crush it beneath a stack of books.

Maybe I'm overthinking things, but the journal weirds me out because it seems to be mocking my theory by means of supporting it. There are random pages just shorn out of it, like something was meant to be wiped out, which might seem normal, but I personally am incapable of tearing things out of journals for mere aesthetic and preservation purposes – I just don't do it. Period. It's out of my character. But the last page has been violently ripped out, and traces of whatever was written there are slightly imprinted onto the back inside cover, just faint enough that I can't make out what it says besides a couple very strong *Nos*.

But maybe I'm just afraid of dying, of becoming only a faint trace of my own soul. Maybe I'm afraid of my matter shifting energies and being pushed further from home than I'd want to know. Maybe I love too little of the universe too much and too often lay on safe rocks in the night, gazing at that same sky even though now it feels empty and frozen, and the coldness molds itself to my bones, and I've grown so close to this cold that I've forgotten I am somehow alive. But maybe I'm afraid I'm already dead because I hardly recognize this flesh vessel I'm in.

I can't believe what happened today. Nobody's going to believe what happened. Fraley saw it too, so I'm not crazy. God this really can't have happened.

We were walking back from talking with the Chaplain when a girl came up to the Chaplain, pleading for her to come help a sick girl. She seemed urgent, but we figured she just ate some bad chicken or had a fever or some physical ailment. Not thinking anything of it, we went with, but we were not expecting what we found. This girl was anything but ill.

She sat on her dorm's concrete steps, shaking her head saying she felt funny and that something was wrong. None of her friends could calm her down and she just got angrier and

angrier to the point where she would attack anyone who came near. She flailed her arms and snarled at anyone who tried to touch her, she clawed at anyone who spoke to her and eventually she seemed to lose control of her limbs altogether. Five of her friends grabbed her arms and legs to stop her thrashing so the Chaplain could bless her and expel whatever evil she was against, but this didn't work so the girl just screamed.

I think that scream was the most blood churning scream I have ever heard in my life, and I pray that if I ever read this again, I will have long forgotten the sound of it. It was double-toned – it sounded both like a strangle/gurgle but also like twisting steel. I think if death and hatred could have a voice, that is what it would sound like.

So she was half dragged half carried to the concrete stage where we usually meet for prayer each morning and evening, and her friends set her body onto it. The entire time this is happening, the Chaplain was blessing her and praying for her, trying to free the girl of whatever she'd been overcome with and bring her back. In the weak light from the streetlight I noticed her eyes were less like eyes and more like black marbles sunk into her face, rimmed a little red. She started to seize, and she looked like she was drowning or suffocating underneath something we couldn't see – her arms still flailing the entire time. I thought for a minute if she was burning up or if somebody had somehow set her insides on fire and she was burning to death right there in front of us in the dark. I think we all thought we were going to lose her.

The Chaplain started shouting her blessings and prayers, and finally put her hand on the girl's forehead while pressing a cross into the girl's chest. After another scream (ughhhhh it was just as terrible as the first one if not worse) and the girl's entire body went limp.

After a few moments, the girl sat up with the help of the Chaplain and her five friends. She had no memory of what just happened, and only asked us what happened and why we looked

so terrified and why her friends had wounds and bruises. The Chaplain was still out of breath at this point, but she bent down next to the girl, grasped and shook the girl's hands, whispering, "You must remember to pray."

We had a company meeting after we got back to our cabin, and nobody took this news very well. News in Africa, especially Tanzania, is always good, but there was nothing good about this. Our group discussion about this more or less made me more upset. Mainly because everyone seemed really closed-minded about it, and people were trying to give answers to and explain something that there really is no rational explanation for. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] *exactly why I don't talk about this.*

I just had déjà vu while writing this. So I guess I'll just leave my day at that. I think a part of me has just died.

What I find so funny about dark energy is that it shouldn't seem so dark to me. Elusive or hidden might be more appropriate words, but never dark. I know it's only called dark energy because it doesn't interact with light, but calling it dark gives it a generally negative connotation. Maybe I only think this because I'm discomforted by the notion that the universe is saturated by

something so sinister sounding, and I'd rather think of it as being embraced by, I don't know, love? I mean, if time is the fourth dimension (and there's a lot of debate around that anyway), it makes sense to me that all the higher dimensions would have love as a main fabric, hidden from us because we are limited beings. And, not to stray at all, but doesn't the Bible say something along the lines of "God is love"? If He really did make everything and is everything and the universe is Him, I'd expect the universe to reflect that in a major percentage, even if I don't completely understand it. Even if I call it dark matter or dark energy or exorcisms and really they mean no harm because they just are. I only wish the universe didn't scare me sometimes.

Was feeling really sick yesterday, so I forgot to do a journal entry. Oops. Oh well.

So, back to yesterday. We had to say our final goodbyes to the girls at Igumbilo, which was really hard because the night before they swarmed us with hugs and notes and love. But hopefully they will remember us by our love as well as their newly painted dining hall! I know I will miss them all especially bad and won't ever forget any of them.

Back on the note of the girl who got possessed. I can't get that out of my head. I don't even know what I'm supposed to say or what I'm supposed to feel. I just have this weird feeling that it's my fault. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

don't want to think about it anymore.

A few months after I got back from Africa, my mother heard that some of us had seen an exorcism there, and she asked if I had seen it. I don't think she understood exactly what dark matters she was asking me to dig up. I don't think she understood the empty death inside me, the dead memory I wanted left buried in the dark and cold, so I shrugged and said, "yeah, I guess, if you believe in that sort of thing." She hasn't asked about it since. I haven't talked about it since.

The cutest thing happened to me when we first arrived in Ruaha (it was much needed too). We were on the balconies of the main building (I was on the lower one) enjoying the view when all of the sudden this adorable little girl comes and stands next to me. I didn't think anything of it because she seemed occupied with kicking the stray cat away. But once the cat left she remained by my side – rather close might I add. Then without hesitation and to my surprise, she wrapped her arms around my right leg. Just like a shy child would do to her mother. She just... CLUNG to me like I was the best thing ever and stayed attached to me for what felt like forever. After a while, Fraley noticed us and said, "Well, Miranda, it looks like you've found a friend." And I replied, "No. I think a friend found me."

Because she did. That was the truth. That small gesture, that long moment felt... I don't know what I felt. But it was perfect. It felt perfect to be found. And loved.

Years later, I have found myself again sitting on the floor in my room, gingerly reading through the letters the girls at Igumbilo wrote to us before we left. Even though the paper is thick, it feels delicate, nearly frail, in my fingers, as if my cherished memories will dissolve if the paper does, and there's a rock in my chest that tumbles around when small droplets start appearing on the pages the moment I realize I miss them – each and every person. And there is no "them" and there is no "us" – there is only we because we're meant to be family. Families are

supposed to love and take care of each other. And I know that girl has taken care of me in ways I can't repay nor express.

It might be a stretch to believe that some invisible, entangled universe thread or loop or string-theory-complicated blanket brought her and I together. But I do, even though this idea seems wildly absurd and unlikely, because of this one particular letter written to me by a pen pal, randomly chosen for middle school culture studies, named Tanyeh many years before I even thought of going to Tanzania. She wrote about her favorite school subjects at Igumbilo, her hobbies, friends, her family. She wrote about her younger sister named Happy. And I distinctly remember walking arm in arm one sunny day at Igumbilo with a girl who taught me how to count to ten in Swahili, played soccer with me, sang songs and skipped with me, and hugged me tight every night before bed. Her name was Happy. She spoke about her family members that had gone to Igumbilo before. She spoke about her older sister named Tanyeh.

I wish I had learned the name of the girl I saw that night, but we left Igumbilo the next morning before the girls awoke. What I would say to her is unknown because apologizing feels like it would belittle her situation, and thanking her would be even more a belittling as well as an acknowledgment of my own harbor of dark secrets. And I don't want to acknowledge those, which only makes them and me worse. I don't even know if a hug would have sufficed because there are no words or actions to express anything about that night at all. But maybe it's better this way, better that we both don't know each other. Maybe it's better for us to have only briefly encountered each other. Maybe it's really not better though, but it's much easier to believe the universe maneuvered energies around and through us both to bring us together, not to save us from anything, really, but to remind us of what binds us together. To remind us that all matter, both light and dark, exist in us all whether we can see it or not.

Maybe it is a little morbid, me lying awake, aware of that painting and thinking it's strangely lovely because we are actively in the art of dying just as much as the art of living. This might be my way of reminding myself that death, cold, and elusive matter are okay, and the quiet dark of my room is comfortably cold, the pale wall against my back making it feel colder. I even leave the window open during winter, and the black curtains occasionally flail against a strong blast of wind, frantic against what we can't see. Sometimes I shine my flashlight in the corner, just to see if I can catch any elusive thing momentarily forgetting to hide. But my light usually lands on a stack of books, a bright red binding sneering out from the bottom, and I remember the things we want hidden often aren't. The things we try to hide from most, we most often can't.

I wish I could forget the shame and regret greasing my insides, the knowledge she experienced something so horrific, and we could only watch. This shame has spread to my veins now, and I can't help but believe we all share the same blood. All the world's blood was once bound together in a single particle and remains connected, invisibly intact, and all my infections and diseases infect others. I can't bury my mistakes under the weight of books, gothic novels, astronomy and physics textbooks, journals about dark matter and dark energy, guides to quantum entanglement and string theory. The truth is the fear of myself and what I had done a long time ago was projected onto somebody undeserving of fear and horror. I wasn't afraid of her or what happened, but I was afraid to admit that maybe I'm the one that needed an exorcism. That I am cold and defunct.

That I'm afraid I still am.

The Nth Dimension

“There is a theory which states that if anyone discovers exactly what the universe is for and why it’s here, it will instantly disappear and be replaced by something even more bizarre and inexplicable. There is another theory that states this has already happened.” – Douglass Adams

I grew up in a very strange house, and the strangeness of it strangled me enough that I eventually made an imaginary companion to be my constant comrade to cope with the horrific oldness of the decomposing hole I once called home. To this day, I’m still unsure whether or not that friend was actually imaginary, and even though my childhood home no longer stands – though “leans” is far more accurate – I still have nightmares about this place despite an undying nostalgia for it nestling in my heart.

I have always been afraid of windows ever since I was a little girl. This is mainly because I was continuously plagued by nightmares that the window next to my bed would somehow suck me up and trap me into an alternate dimension - a sort of personal hell that awaited me on the other side of it. As I grew older, this fear of windows translated and transfigured itself into a deathly terror of mirrors, but there’s no telling when this translation occurred because there was no single moment where I stood in front of a dark bathroom mirror and chanted an obscure ghost’s name, and though I’ve never been superstitious in the traditional sense, dabbling in those kinds of activities seemed reckless as well as ludicrous. No, I was afraid because I knew the physics of mirrors, and this disturbed me greatly.

When I first discovered the physics behind mirrors, I stood in front of one – counting and recounting the real and virtual images. First there was me in my physical form that existed outside the mirror, the real image. There was my make-up, glasses, unbrushed hair, the light fixture, the door, my television, stack of unread books, all of them I knew to be real. Then there were the virtual images that only appear where light doesn't actually come from. The light fixture gave off light, but somehow the light reflected in the mirror wasn't real, and I pressed my palm against the mirror to confirm the absence of space for light to truly exist in it. My fingers bent as I pressed harder to dig out space for light to really be there instead of simply filled in by my imagination, and the only thing I could think was *the mirror can't interact with light the mirror can't interact with light*, scanning for anything in the mirror that I might not see outside of it in the “real” world. I finally smashed my fist into the mirror, splitting it into crunching shards and splinters, some sliding down from their place in the frame, and my knuckle started to bleed as I bent to examine a fragment and the space around it, behind it. Because there's something else that can't interact with light.

Dark matter.

I've often wondered at what point in our lives do imaginary companions stop being imaginary or when they start to show up daily – hiding toothbrushes, spilling water glasses, poking our sides when we play piano, hiding behind blue leather couches, tugging covers off at night, pulling us down the length of the bed by our ankles, scratching us when they're upset, scrawling cruel messages in secret notebooks and carving strange images into hidden sketchbooks. Or showing up in the mirror next to our own reflections. But then I also think how imaginative I must have been to think this all happened.

It used to be a party house, the house I grew up in, though none of us knew that when we first moved in until multiple people came up to tell us we were living in essentially a designated drunk dump. Because it wasn't just a party house, it was *the* party house, and the previous owners used to throw keggers frequently. Its overwhelming darkness made sense then – what better place to conceal the wild ruckus of a house party than a dismal, decrepit farmhouse on an acreage bordering the fringe of town? And though I still hold a weird sense of pride for once living in a social hot spot, I tried and still try not to imagine anything that could have happened there, and this uneasiness is less about what guests might have done and more about the fact that house was flat out ghastly.

The basement was merely a rectangular dirt floor with buckling concrete walls and a large mysterious hole, about three feet in diameter, smack in the middle of the wall nearest the crumbling, slanted stairs. Greyed pink insulation had apparently been used to try to cover up the hole, but most of it had fallen out or was barely dangling from the hole's jagged edges. A few rocks adorned the floor beneath it, an indication of the continuation of foundational collapse. Either that or something crawled out and knocked some rocks with it, but the blackness was so pure and endless we couldn't tell if there was room for anything to live in there. My father finally went in one day out of curiosity, and though he has never been a small nor cowardly man, he emerged from the hole looking a little smaller and significantly less brave than when he entered, shaking his head saying *nope, nope, never again* and nothing more. We were always very alert of that hole whenever we were in the basement after that. I then believed my imaginary companion had some other imaginary friends that lived in there.

When I was little, I believed my imaginary companion would lie in bed next to me at night, keeping me company during the dark hours. At the time, this seemed quite comforting

because the strangeness of the house was overwhelming in the dark, but as I grew older, the more disturbing it felt to think something watched me while I slept. Eventually I wholly convinced myself that there was always some entity hiding in my bed whether I was in it or not, and the paralyzing fear of turning over during the night to find a decomposing corpse lying next to me caused me to become an involuntary insomniac, which I continue to identify as to this very day. Sleep remains dreadful because I'm still haunted by nightmares of strange smiling men in bed next to me. Sometimes in these dreams I will get up and yell at them to leave, and sometimes they will start chanting at me, or pounding on the wall, and sometimes this summons a horned beast into my room that tries to devour my insides until I wake up crying and squeaking out prayers and amens. Sometimes I'm not sure these things are even dreams, but I don't know if I want them to be the sole work of my imagination. I also don't want them to be real.

Most nights I anxiously stare at the dark wall nearest my bed and frequently turn my phone flashlight on and off, peeking over my shoulder, to confirm there's nothing on the other side of me. But then I remember that this weak light can't verify there's nothing there, that dark matter doesn't interact with light and there's a mirror now turned toward the wall to prove empty space is not always empty and my imagination might not be as strange as the fact that dark matter can be a fresh manifestation of the more unsettling strange matter. This petrifies me.

I've waited years for the discovery of something so insanely bizarre that it both defies all supposed laws of the universe while fundamentally explaining them, connecting every aspect of physics – interdimensionality, geometry, cosmic string theory and axially symmetric space-time, quarks, quasiparticles, quantum chromodynamics, thermodynamics, galactic rotation, an endless list with strange matter at its core. And as exciting as this is, I have a strange feeling we really shouldn't know all about this substance, and this feeling shifts around me in a smoky cloud I

continuously inhale, and it forebodingly flows through my veins, only ceasing its dominion over me once I break another mirror and remind myself I'm real. But I think of my imaginary companion and its friends in the basement hole, wondering if they're really the ones imagining me because I can't interact with them because dark matter and dark energy don't interact with light, but light means nothing to the gravity-control-freak post-supernova nub in its quasi stable state before ripening into an infamous, anomalous black hole. Light means nothing to strange matter.

I once poked my head into an odd looking hole in the closet corner of the house I grew up in. Unlike the basement, this hole had a precise square door with an immovable wooden nob in its center. The only way to open this door was to shimmy it around in its frame before sliding it out from the wall, and I remember wondering, as I set the door off to the side, if something died in that hole because it smelled musty and putrid. I don't know what I was expecting besides the infinity of dark nothingness found – the hole went nowhere for no reason, a yawning event horizon that sucked up whatever it could and spat out things worse than imaginary if not closed up properly. I still have dreams about this hole too, and I'm always opening it to discover that the abyss remains, but the door widens, swallows me. I fall endlessly in the dark nothing, not knowing where I am, where I'm going, or if there's even a place to go.

I haven't yet mentioned the other oddities of my childhood home such as the rust-stained jars filled with strange substances that appeared to glow radioactively behind their glass tombs. Or the boarded up door in a hidden storage room that nobody had the courage to ask what lurked behind or why it was boarded up. Or the one square ceiling tile that led to the rat-bat attic hell. Or the white hallway cabinet that was kept empty but locked for unknown reasons. Or even the fact the core of the house was sinking into itself, imploding into the basement below, causing the

lean-to to lean in on all sides towards the buckling center stairs. Or the million other things that I simply don't talk about. These things were all very normal to me. As normal as my life-long imaginary companion.

I doubt my nightmares will ever end, and mirrors will always be emotionally crippling, especially when I pass by one in the dark. But what maybe bothers me most is my imaginary companion – I haven't seen them even after all these years. I'm afraid to think they have disappeared and there is no way to know where they've gone or why. But I do know that when my father set fire to the house I grew up in, it screamed and screamed for hours, torched from the inside out along with every single strange thing inside, and that strange old house was replaced with an even stranger new house, but their anomalous qualities differed significantly, each one a separate singularity I lacked the capacity to fully understand beyond their respective thresholds. All I know is I somehow lived in the old house but somehow just barely survived the new one. And that old house is all imaginary now.

Time.

Three days. Three days is the maximum time capacity I can spend in the house I left behind when I came to college. Sometimes I don't even make it the whole three days because I'm convinced that, to be in that house, a person has to be either insane or drunk, and since I am no longer insane (I think) I prefer to be drunk whenever I am there. But, of course, this isn't socially acceptable, so three days is my max, and I spend most of this time looking across the acreage to where the old house I grew up in used to stand.

I know time travel to the past is impossible since our physical molecules can't go that direction, but I do know that for every event that creates a wave that goes forward in time, there is another wave that travels backwards in time – an extension of “for every action there is an equal and opposite reaction” or for every broken hearted woman there is an equal and opposite broken hearted little girl in her past, watching her childhood home disintegrate in flames. The deck near which she plucked a dozen four-leaf clovers, the creepy storage room she loved to stand in for no reason at all, the lightless rooms, the doorless and floorless upstairs bathroom she flooded once or twice, the stone chimney that squirrels occasionally fell into, even the basement with its mysterious hole in the wall – all of this gone except for the woman's memory of them. And this woman frequently wishes to send a message to said little girl saying *just run in there, in the flames, it will only hurt a moment and you can die among everything you ever loved.*

And she often wonders if her unseen waves of love travel back to their source at the exact moment of initial emission. And if the little girl can feel them.

There's a beat-up Steinway sitting in an empty room at the new house, and this is the first thing I go to whenever I find myself back there. Somebody has closed its lid, and a laptop sits upon it in a layer of dust along with some storage boxes filled with junk my mother is trying to

sell on eBay, but I brush the dust clumps away and lift the hurt, glistening lid and the fallboard. I stand there a few moments, feeling the dead and dust inside me too, before sitting and stroking the keys who smile despite my prolonged absence and neglect. And I always play the very first piece I ever composed before playing anything else. I don't know why. A lot of it likely has to do with string theory and quantum entanglement and my own hope that there is a dimension where a little girl didn't have to watch her world burn and scream from the inside out or that time will favor her by relaying this melody that only she knows. I think I secretly hope she will hear it and remember me.

I hope she remembers me when she sits down at the piano, her little fingers still too small to spread a whole octave. She will forever recognize the strong cosmic feeling that the music was coming from somewhere else, but she won't know an old Steinway played by her own older fingers carried the tune until she finds out she needs to understand string theory and strange matter to explain the darker matters that happened in her lifetime, before she can really fall in love with her life and things like pianos and old photographs.

When I look in the mirror now, I see everything that's ever happened to me, and the images appear to be very real instead of virtual because they're etched into my face, not unlike the crevasses visible on my sister's, but mine are also seared hot into my arms, stomach, legs, hands, throat, even posture to make one glowing, nebulous entity that is entirely invisible to everyone but me. They make a closely pulsating, parasitic dark matter, a breathable gelatinous smoke that fills my lungs and flumes through my body before oozing out my pores only to be inhaled again, and I'm still terrified to look in a mirror because I don't want to see these things. I don't want to remember every version of myself because some of them are dead to me and others

have simply died, and each time I find myself standing face to face with my own living corpse, I turn cold and die a little more.

Some people say everything gets better in time, but I am not one of those people. There is no reconciling with the wretched people I once was nor thanking and apologizing to the cherished children I used to be for all the wrongs they've been put through. They will all exist simultaneously in a time-fluid dimension attached yet imperceptible to the one I'm confined and confined in. I can't embrace them or whisk them out of traumatic situations like housefires or exorcisms, abuse, loneliness, or neglect. I can't hold their hands and tell them I love them or remind them to keep loving stargazing, pianos, physics, imaginary companions, unimaginary friends, sisters, and even themselves. No, I can only look at them in photographs from afar, knowing they will have to figure it out before they live long enough to understand what it all meant.

There is a photograph somewhere of my sister and me when we were small. I'm sitting in a plastic turquoise and yellow Fisher Price car, cheesied cheeks pout and all, with my hands on the wheel. She had apparently been pushing me around in the car and stopped to pose for the photo in her slick purple rainboots and her black hoodie hood pulled up, because my face is turned to glare at her and her face is turned to blow a pink bubble with her gum at the camera. She's holding the front paws of our copper colored dog up to her hip, and the dog nuzzles her hand to be let down, but she is bent forward with one eye peeking out from her hood as if to say *you're gonna remember me*. This is my favorite photo of us, and I wish I wasn't glaring at her or at least knew she would someday need her sister to remember her instead of heat, smoke, and black holes. I'm going to see her tomorrow.

But tomorrow doesn't make up for everything, and in times like this I wish the universe or God or even future me would send a message across the loops and folds of space-time, telling me things I should do or know because I am lost even though the universe is tethered together by an untearable thread, every dimension connected by webbing I can't see or understand but can feel vibrating underneath my skin. I sometimes want to cut it open to see what's there, to watch a red burst of blood erupt and run down my arm, and release the dimensions pressing against the thin membrane of this vessel I'm in. And this liquid iron from previous stars will fall, drop by drop, onto the ground because it is not mere stardust that makes us up. We are all made of parts of the oldest mother particle in the universe, the essence of the Higgs Boson awakens and stretches as we stretch in the morning, and the universe extends its limbs because it is not finished growing and time will not stop it. We are made of sunfire and wind and passion and breath and will not perish until eternity determines it no longer wants to be. And even then we will remain as glittering remnants of supernovas or dense clouds of diamonds that drop by drop fall onto Saturn. It rains diamonds on Jupiter too, and I wonder which ancestral drops I am descended from.

On nights when my mother and I would gaze at the stars, we would always take note how small and insignificant we felt compared to them and that our lives were a mere blip on the universe's clock. The stars had no interest in our lives no matter how long we admired them in their flowing dark blanket, nor was there any way to ask them to care about us in the ways we cared about them. But I think now, if we are descended from a single particle, those stars must somehow care and feel how we feel whether we (or they) know it or not because we were once them and they were once us, and I think time and distance have not entirely severed our connection. The thought of rejecting the idea that I have never been made of anything more than

merely me, tied to nothing else in the universe, is crushing. The universe must feel this too, but I can only do so much. There was one night, though, when the silence settled between my mother and I as we admired at the sky, and I remember her breaking this silence to tell me, still staring at the stars as she spoke, that if I do nothing else in my entire life, the very least I can do is find something to love. Because that will mean the very most.

And I think of that woman, the one who loves the little girl so much she would rather the girl perish in housefire than endure things worse than losing her childhood home to that same blaring blaze. Because if that little girl listened and plunged herself into the fire, she would never have to know billiard ball bruises, estranged sisterhood, death and dark matters that seep into her dreams, loneliness, insecurities about romantic relationships, a paralyzing fear of mirrors, or blistering hatred for anyone and anything that ever hurt her.

But she also never would have gotten to lay on safe rocks under an African sky, or sit with her mother on a green patio loveseat, or miss her sister, or have nostalgia for childhood homes, or become attached to pianos, or obsess about physics and stars and celestial ancestors to carry around in her heart. No, she might not have known heartache and hatred, but she also would not have ever known love or that this woman was really with her all along. That I am with her all along.

Love's Cosmic Structures: A Critical Essay on *Quanta*

All my life I have loved math and science, and in high school I discovered physics which turned into an obsession with astronomy in college. I can trace this obsession back to childhood nights when my mother and I would sit outside staring at the stars, and I would do pseudo-calculations in my head regarding the galaxies while she and I would take a jab at philosophy in candid, sentimental conversation about our everyday lives, the occurrences in them, our hardships, our joys and strengths, social issues – there was no such thing as a taboo topic while we were under those stars. It's no surprise, then, that the more I toyed with the idea of doing an undergrad project, the more I was drawn to this strange combination of abstract sentimentality and security of love within the realms of scientific thought and the more I wanted to capture and recreate the feeling of these moments. This thesis functions as an attempt to explicate universal, existential questions by uniting two things that seem irreconcilable – multifaceted human existence and astrophysics.

When I decided to write a collection of non-fiction essays, much of it was fueled by my very real need to purge my mind of my own misunderstandings in life, guided by the fundamental aspects that can be applied to the universe in general – physics/astronomy, how the universe loves, and narrative. Being a student with background in the discipline of physics and astronomy, I have a habit of attempting to justify every experience (especially hostile ones) through physics and astronomy. This habit of mine transformed into a desire to share these sentiments with others in hopes to reach their own experiences and emotions, offering a sort of sanctuary of thought that rationalizes the (sometimes terribly brutal) world, reassuring that love exists in everything as long as we strive to seek and identify the many forms love can take.

Much of my previous work has been separated into two distinct categories – science writing and creative non-fiction narrative. However, for this project I decided to attempt to combine the two writing styles in a way that seamlessly reflects the union of ourselves and the universe, allowing them to converse with each other and potentially answer questions the other poses and has difficulty answering. The audience remains in focus with this hybrid, hopefully reaching a wider range of people - those who understand prose might come to understand or appreciate science while others who read mostly science might appreciate narrative and prose while both audiences are entangled in the bewilderment of cosmic existence and love.

In the introduction to *Absence of Mind*, Marilynne Robinson conjures the thoughts of Heraclitus, “we are of one substance with the fire that is the essence of the cosmos” (xiii). Not to dwell on formal definitions (though the majority of science writing depends solely on formal definitions) it is useful to break down what is essentially meant by cosmos, or rather, “universe.” Derived from Latin as “universum” meaning everything, the whole world, broken down even further we obtain “uni” which means “one” and “verse” which is the past participle of *vertere*, meaning “turn,” so simplified, universe etymologically means “turned into one” – a single unified being of existence. With both this definition and Heraclitus’s summoned words in mind, there lies an implication that the universe has an allegiance to us as well as us to it. There is no need to attempt to unite our existence with the calculated breaths of the universe because they were never disparate from each other to begin. This redirects the age old question of “how can we unite ourselves and human subjectivity with the mathematical and scientific workings of the universe” to understanding *how* this union works and *why*.

Emulating the exploration of how and why the universe functions with humanity, it is useful to examine the formal structure of the work regarding, again, how and why it is

functioning in relation to itself and a larger audience. Because of this shift away from attempting to marry science/universe to human experience, there is a new focus on a different sort of marriage – the marriage of two types of non-fiction. Critical non-fiction and creative non-fiction seemingly exist in two mutually exclusive spheres. Critical/academic non-fiction thrives in scientific journals, lab reports, analyses of literary works, textbooks, and explanatory works such as Brian Greene’s *The Elegant Universe* or Lee Smolin’s *Quantum Gravity*. Creative non-fiction remains fairly self-explanatory in its structure driven largely by narrative, themes, literary styles and techniques, and a similar shape to fiction such as Jo Ann Beard’s *The Fourth State of Matter* or Amy Leach’s *Things That Are*. What this work does is attempt to fuse these two spheres of non-fiction writing together by simultaneously parsing through personal narrative within the larger framework of scientific modes of thought and writing.

Another formal structure of this work that is perhaps significant is the fragmentary style through which the narrative is presented. Unlike most other narratives which strive for tight cohesion, this work presents information in pieces and vignettes, short memories followed by veering explanations of astronomical phenomena, such as in “The Entropy of Black Holes” where the narrator reveals small and subtle clips from a presumably unreliable memory bank and neglects to follow through these memories with explanation and detail, replacing the space that detail would take up with information about astrophysics. Readers are left wondering if this information will ever be brought up again or if there will ever be closure regarding particular events, such as an implied sexual assault or a sort of fist fight in the essay mentioned above. This fragmentary style is also present in the essay “Park Benches” as the narrator more or less veers off-topic multiple times in discussion of quantum entanglement, which could be interpreted as an avoidance of the matter that is troubling her that is revealed nearer the end when it is implied that

previous romantic relationships have left her distrusting, wary, and a little skeptical. Similarly, “Shifting Winter Cemeteries” transfers back and forth between reflective narrative, a discussion of dark matter and dark energy, and the writings in the narrator’s personal journal, separating the things that seem to link the event together. This fragmentary narrative attempts to make it difficult for the reader to fully grasp the character of the narrator, similar to how it is difficult to grasp the essence of the universe in its entirety, and the only thing that is meant to hold this fragmentary narrative together is the idea of the varying types and degrees of love.

Despite the fragmented narration, passages and sometimes major portions of paragraphs are repeated throughout the work, linking each piece with another. For instance, a paragraph about the narrator’s knowledge about string theory appears in both “Park Benches” as well as “Music Theory of Strings,” and images such as pink latex balloons (or bubble gum) continuously circulate, generating what could be interpreted as a universe itself derived from a single source but fragmented but still connected within its distinct parts. This is likely most prominent in the essay “Time.” which attempts to encapsulate moments from all previous essays, eschewing the chronology and structure of time itself to combine occurrences into something understandably cohesive, a fluidity of infinite time itself, linked by love at the core. The work functions as its own bubble of a universe, and each portion informs the other, sharing the closed-system universe space of the piece that has been stretched out to create a narrative (or narratives). This feeds directly into the constantly shifting narrator.

Regarding this seemingly inconsistent and constantly shifting narrator, one might say the narrator is not necessarily shifting but is instead fluid or flexible in existence, much like humans can be when placed in different situations. A narrator who compartmentalizes everything, pushing everything aside and turning to scientific understanding, may not be a character easily

grasped onto, much like how only portions of existence in the vast universe may be understood while the whole of it remains largely mysterious and misunderstood, linking closely with the fragmentary style of narration. Readers depend on consistent, reliable narrators to weave a story, but this narrator could be seen as evasive, making her seem not only unreliable but perhaps losing grasp on reality itself. With the increasing descent into the mind of the narrator, the theme of love in the larger framework of the universe attempts to be the only thread left for the reader to cling onto. This character shifting allows a freedom to further explore the many different places love can be found in the universe that might not otherwise be examined if the narrator wasn't attempting to shift with the universe, attempting to let the universe explain itself while she remains very confused and unsettled by her existence.

Further regarding the unreliability of the narrator, the most prominent essay that conveys this quality is "The Nth Dimension" because the narrator appears to be confused about what is reality and what is imagination. At the end, the reader no longer knows if this old house actually existed and if the narrator really grew up in it or if the narrator has simply imagined all of this and has actually begun to lose her mind. What makes this even more difficult is this unreliable narrator starts to make the reader wonder if the physics presented is reliable as well, and this could be extremely problematic. However, this could also be emulative of the reality of healthy scientific skepticism or at least the awareness that humanity can't fully understand the universe regardless, and everything that we know (or believe we know) could potentially be partially (if not entirely) incorrect. Therefore, paired with a seemingly unreliable personal narrative, it seems the work is acknowledging the fact that it could be very wrong in memory, and the narrator even states this in the essay "Music Theory of Strings" when she says "our memories are often wrong"

(20). This implies that the universe is comprised of multiple ideas and perspectives, laws and physics, that are often misunderstood and fall short of explaining the universe as a whole.

Another thing worth noting is the fact that some portions of the narrative are heavily focused on the “I” within them, particularly “The Entropy of Black Holes” and “Music Theory of Strings,” but this seems to be doing something to the narrative itself that links back to the idea that this narrator’s universe is a closed system, much like our real universe, and only she can observe and experience it. She serves as a sort of heliocentric model that knows only her own experiences and does not attempt to account for others that she is certain she can never know about in full. This heavy “I”ness seems more reflective of the narrator’s mental state than anything – she is so wrapped up in her world of physics and personal issues that she can’t see or understand anything else. Additionally, all her energy is seemingly put into avoiding the emotionally-charged situations by talking about physics instead of fully engaging with others, and this is emulative of the world of theoretical physics and astronomy where it’s only possible to be objective, unfeeling observers.

In the essay “Park Benches,” the narration is in the second person, blurring any and all interpretations of who “you” is. This blurring is a reiteration of the oneness of the universe because the “you” is simultaneously all interpretations of it – it is the narrator’s lover, it is the reader, and it is the universe itself. This further emphasizes the theme of the many different ways the universe can love a person or thing because love *is* a universal thing. Through this narration, the narrator is perhaps attempting to examine the role of love in the universe by applying it to whatever person or object encounters the essay. This is complicated by the fact that the essay provides a detailed account of the narrator’s experience with romantic love since this particular type of love cannot be attributed to everything. However, it could still function as the narrator’s

attempt to both understand a sort of universal love and apply this love to everything. It's also useful to note the abrupt shift from first person to second at the end of "The Entropy of Black Holes" where the "you" can also be interpreted as the reader but also an acknowledgment that the narrator is attempting to reconcile her love of her sibling as well as the universe despite any hard feelings that have been acquired.

In the essay "Time," the narrator uncomfortably moves around from first person to third person, arguably another indication of the narrator's difficulty in expressing emotions and applying feelings to a situation. Continuing to distance herself from the situation, the narrator seems to be overtly attempting to deny that the feelings conveyed throughout the essay as well as the entire work were ever her own by transferring these emotions to a separate entity. However, the narrator seems to come to a sort of surrender by finally implying that she was indeed the person in all the stories by using the theme of time to admit she was the little girl, is the woman, and will continue to be both of these as time moves forward while continuously shifting as a person throughout her life.

This shifting narrator also moves from personal narrative to scientific thought as a means of weaving together creative non-fiction and scientific writing, as aforementioned. Particularly in "The Entropy of Black Holes," the personal, again fragmented, narrative is interrupted by segments of scientific thought – the narrator's sort of regurgitation of astronomical knowledge as a means of avoiding personal problems and compartmentalizing emotions, both of which the narrator might not even be aware of in her own behavior. In Lee Smolin's *Quantum Gravity*, he talks at great length about his notions on black holes, gravity, and (most specifically) the entropy of black holes and how temperature is directly proportional to mass. This can be seen repeatedly in the essay "The Entropy of Black Holes" as the narrator often has difficulty confronting

emotional responses because cognition and scientific exploration function in the narrator's mind as the basic framework of analysis as well as a means of compartmentalizing difficult, unpleasant, and traumatic memories/situations. Physics, then, is often the only route the narrator can take in attempting to understand emotional situations.

The last formal element of significance is the amount of information that lacks full explanation, both in the personal and scientific narratives. In "Music Theory of Strings," the narrator mentions string theory but fails to fully connect it to music and the piano as well as effectively explain string theory in detail to the reader. This happens again in "Park Benches" where the narrator alludes to quantum entanglement and a few of its complicated facets but never fully delves into each one, and the narrator never gives the full backstory to what seems like an all-too-ideal relationship (which also makes the narrator seem unreliable). Though this might be problematic in most typical nonfiction, here it seems emblematic of the incomprehensible nature of the universe. Perhaps this narrator is attempting to emulate the notion that we don't necessarily have to fully comprehend the universe in order to appreciate it and acknowledge its strange existence, nor do we have to fully understand the multiple ways it loves everything in existence, including humans.

Diverging a bit, it might also be useful, in the conversation of formal structure, to keep in mind the definition of essay which is, loosely "to try." As a collection of essays, or "attempts," the theme of parsing through the universe in an effort to understand it and its love for all existence is sustained. The universe, as most everyone in the scientific community agrees, is essentially impossible to entirely understand and comprehend. In the words of the essay "Shifting Winter Cemeteries," "more is unknown than is known" not only about dark matter but about the universe in general. We as humans can only attempt to understand it, and we will likely

make multiple attempts to do so through many different experiments of varying degrees. This also ties in with the title of the work, *Quanta*, as the universe is a collection of things ranging from the smallest molecule to the largest supercluster, and each essay could be akin to a new experiment to understand how the universe works with humanity through notions of love.

That being said, much of this thesis centers around boiling down larger ideas and concepts in physics and astronomy, revealing the notion that human understanding is limited, and we eventually will have to accept that we cannot simply understand everything entirely. This notion then turns our gaze inward, grasping for a reasoning on why certain things occur and others don't, why the universe is saturated with fascinating phenomena as well as the wondrous existence of humans, of us. This gaze lands upon deeper notions about what it means fundamentally to exist, exploring the many ways the universe loves – and how it loves each and every thing and person differently.

Ultimately, I hope that readers find some scientific reassurance within these essays that it's okay to not completely understand the world and to even hate the things that occur, but if one strives to see the love within each and every thing, the universe blossoms within our mentalities and spirits, spreading petals of every shade and color of love that can possibly exist. Similar to the readers, the narrator does not understand the universe wholly, despite all attempts to rationalize it, but there seems to be no rationalizing of love, which becomes even more abstract when it is the *universe* that is providing the love even when it seems most hostile. I hope that readers come away from this piece feeling that love exists in incomprehensible things, and we humans, as fragile as we are, are recipients of such love simply by our own beautiful and terrifying existence.

Annotated Bibliography

Beard, Jo Ann. "The Fourth State of Matter." *The New Yorker*, 14 Oct. 2015, www.newyorker.com/magazine/1996/06/24/the-fourth-state-of-matter.

How could one studying English at the University of Iowa not read this piece of work? What has been most useful in re-reading this piece is the way Beard weaves the personal in with the scientific, even though the scientific is never fully explained. The threading of themes and recurring images in this piece are impressive and effective in giving the reader something to latch onto. This piece has proved useful as it has remained in the back of my mind while I write my thesis – I must balance the personal with the scientific or otherwise find a way to incorporate or reconcile the two artistically and meaningfully in my work.

Berrigan, Ted. *The Sonnets*.

These complex poems made me rethink the way time and space (and, therefore, physics itself) can function within a work and be incorporated into a work seamlessly to not only explicate details and events but to simultaneously discuss the science behind each. These were especially useful in sparking the initial draft of the essay "Time." and proved useful in revising other essays.

Biss, Eula. *On Immunity: An Inoculation*. Graywolf Press. 2014.

This work of nonfiction gives a thorough parsing of what it means to be vaccinated and every definition of immunity that includes a discussion of the government, medical community, science, as well as Biss's personal experience as a mother. This book helped me think about ways I could incorporate science into my writing while maintaining the natural flow of personal narrative. This also helped me in revising much of the "Shifting Winter Cemeteries" essay by allowing me to think about ways to go about writing that essay to maneuver around topics that readers might misinterpret if not attended to carefully.

Clark, David H., and Matthew D. H. Clark. *Measuring the Cosmos: How Scientists Discovered the Dimensions of the Universe*. New Brunswick: Rutgers, 2004.

This nonfiction book gives a detailed account about the lives of both the well-known and the not-so-well-known physicists and astronomers who have made significant discoveries in the field of astronomy. Because the human experience saturates history, it's fitting to incorporate the real people who contributed to the knowledge that we have today, and perhaps imagine it through their eyes in modern day society. Though I ended up leaving out details of specific individuals, this piece sparked the idea of incorporating the theme of "founding fathers" of astronomy in the introduction.

Clegg, Brian. *30-Second Quantum Theory*. United Kingdom: Ivy Press, 2014.

I didn't intend to use this, but it proved quite useful in not only refreshing my mind on quantum entanglement in a concise way but also entertaining me in its presentations of quantum theories. It's filled with small tidbits about the life of particular scientists and physicists, mini factoids about quarrels among physicists, and fascinating illustrations that actually made me

think of new ways to present information, which proved useful given the themes and focus of my thesis. Ultimately, this book became my most useful resource when writing the essay “Park Benches” about quantum entanglement and aided in a rethinking of how I could manipulate time in the essay “Time.”

Clegg, Brian, *The Universe Inside You: The Extreme Science of the Human Body*. New York: MJF Books, 2012.

This book does something related to what I intended to do in my own work. It explains and discusses all the fascinating functions and capabilities of the human body and how these functions relate to the universe and are akin to the universe itself. Providing this knowledge and perspective, this book was useful in how it already relates the universe to the visceral, physical existence we as humans endure. It proved most useful in the detailing of moments when the universe interacts with the body and they become one, such as the moment in “Time.” when the narrator is looking in the mirror and dark matter appears as breathable smoke that courses through the body. This book also allowed me to revisit some about the universe as a body that is our body and offered interesting insights about the universe and human existence, which was a good place to draw ideas and inspirations from.

“Dark Energy, Dark Matter.” NASA, NASA, science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy.

This article was a good brush up on dark energy and source for some percentages that I needed to double check, and it proved most useful for the essays “Shifting Winter Cemeteries” as well as “The Nth Dimension.”

Einstein, Albert. *Relativity: The Special and the General Theory*. New York: Three Rivers Press, n.d.

This nonfiction book centers around Einstein’s work in theoretical physics regarding special and general relativity. Much of this work is the foundation for modern theoretical physics and astronomy as it deals with both large cosmic bodies as well as the function of molecules on the atomic level regarding different forces, particularly gravity. This knowledge was also fundamental for my intent to present (and explore) my ideas through the scope of physics and astronomy. In addition, I have always admired Einstein and his work, and his ideas are presented so clearly, and written in such an inspiring way – which I hoped to emulate in my own writing.

Leach, Amy. *Things That Are*. Milkweed Editions, 2012.

This collection of nonfiction essays successfully combines scientific writing and personal narrative into one, and it is with enormous tact that Leach gracefully maneuvers through different spheres in her writing – beginning with one thing and parsing through it in so much detail that she ends up at another thing entirely. Her essays generate a dialogue between human existence and the scientific as well as natural world, and they move freely about and between a personal narrative and the scientific spheres where personal narrative can exist, conflating them to make a cohesive whole. Though this work was an initial source of inspiration for my thesis and I wanted to emulate the balance of personal and scientific narrative, I wanted to create my

own way of doing that, and re-reading this actually helped me think about how I could do that in a useful and meaningful manner.

Messiah, Albert. *Quantum Mechanics*. Mineola: Dover Publications, 2014.

This nonfiction book (basically textbook) covers a hefty amount of material about quantum physics and mechanics. Modern day physics is impossible to fully grasp and approach seriously unless one has at least some basic knowledge of quantum mechanics. Because my work is presented through the scope of physics and astronomy, this book was fundamental to the creation of my thesis since a thorough understanding of quantum mechanics was crucial in how I used it to explore the themes, concepts, and ideas in my own work. What I appreciate so much about this work is its thorough simplicity and its inclusion of formulas, making it cognitively accessible in its explanations to everyone, which again, made me rethink how to approach making things both accessible and inaccessible in my own work artistically.

Palen, Stacy et al. *Understanding Our Universe*. New York, W.W. Norton, 2012.

This textbook has been a useful reference for me in my portrayal of astronomical phenomena throughout my thesis as it was a book I used in an introductory astronomy course here at the university. It is not as thorough as some other astronomy books I have, but it is detailed enough to be a useful reminder of how to make astronomy accessible to everyone who comes across it, and it includes effective illustrations that helped me rethink how I might present material. It also does a great job in relating the universe to us in terms of larger cosmic structures, interactions with light and heat, and the anatomy of many stars, planets, nebulas, etc.

Pederson, Miranda. *Africa*. N.p. 2013.

Though this isn't a published thing, it is my own personal journal (literally, it's huge) filled with detailed accounts of my time spent in Africa – including a very vivid recounting of the exorcism that occurred there. This was exceptionally useful in jogging my memory of the event and provided useful real-time responses from when it happened were both included in the essay and helped to both inform and inspire it.

Robinson, Marilynne. *Absence of Mind*. Yale University Press, 2010.

This work of nonfiction is most admirable because it tightly weaves in cosmological and philosophical (as well as theological) notions into accessible segments for rumination. What I find most striking about this work, along with my own love for Robinson's writing style, is how lyric the work is even at the sentence level while maintaining a high level of cognitive engagement – proving that beauty/love are not mutually exclusive from heavy-handed scientific thought. I have attempted to emulate this throughout my own writing as well.

Robinson, Marilynne. *The Givenness of Things*. New York: Farrar, Straus, and Giroux, 2015.

Here again (it's probably very obvious that I derive much of my inspiration from Robinson as I bring her work up frequently) the quality of the prose writing in conversation with the level of intellectual rigor within this work of nonfiction is astounding. Robinson summons the cosmos itself into the very language of her work, incorporating cosmic thought into the

rumination on human existence and religion. This work in particular fed very much into the theme of the universe loving everyone (and loving everyone differently) as I read it in conjunction with the more hard-hitting astronomical books I had on hand.

Robinson, Marilynne. *Housekeeping*. New York: Picador, 1980.

Though this fiction novel has almost nothing to do with the content of my thesis, I have, again, always been incredibly struck by Robinson's prose style. Her prose is the embodiment of what appears to be cosmic, motherly wisdom dispensed freely and lusciously to her readers. She has such tact in transforming ordinary objects and experiences into extraordinary ones, which is a foundational inspiration for this thesis in general, and her writing style is something I have been attempting to emulate throughout this thesis.

Sagan, Carl. *Cosmos*. New York: Ballantine Books, 2013.

Though this book might seem a bit more pleasure than hard scientific knowledge/research, Sagan provides a fairly thorough scope of the history of astronomy and astronomical research and discovery (I think history is incredibly relevant to the current human condition/experience). As a well-known and trusted astronomer, Sagan is a solid resource for the general history of space, and he often provides an extensive amount of cognitive exploration of what this history has meant for humanity and its impacts on favorite historical astronomers. And it's always handy to have a history of space (as we understand it) nearby while I'm writing. I also find his writing be almost philosophically dreamy – a little on the romantic side that gives this book an ethereal quality.

Smolin, Lee. *Three Roads to Quantum Gravity*. Great Britain, Weidenfelt and Nicolson, 2000.

Although this is a nonfiction book that thoroughly explains one of the most complex theoretical physics concepts of all time – how gravity and minuscule atomic forces interact – this book also provides fundamental information for understanding research done regarding how these two conflicting forces interact and how this knowledge affects the scientific community (and us as humans). What really draws me to this source though is Smolin's ability to construct compelling prose that is equal parts beautiful and informative – something that I wish to emulate in my own work. His writing is strangely riveting, even in the rare moments when his thoughts are unclear, and this book has proved most useful in my own essay "The Entropy of Black Holes," mainly for the very robust discussion of temperature and mass in a black hole.

Smolin, Lee. *The Life of the Cosmos*. New York: Oxford, 1997.

This nonfiction book offers a sort of inversion of scientific models of the universe by centering around a theory that the universe developed in much the same way that humans developed – through biological evolution reproduced by black holes undergoing self-organization through natural selection. With my focus being on exploring the human condition through the perspective of astronomy and physics, this book was useful in offering knowledge to branch off of, especially since it's already so closely tying human existence with cosmic models. I also find Smolin's writing style to be riveting, which inspired me to attempt to emulate some of his stylistic components in my own writing.

Smolin, Lee. *Time Reborn: From the Crisis in Physics to the Future of the Universe*. Boston: Houghton Mifflin Harcourt, 2013.

This nonfiction book centers around how time, as we perceive it, is a human construct that helps us organize our world, but we cannot fully grasp it since it is also the fourth dimension and becomes muddy and troublesome in the larger scope of physics. Because time is the closest intangible thing to human existence that we interact with each day, it was useful to incorporate it and the research done on it in my essays, particularly the essay “Time” in an effort to manipulate time in ways different than the traditional structure of it. Additionally, time is extremely fundamental in understanding any part of physics, so its inclusion is indeed necessary (and it is simply crazy cool to explore cognitively as well).

Xu, Renxin, and Guo, Yanjun. “Strange Matter: a state before black hole.” *International Journal of Modern Physics D*. 22 January 2016, pp. 1-21.

This was inexpressibly helpful in really detailing to me the intricacies of strange matter and strange quark matter, which heavily informed how I went about writing the essay “The Nth Dimension” because of its explanation on how strange matter relates to dark matter as well as it being a potential precursor to black holes. Though, admittedly, it was one of the stranger articles to parse through because of the nature of the experiments detailed in it, this strangeness actually inspired me to write the essay as if the narrator was losing her mind.