HEARING SPACE IN MUSIC COMPOSITION: ANALYTICAL DESCRIPTORS FOR SONIC SPATIALIZATION

by

DANIEL KARCHER

(Under the Direction of Peter Van Zandt Lane)

ABSTRACT

The field of music composition delights in discovering new ways to organize elements of music, be it pitch, rhythm, harmony, timbre, texture, or dynamics. But one fundamental component of sound has been comparatively underexplored: its spatial quality. The location of a sound source, or where a sound is perceived to be within space, can be as emotively and rhetorically important to a piece of music as the intervals in a melody or timbres of the instruments. One potential reason that spatialization is underdiscussed is a dearth of language and analytical tools to describe how it is used in a composition. To remedy that, my research consists of adapting Steve Larson's theory of musical forces from a tonal context to a spatial one. Larson's theory compares events in common practice music to physical phenomena and suggests that listeners use these metaphors to interpret music. These forces include gravity (the tendency for notes to descend to an established point), magnetism (the tendency for some notes to predictably lead to certain others), and inertia (the tendency for a pattern to continue). These same forces easily map onto a spatial context. In this new usage, gravity describes a fixed sound stuck in a single location, magnetism can be gestures that move towards each other or repeal away, and inertia is heard in how sounds may skirt along a predictable path. By using the analogy of musical forces to describe how sounds interact with each other in space, I hope to lay the groundwork for future research to talk about the role of space more critically in music composition.

INDEX WORDS: Ambisonics, Chion, Electroacoustic Music, Fixed-Media, Larson, Music Theory Pedagogy Musical Elements, Musical Forces, Monk, Motion, Park, Space, Spatialization, Surround Sound

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF MUSICAL ARTS

ATHENS, GEORGIA

2023

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August 2023

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CHAPTER I

EXPOSITION

The Need for More Space

In 2001, *Computer Music Journal* published a quote by York Höller, the last artistic director of the *Elektronische Studio des West-deutscher Rundfunk* (West German Radio in Cologne, or WDR), in which he claimed tape pieces (fixed-media) were obsolete and disparaged spatialization in music as superfluous:

> Of course, a lot of effort is made to add new dimensions to electroacoustic music– for example, with spatial qualities. But one should not be tricked. The spatialization of music is a superficial quality that seems to be attractive at first but quickly loses its excitement for the experienced listener. For these listeners, the central content of music counts…Because of that, I think that the development of expensive multi-channel electronic music with multiple speakers does not make sense; the priorities have to be somewhere different….[1]

Computer Music Journal then invited responses from its readership which consists largely of composers who specialize in creating the very tape music that Höller had accused of being passé. Consequently, many of the well-known practitioners in electronic music took turns eviscerating the above quote. These responses were a mix of defenses for acousmatic music and querying remarks connecting Höller's role as director of WDR to its demise a year earlier. There were also many repudiations of Höller characterization of spatial music as lesser than "central content" (presumably a combination of pitch, harmony, and timbre), but each repudiation viewed the role of spatialization differently. Jonty Harrison characterized spatial elements as qualities inherent in

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[1] Brümmer, Ludger, Guenther Rabl, Konrad Boehmer, Jean-Claude Risset, Jonty Harrison, François Bayle, Johannes Goebel, Francis Dhomont, and Karlheinz Stockhausen. "Is Tape Music Obsolete? Is Spatialization Superficial?" *Computer Music Journal* 25, no. 4 (2001): 5–11, accessed November 4th, 2021, http://www.jstor.org/stable/3681949.

the material a composer chooses to work with.[2] Johannes Gobel thought of it similar to loudness, yielding "far less potential for aesthetic differentiation"[3] compared to pitch and timbre, but still a highly sophisticated element in some pieces. Jean-Claude Risset describes it as playing a structural role in the perceptual organization of melodies and rhythms.[4] And the final response came from the director of the WDR preceding Höller, Karlheinz Stockhausen, who declared that Höller was someone who "has not composed any spatial music" and thus that "one should not care about his opinion."[5] Stockhausen then predicted that spatial music has the potential to supplant the need for visuals in a concert setting and forestalled Höller's prophesied doom of tape pieces by describing how his recent concerts of electronics have all been sold out.[6] Against Stockhausen's advice, I believe it is worth paying attention to Höller's opinion on spatial music because it reveals a belief that apparently exists even among those familiar with computer music: that spatialization is not as important as other elements of music and never will be. The purpose of this paper is to refute that notion.

Taking a step back, it is important to define what is meant by "the use of space" in a piece of music. Especially because some music theorists have previously used the term to describe other aspects of music, such as pitches moving in a metaphorical space and the occurrence of musical gestures being spaced out in time.[7] For my purposes, I would define it as the location of a sound in an area or field, how it moves in the field, and if the sound has acoustic properties that suggests it comes from a certain place (such as a cave, or a kitchen, or concert hall, etc.). It is

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[2] Brümmer, "Is Tape Music Obsolete?," 7.
[3] Ibidem, 9.
[4] Ibidem, 6.
[5] Ibidem, 11.
[6] Ibid., 11.
[7] Elvira Di Bona, "Listening to the Space of Music," *Rivista di estetica*, 66 (2017): 93-105, accessed July 13, 2023, https://doi.org/10.4000/estetica.3112.

also worth mentioning that spatialization is a fundamental element of sound, like frequency or amplitude. All sound shared amongst people must have a source, be it an instrument for acoustic music or any number of speaker channels[8] for electronic music. And since space is a fundamental aspect of sound, it is also a building block of music composition, the same as pitch, rhythm, harmony, timbre, texture, and dynamics.

In the responses to Höller's comment, even the staunchest proponents of spatial music all viewed the role of space as having different degrees of structural importance in a composition. Some viewed it as mostly decorative[9] and some as a tool to make musical ideas easier to differentiate in complex textures.[10] One reason for this lack of consensus could be that even though creative use of spatialization is not something new (the first use of multiple audio channels happened in 1881[11] and acoustic pieces that spatialized sound using polychoral antiphonal choirs existed throughout the renaissance[12]) there is not yet widely used terminology or analytical tools for talking about the location of sound in pieces of music.

Compared to practitioners of electronic music who have an interest in spatialization, it is difficult for the broader public to have the ability to hear sound moving in a concert setting because such concerts often require prohibitively expensive equipment and specialized venues. While all instances of sound have a location that it is generated from, it is often the case that more nuanced uses of space require a large array of speakers for electronic music or balconies

[8] An audio channel is a single signal path, but usually refers to a playback source that leads to a speaker. For example, stereo headphones have two channels with two speakers, one for each ear.
[9] Brümmer, "Is Tape Music Obsolete?," 9.
[10] Ibidem, 7.
[11] David G. Malham and Anthony Myatt, "3-D Sound Spatialization Using Ambisonic Techniques" *Computer Music Journal* 19, no. 4 (1995): 58–70, accessed November 4, 2021, https://doi.org/10.2307/3680991.
[12] Grove Music Online 2001, s.v. "Cori spezzati/polychoral," accessed November 9, 2021, https://doi.org/10.1093/gmo/9781561592630.article.06486

with offstage corridors for acoustic music. Creating such places is costly and the belief that space is a superfluous musical element can weigh against such a purchase, as evinced by Höller's reluctance to buy expensive speakers (mentioned in his quote above). Therefore, it becomes necessary to change the perception that space is a secondary musical element to convince patrons to invest in building venues needed to realize the potential of spatial music.

Besides the need for special venues, it is rare for spatialization to be taught or discussed in music schools outside of an electroacoustic context. This results in professional musicians focusing on the notes, rhythms, and harmonies (that they were trained to listen for) rather than listening for a sound's location, passing such values onto their own students. In academic settings, music students should be taught to consider where the sound of their performance is coming from because it can make performances more engaging for audiences. Students could begin a solo recital playing offstage or do an encore standing amongst the audience. By teaching future music students to listen for and think about where a sound is located, they learn to challenge conventional ideas of what a concert is supposed to be, which results in more creative concertizing.

One solution to help evangelize musical space as an equally important musical element is to make analytical tools for labeling and categorizing it. When spatial topics and ideas are categorized, it is easier to see how they work in tandem with other musical elements to create the rhetoric of a composition. There is also a pressing need for more analytical spatial terminology because, in contrast to the rarity of being able to hear spatial audio in a concert setting, technology that allows people to hear spatial audio through headphones is becoming much more common. Binaural audio[13] is a format for sharing spatial that can be heard on any pair of

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[13] Binaural audio is a playback format for headphones that simulates 3d space.

headphones and is becoming more common. Outside three-dimensional audio, most popular music made nowadays incorporates some use of spatial gestures that pan back and forth in a two-dimensional stereo field. Additionally, virtual reality headsets and other technologies are making 3D audio more accessible. And as more informed listeners are able to talk about what is being done with space, composers will feel encouraged to write interesting spatial patterns because a greater number of people are likely to notice them. This creates an artistic feedback loop that builds musical literacy and combats Höller's notion that space is superfluous in comparison to other musical elements.

To forge new analytical tools needed to dig into the topic of musical space, it is expedient to borrow tried and true tools and metaphors that already exist. Steve Larson's (2012) theory of musical forces proves especially adept when transplanted into discussions on spatialization, as does Hatten's (2018) concept of a virtual environment. Both these theories were developed to talk about patterns of pitch,[14] showing how stylistic traits from common practice music can be related to forces of gravity, magnetism, and inertia working within the constraints of a virtual environment.[15] When mapped onto spatial music, the sonic field can be thought of as a virtual environment in which sound moves based on imaginary laws of physics germane to a particular piece of music. The three forces of gravity, magnetism, and inertia serve well to discuss many ways space is utilized in music, but to cover some unique cases, I will propose using the metaphors of "evaporation" and "pressure" as well. By using these terms to categorize and describe spatial motion in music, I hope to fill a gap in recent spatial research, which is mostly

[14] In this context, Hatten's work exists as an outgrowth of Larson's original theory of musical forces.
[15] Robert S. Hatten, *A Theory of Virtual Agency for Western Art Music* (Bloomington: Indiana University Press, 2018), 47.

concerned with the technical or aesthetic aspects of composing with electronics rather than making analytical listening strategies for lay listeners.

State of Current Spatial Research

Current research into spatial music focuses on technical issues, often written by composers for composers. Natasha Barrett, a foremost artist and researcher in the field of spatial music, has written numerous papers on technical aspects of electronic music and how they connect to aesthetic principles of the genre. Regarding *Kernal Expansion,*[16] she discusses her use of higher order ambisonics sound fields (a surround sound format) to fulfill her aesthetic goal of creating a sense of immersion. Another of her papers connects Pierre Schaeffer's idea of "allure"[17] in acousmatic music to spatialized sound images[18] and discusses the technical and practical issues in creating them using higher order ambisonics (HOA). Barrett's research demonstrates how technical ways of making spatial music are shared amongst practitioners in the field along with strategies to achieve specific aesthetic effects.

Other current trends in spatial music research include surveys of what technology composers are currently using to write with, categorizations of why these pieces are being written, and catalogs of the resources for creating it. In a *Computer Music Journal* article by Nils Peteres, Georgios Marentakis and Stephen McAdams, composers from around the world (in mostly English-speaking countries) responded to a questionnaire about their methods and concerns when writing spatialized electronic music. Like Barrett, this work categorizes and shows what topics about space are aesthetically important in the field. Some categories included

[16] Natasha Barrett, "Kernel Expansion: a three-dimensional spatial composition combining different ambisonics spatialisation techniques" (Proc. of the 2nd International Symposium on Ambisonics and Spherical Acoustics, IRCAM, Paris, France, 2010).
[17] Natasha Barrett, "Composing Images in Space: Schaeffer's Allure Project in Higher-Order Ambisonics" (Proc. of The International Computer Music Conference, New York, 2019).
[18] Barret "Kernel Expansion," 3.

statements like: “to enhance the listening experience,” “as a paradigm for artistic expression,” “to organize and structure sounds,” “to experiment with technology and spatial effects,” among others.[19] Another question asked how composers used sound elements to realize a “spatial sound experience,” which resulted in a summation of spatial configurations that my analytical tool addresses (Table 1).

Table 1: Categories of spatialization used by composers. Taken from the article “Current Technologies and Compositional Practices for Spatialization” by Nils Peteres, Georgios Marentakis, and Stephen McAdams[20]

How Do You Configure Sound Elements to Achieve Spatialized Sound Experience?	
Category	*Example*
Distribution and position	Distance and depth Algorithmically generated distributions Spatial organization according to timbre, texture, and musical function Spatial granularization Stereo tracks as source material Diffuse sounds (multi-speaker distribution) Mono sound reproduced from one or two adjacent loudspeakers Size of spatial image Planes, subspaces, and hierarchical sound layers Front (stage) is the focal point
Movements	Slight movements Contrast static vs. dynamic Many movements with a small number of sounds Strength of movements according to musical function: melody moves more than other sounds Prepared trajectories Instrumentalists move during composition Live performers moving loudspeakers
Others	Changing loudness and dynamics Spectral filtering Reverberation Simulating room acoustics Surreal spatial impressions

Forty-seven responses in open-comment form

[19] Nils Peteres, Georgios Marentakis, and Stephen McAdams. “Current Technologies and Compositional Practices for Spatialization: A Qualitative and Quantitative Analysis,” *Computer Music Journal* 35, no. 1 (2011): 10–27, accessed November 4, 2021, http://www.jstor.org/stable/41241704.
[20] Ibid., 14.

In a dissertation from 2019, Daniel R. Dehaan[21] creates an invaluable resource for helping composers get started in writing spatial electronic music as well as an overview of music made in virtual reality. His paper details definitions and concepts on the acoustics of spatial perception, different types of headphone and speaker configurations, available digital Ambisonics software, audio formats, and virtual reality equipment. He also gives some guidelines on writing for spatialized audio,[22] which can be viewed as an early example of attempting to pass down aesthetic values about spatial music. Dehaan suggests using mono sound sources, complex timbres, and keep sonic gestures simple for greatest effect. All of this is helpful advice for someone trying to create a clear and trackable sonic gesture, but it does assume clarity as an aesthetic goal. Dehaan's target audience is likely composers new to writing spatial music who might learn the craft easier using his advice, but it may be interesting to see if the aesthetic of clear and trackable spatial audio someday goes out of fashion in the future in favor of dense ambient gestures.

The current research topics in spatial music mentioned so far are all useful for helping composers write spatialized music: technical solutions to achieve certain sounds, surveys of how space is used by other composers, and lists of potential resources to explore. But not many of them include analytical tools or listening strategies for audiences to think about and digest spatial concepts. The most notable work so far in this vein is Jason Wyatt Solomon's paper classifying spatial gestures using Gestalt psychology while using Image-schema theory to talk about how space is used metaphorically.[23] Solomon's paper is primarily concerned with acoustic

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[21] Daniel R. Dehaan, "Compositional Possibilities of New Interactive and Immersive Digital Formats" (DMA diss., Northwestern University, 2019) accessed July 15, 2023, https://doi.org/10.21985/N2HJ46.
[22] Dehan, "Compositional Possibilities of New Interactive and Immersive Digital Formats," 63.
[23] Solomon, Jason Wyatt, "Spatialization in Music: The Analysis and Interpretation of Spatial Gestures" (University of Georgia, 2007), accessed November 4, 2021, http://getd.libs.uga.edu/pdfs/solomon_jason_w_200705_phd.pdf.

instruments and how spatial gestures arise from scoring in an ensemble setting. Gestures are then categorized into spatial gesture numbers (using the notation: SG-|x|) by assigning each sound source a number and taking note of the place of each event occurred. If you had a quartet where each player performed a sound sequentially left to right, Solomon's SG number would be SG-|0,1,2,3|. The first player is number 0, the second player 1, and so on. This method is applicable for analyzing sound sources that are difficult to move, like a piano or an entire orchestra.

Ensembles don't always have standardized seating charts, so Solomon's theory acts irrespective of a composer's intention. Unless a composer specifically marks where they want each performer to be on stage, spatial gestures will result from how an ensemble chooses to arrange itself, not from a score. This makes the theory more applicable to how music is perceived, resulting in a need for terminology to talk about every single perceptual possibility of space. His theory is focused on two-dimensional sounds, due to being tailored for acoustic music, and while three-dimensions are discussed, there is room for further research in the third dimension. My approach to analyzing space borrows from Solomon's ideas of categorizing spatial gestures and mapping them onto conceptual metaphors, but it also looks deeper into electronic music and how technology opens up new possibilities for music localized in three-dimensions. The notation for SG numbers can only describe the location a sound starts in, so there is still a need to describe how sounds may accelerate or change as they move between locations. This is a pressing need in electronic music, since technology allows for more continuous gestures in space in comparison to the discrete ones found in acoustic music.[24] Solomon also doesn't touch on how recorded sounds can imply types of spaces, such as

[24] Solomon "Spatialization in Music," 225.

reverberant sounds suggesting large rooms and dry sounds suggesting small ones, which is of paramount concern in the spatialization of recorded music.

In a short letter published in *Computer Music Journal*, James Dashow's presents another interesting way of talking about auditory motion, by dividing spatialization into either "movement *in* space; and movement *of* space."[25] Movement in space is what will mostly be addressed in this paper, sounds that accelerate from place to place, dancing to avoid each other, or getting stuck in place. Dashow's other category is less common by his own admittance, stating: "I myself have only managed it a few times."[26] Movement of space, according to him, is where a space itself becomes an object that moves around the listener, and if multiple spaces are present, counterpoint can occur between them. This idea may take on greater relevance as more institutions investing in building speaker arrays capable of creating such auditory illusions and is mentioned here as a topic for future exploration.

This overview of current research of spatial music suggests that while much is being done to aid the composition of future works, there is a dearth of analytical tools. Specifically, tools robust enough to encapsulate the limitless patterns possible in electroacoustic music while at the same time accessible to those not accustomed to paying attention to the location of sound sources. This middle ground of both robust and accessible tools can be achieved with the proposed solution of bastardizing the work of tonal music theorists and reapplying their ideas to the concept of musical space instead. In a tonal context, Steve Larson's theory of musical forces describes the sense of motion found in common practice melodies as being due to three overall

[25] James Dashow, "On Spatialization," *Computer Music Journal* 37, no. 3 (2013): 4–6, accessed November 4, 2021, http://www.jstor.org/stable/24265509.
[26] Dashow, "On Spatialization," 5.

forces: gravity, magnetism, and inertia.[27] These forces metaphorically describe how melodies operate, such as the melodic contour often being pulled down to a tonal center by gravity or a tendency tone being magnetically attracted up to a tonal center against said gravity. Robert Hatten then expands on these ideas by suggesting the forces form a "virtual environment"[28] where tones operate according to imaginary laws of physics set up in the piece. That terminology can also help frame moments when a musical idea doesn't follow the rules of the environment: if a melody struggles against a clear force of established gravity, the melody can be described as having a will of its own to fight against the laws of its virtual environment.

The idea of a musical agent connects to Seth Monahan's work on musical agency,[29] which posits that much discussion about music involves describing fictional concepts as if they are actually doing things or have agency in causing actions. From his various agential categories,[30] two involve the music having agency: the individual elements in the music (tones "wanting" to go someplace, chords "feeling" at rest) and the work-persona (the third movement "disagreeing" with the previous two). His other categories are personifications of the fictional composer and the fictional music theorist, which will receive less treatment in the context of space. But musical space itself will be an important subcategory of an element with agency. If, for instance, one speaker in a performance of a spatial work always plays back gestures quieter or louder than other locations in the room, listeners may start to describe the place where the speaker sits as having agency over the dynamic of the music. In other words, the location is personified as an agent "doing something."

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[27] Steve Larson, *Musical Forces: Motion, Metaphor, and Meaning in Music* (Bloomington: Indiana University Press. 2012), 82.
[28] Hatten, *A Theory of Virtual Agency for Western Art Music*, 47.
[29] Seth Monahan, "Action and Agency Revisited," *Journal of Music Theory* 57, no. 2 (2013): 321-71, accessed July 15, 2023, http://www.jstor.org/stable/43305055.
[30] Monahan, "Action and Agency Revisited," 329-333.

By using the ideas of musical forces, virtual environments, and musical agency all together, relationships can be more easily described between moving sounds. The next section of this paper includes in-depth descriptions of how Larson's musical forces can be heard through a spatial lens. Following this will be several analyses of work by Meredith Monk, Michel Chion, and Joo Won Park to demonstrate how these tools can be applied to preexisting works that include spatial elements. Lastly, I will use this terminology to examine my own piece *With Paradise Above*, a work for saxophone quartet and speaker array, to show how I employed the idea of spatial forces as a creative tool.

CHAPTER II

TOOLS AND TERMINOLOGY

In a discussion about space in music, it is helpful to clarify the relevant terminology, especially because, as noted before, "space" in music has several conflicting and competing definitions. Space can refer to distance between pitches, the space of time between rhythms, and the physical space of a room. Solomon begins his paper on physical space by acknowledging how several other theorists associate the term more often with pitch and even suggest that the pitch space metaphor could guide the conceptualization of models for physical space.[31] For the purposes of my analytical model, spatial concepts signify both the location of where sounds come from and how the reverberations of sounds suggest a physical location. While this is the same "physical space" that Solomon talks about, spatialization also refers to perceived physical space, meaning auditory illusions are included as well. If you are listening to headphones and hear one sound pan from the right to the left, the sound has not physically moved at all but instead the volume was lowered on the right transducer and raised on the left. A computer can also pretend a sound exists in a space it does not by mimicking how it might reflect off walls and surfaces of an entirely different sized room. In addition, the frequency spectrum of a recorded sample can be altered to make it sound as if it is close or faraway to the listener (without the sound source actually moving) by either emphasizing or reducing higher partials. In both these cases, the movement and reverberation of sound in an electronic piece of music takes advantage of how humans hear to create illusions of spatialization. But to avoid confusion with Hatten's

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[31] Solomon "Spatialization in Music," 20.

idea of a virtual environment, the digital simulation of space through panning or reverb will be considered “real” and not “virtual.”

Typical formats for listening to electronic music include: 1) headphones with two audio channels for panning (in the left and right ears), 2) stereo speaker systems, and 3) quadrophonic or octophonic[32] surround sound speaker arrays. Other less standard configurations of speakers are used as well, depending on the performance space. To simulate three-dimensions, binaural audio is used on headphones to digitally simulate sounds above and below, and multi-channel speaker arrays can be set up with sound sources overhead and underneath an audience.

For many spatial composers and pieces, more speakers means that the movement of gestures are easier to hear, so more speakers are often considered better than fewer. This can result in unstandardized speaker set-ups as all available speakers are included. For venues with a variable number of speakers, Ambisonics formats are used to compose music that is playable regardless of the number of channels available. Ambisonics encodes and stores spatial audio information in a way that can be decoded digitally for any imaginable arrangement of sound sources. This gets around the problem a composer might have of writing a piece of music for 37 specific channels and trying to get the piece played in a venue with only 23 channels of audio available and having to drop out 14 tracks of music. An ambisonics piece would sound approximately the same in both rooms with 23 and 37 speakers, with perhaps greater fidelity of sound localization in the hall with more.

While electronic music has tools for creating three-dimensional audio and tools for panning sound continuously, acoustic music does sometimes involve three-dimensions and continuous movement as well. Continuous movement is more often the case when a performer

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[32] Quadrophonic is usually four speakers, one in each corner. Octophonic is eight speakers surrounding the audience.

can move with their instrument around, such as members of a marching band. And three-dimensional acoustic performances require a venue that allows performers to be above/below the audience, like a long stairwell. The majority of the examples in this paper will focus on electronic music due to availability and reproducibility of examples, but the adaptation of Larson's musical forces (Gravity, Magnetism, and Inertia) to a spatial context can apply to all music broadly.

Gravity

The first of Larson's forces used to describe a sense of motion in music is the idea of gravity. In Larson's theory, gravity occurs when a "ground floor" or a platform of pitch centricity has been metaphorically established that a melody occurs over. The force of gravity pulls the melody downward, usually sinking to tonic.[33] When applied to spatial music, the ground floor becomes akin to a position in the spatial field that a sound is fastened to. In most cases, spatial force will be used to describe sounds that are held in place, like humans gravitationally stuck to a planet. Figure 1 shows a sound source fixed in place in a spatial field irrespective of the listener's orientation. Musical events that are held by this force may wiggle side to side or away from it a bit, like people jumping up and down in gravitational orbit, but the spatial force locks the sound down in the general area.

An example of this kind of spatial force can be found in Mark Applebaum's piece *Pre-Composition*. This work is written for eight channels of speakers but is available on stereo as well. In it, the composer ascribes a character to each of the eight channels that are gravitationally stuck in place. In the stereo version, those gravitational positions are spread out in the stereo field in eight positions between the listener's ears. Each of these eight characters is voiced by the

[33] Steve Larson, *Musical Forces*, 83.

composer, so they can only be differentiated by their position and personality imbued from the performance. The conceit of the work is that all the personalities belong to the composer who is arguing with himself about what the work should be. By having all eight speakers stuck in place through a force of gravity, Applebaum creates a spatial metaphor for split personalities.

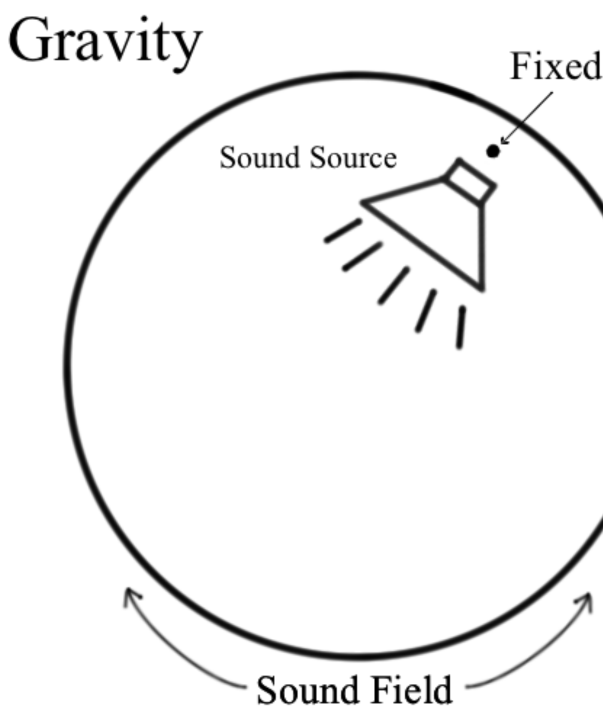

Figure 1: Gravity holds a sound in place

If a work of spatial music has many sound sources gravitationally stuck in place and happening at the same time, the force of gravity isn't perceptible unless the listener can associate each sound source with its location. This means that a work with a thousand short sounds spread in a 3D audio field is probably best analyzed using a different musical force (see "Pressure" below).

Magnetism

According to Larson, the force of magnetism happens in melody when two tones are attracted to one another. Larson grades the level of attraction between different diatonic and chromatic notes to create a hierarchy of expectation for what scale degree may come next. The stronger the attraction (or tonally unstable) a note is, the stronger the force of magnetism can be felt drawing it back to a stable note.[34] An example would be a leading tone resolving to the tonic of a scale. In a spatial field, the force of magnetism can be thought of as an instance when two (or more) sounds are attracted and move towards each other (Figure 2). Conversely, magnetism can also be when sounds repel each other in space (Figure 3). Examples of magnetism can include two independent sounds that move about in tandem by sticking together in space. It can also describe a sonic gesture that is magnetically attracted to a gravitationally fixed position that doesn't move. In Figure 2, the green arrow represents how one sound source can move to a stationary one. The red lines in Figure 2 show sounds moving directly towards each other and the blue arrows indicate a trajectory where two sounds are attracted to the same place in the sound field. The force of attraction could be amplified by other musical elements: if there is a tonic drone in one corner of a room, unstable and dissonant scale degrees on the other side of the room could be magnetically pulled to that corner and glissando down to the tonic pitch. This may be considered a stronger force of attraction by listeners than the same spatial trajectory using non-pitched samples.

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[34] Larson, *Musical Forces*, 88.

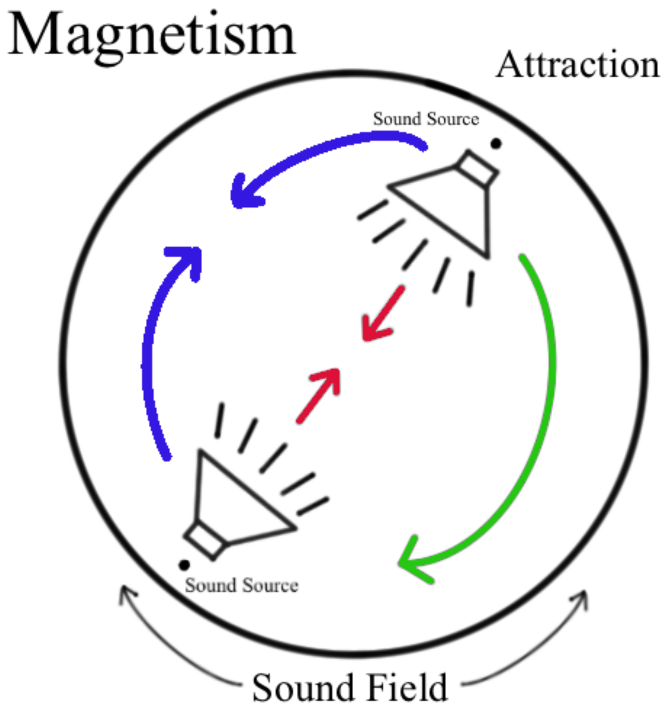

Figure 2: Different types of magnetic attraction between two sounds

Sounds that repel are also subject to magnetism and this often occurs to establish independence between two gestures. In the same way that contrary motion in renaissance counterpoint is used to create independence between musical voices, contrary directions in space also help keep musical gestures independent, allowing them to be more clearly heard.[35] Additionally, sounds that move around but consistently avoid happening in the same place can also be interpreted as having a magnetically repelling force between them. In Figure 3 the red

[35] It is possible that compositions in the future may alternate between magnetic attraction and repulsion to create a new type of spatial contrapuntal language.

arrows show two sounds pulling apart, moving from the center outward. In the same figure, the blue arrows indicate how two sounds may repel each other by never existing in the same space. In this case, their trajectories circle one another and keep to the edges of the spatial field.

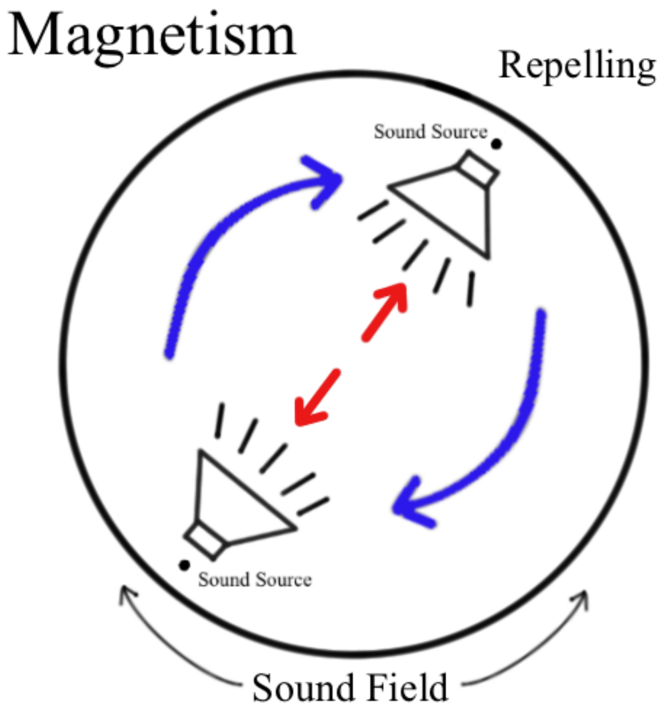

Figure 3: Different types of magnetic repulsion between two sounds

It is also possible for a sound to have a magnetic attraction to a position in the spatial field instead of another sound. This can be heard as distinct from the force of gravity if the sound does not get stuck in that location and consistently pulls away before being drawn back. The repelling version of this spatial technique would be if a sound moves around a spatial field freely except for a particular spot that it is forced to stay away from.

One of the main features of Larson's model of magnetic force (when applied to a tonal melody) is that it allows the listener to sometimes predict where an unstable note will resolve. Spatial magnetism does not inherently allow listeners to predict what (or where) a sound is attracted to except by creating associations between two different sounds. This is done by repeating the magnetic pattern over and over to create the association or by using other musical parameters to create a senses of instability, stability, and resolution exclusive to an individual piece.

Inertia

The forces of gravity and magnetism help explain sounds that move or stay fixed in space, which seems to cover most spatial patterns that could possibly happen in music. What they don't cover is how single gestures move, such as a sound speeding up, slowing down, changing directions for non-magnetic reasons, or traveling in a consistent pattern without consideration for other forces. The force of inertia fills these analytical gaps. Inertia, as defined by Larson, involves patterns of pitches which act so consistently that the listener expects the pattern to continue.[36] An example of this could be an ascending scale working against the force of gravity, or a musical sequence with the same harmonic progression happening over and over. A spatial pattern can build up similar types of metaphorical inertia by establishing a predictable pattern. In Figure 4, a sound moves in a clear arc around the stereo field, creating the assumption that the arc will continue. The expectation that this arc continues creates the force of inertia and gives the sound momentum. If a sound moves slowly in a direction but begins to pick up speed, the gesture also builds inertia since a listener assumes it will continue to accelerate (Figure 5). Inertia can also describe the opposite if a gesture consistently slows down (Figure 6).

[36] Larson, *Musical Forces*, 143.

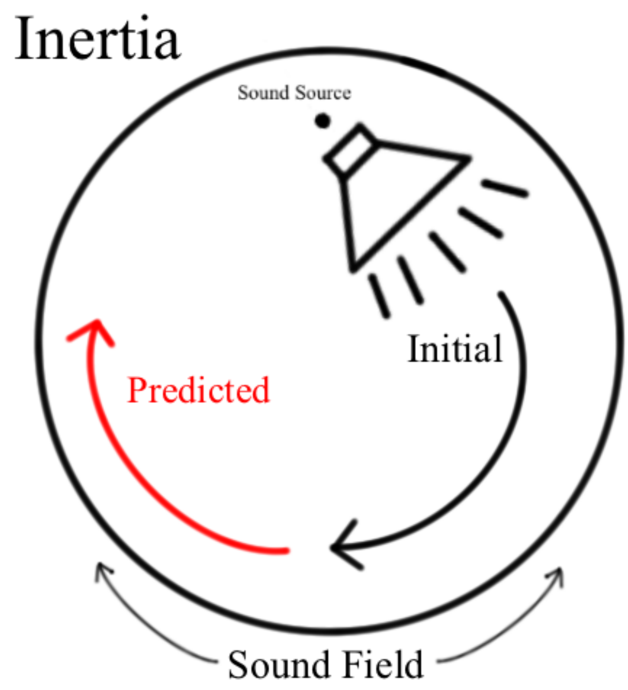

Figure 4: The predicted direction of a sound with inertia

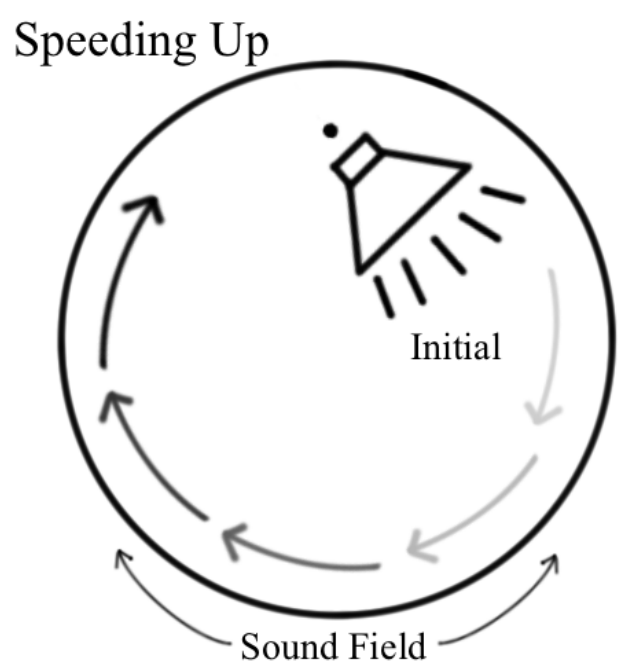

Figure 5: A sound with inertia that is accelerating

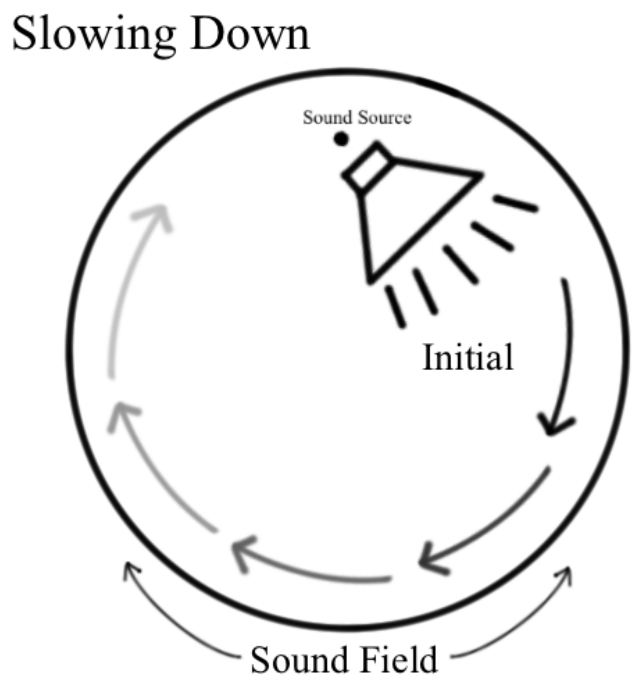

Figure 6: A sound with inertia that is decelerating

Sounds that move in a consistent pattern over time (side to side or in a circle) can be also interpreted through the metaphor of inertia. This is especially useful to talk about gestures that may not be affected by any other metaphorical force, such as magnetism or gravity. Inertia forms in any spatial pattern that seems to follow its own internally consistent movement. But, if some “musical agent” causes a predictable pattern to change, that new event could be ascribed musical agency according to Seth Monahan.[37] For example, if a sound is happily spinning in a circle but is suddenly thrown off course and stopped in place by another sound or event, some sort of musical agent has interacted with it (figure 7). This is akin to when a perambulating person attempts to go through an unseen screen door. The screen forcible causes the person to stop in

[37] Monahan, “Action and Agency Revisited,” 327-328.

their tracks even though they had inertia on their side. We may not be able to see the musical agent acting as the equivalent of a screen door, but we can feel its effect on other musical forces in play.[38] Monahan's idea of musical agency can be used to analyze any personified aspect of music but is especially useful to talk about how spatial trajectories might interact with each other in a composition.

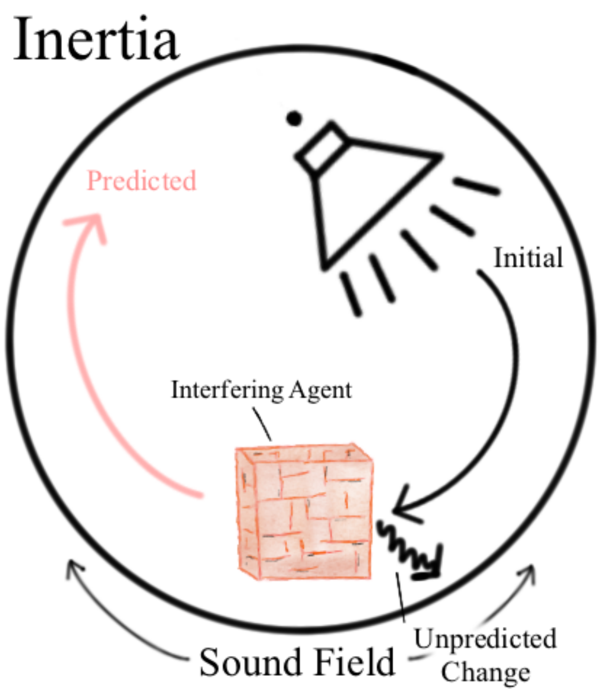

Figure 7: An interfering agent stopping a sound's inertia

[38] In a composition with multiple personified events interacting with each other, any and all may be ascribed their own agency.

Inertia can also be used to describe more abstract spatial patterns. Imagine two musicians, one in a balcony and another on a stage below (Figure 8). If they play alternating notes to create a melody, a spatial pattern emerges. In figure 8, the red line represents what the performer on the stage is playing and the blue line what is heard from the balcony. The dashes in both lines represent how each performer is only playing when the other is not, creating an interlocking pattern of notes. When the pattern between the two spread out performers is consistent and predictable, this hocketing creates a type of spatial inertia. If the performer in the balcony goes downstairs to the stage while still playing the same pattern, the disappearance of the spatial inertia would be audible even though the notes haven't changed. A composition by Meredith Monk named *Hocket*, from her album *Facing North*, will be looked at in more detail as an example of creating similar spatial patterns in acoustic pieces of music.

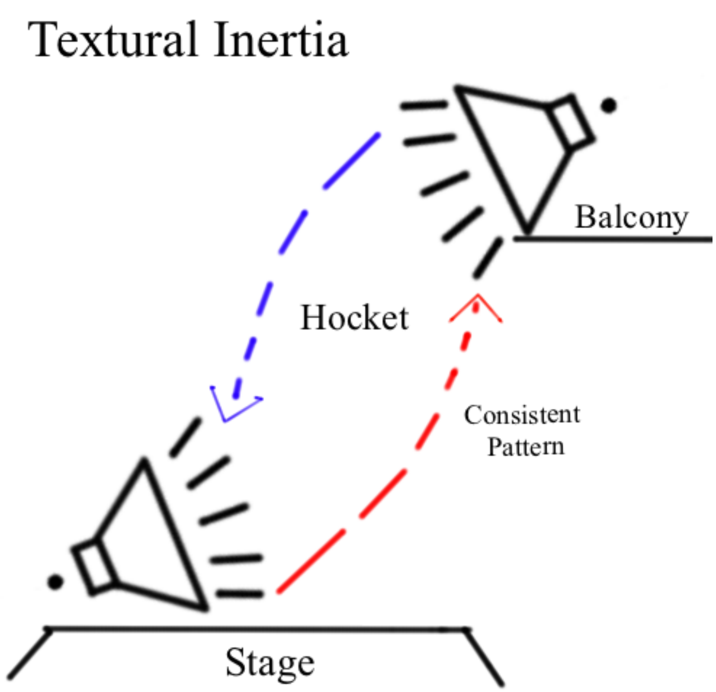

Figure 8: A hocket between two spatially separated players

Pressure

When adapting Larson's musical forces from a tonal context to a spatial one, the three forces covered so far can describe any moving sound, any still sound, and how two or more sounds might interact in space. But there are still two important gaps to fill that will require new metaphorical forces. In recorded music it is possible to layer together multiple samples of many different gestures and play them back at once.[39] While the sound sources themselves can be describe individually using the previous forces, the overall effect is one of accumulating density. This technique can be achieved by layering together so many independent sounds that it is impossible to describe them with inertia, magnetism, or gravity. In keeping with the metaphor of physics terminology, I describe this new force as "Pressure" (Figure 9). Pressure can be categorized into high and low pressure, with less pressure having a smaller number of simultaneous independent sound sources and high pressure having many.

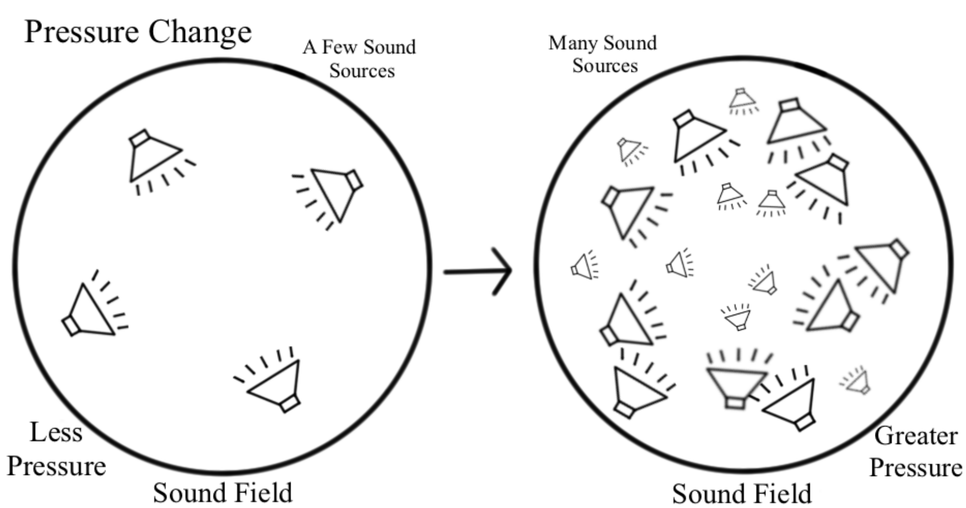

Figure 9: Two different amounts of spatial pressure. The Sound field on the left contains fewer sound sources than the one on the right, causing it to have less spatial pressure.

[39] This could be possible in acoustic music as well but would require a venue where multiple types of reverberation could be heard at once.

An example of pressure used in a composition can be heard in Eli Stein's piece *Vestigial Wings*. In it, he composes several layers of overlapping sounds suggesting different reverberant spaces. The heaviest and densest moment (around 3 minutes in) contains a combination of high-pitched reverberant vocal lines mixed with crackling material in proximity and low ambiguously spaced drones. All these sounds together build up into an instance of high spatial pressure. This force of pressure gives way suddenly and morphs into a lighter texture keeping only the crackling material and some vestigial upper pitches (around 3:22). The change in spatial pressure emphasizes the form of the work as it heralds in new sonic material. Admittedly, this same musical moment could be describe using preexisting musical terminology for texture and timbre instead of space. But because it is common for electronic pieces of music to create simultaneous layers of differing reverberant spaces and gestures, spatial pressure is worthy of its own category as a musical force.

Evaporation

The other notable spatial event not covered by any of the other three spatial forces is when a sound changes its location through reverb or EQ. By simulating a different type of reverberant room or by cutting off bands of frequency from a sound, the implied space of an electronic sample can drastically change while still being recognizably the same sound. If we extended the idea of physical laws to states of matter, it makes sense to describe these changes of perceived space as a "change of state." When adding thermal energy to water, it evaporates and becomes a gas; when adding reverb to the sound of a clap, it becomes more diffuse and metaphorically evaporates as well. A sound that is more reverberant would be described as "wetter"[40] and a less reverberant sound as "dryer." If the higher partials of the sound are boosted

[40] Wet and Dry are common terms for talking about how much an audio effect is applied to a sound (the audio effect often being reverb).

through EQ, it will be heard as nearer to the listener, analogous to how strengthening the molecular bonds of matter causes it to change state but not what element it is. Distant sounds could be described as "airy" and those in proximity as "solid."

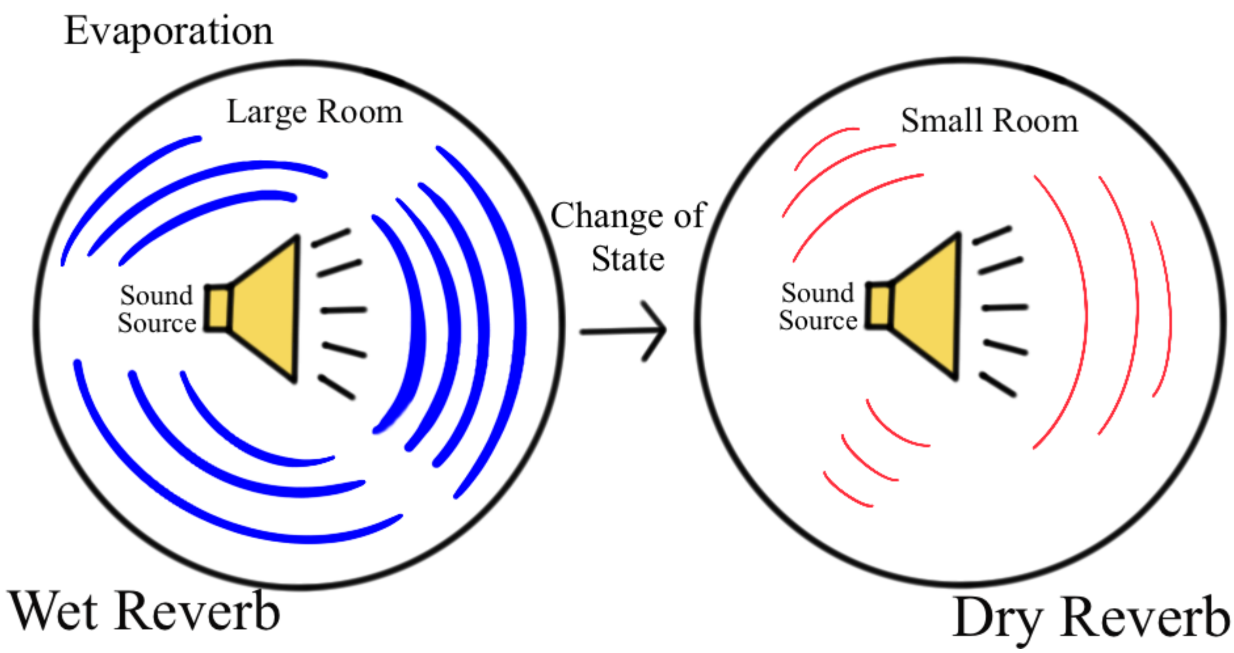

Figure 10: The same sound source with two different reverbs applied. The location of the sound source remains in the middle of the sound field.

Virtual Environments

Among the five spatial forces described there is some overlap in what they cover. Magnetic sounds have inertia when they move, and the force of evaporation may affect a sound fixed in place by gravity or pulled by magnetism. Generally, gravity describes a single sound source, magnetism is for relationships between two or more things (gestures or points in space), inertia describes an independent motion or long-lasting pattern, and pressure is used when there are many spatial sounds happening at once (Figure 11). Evaporation is a special case and describes how an electronic sound is processed regardless of how it is or isn't moving.[41] But These tools should never be considered prescriptive when analyzing spatial music because the malleability is one of the theory's strengths. The overlap helps builds interlocking connections between forces at play.[42]

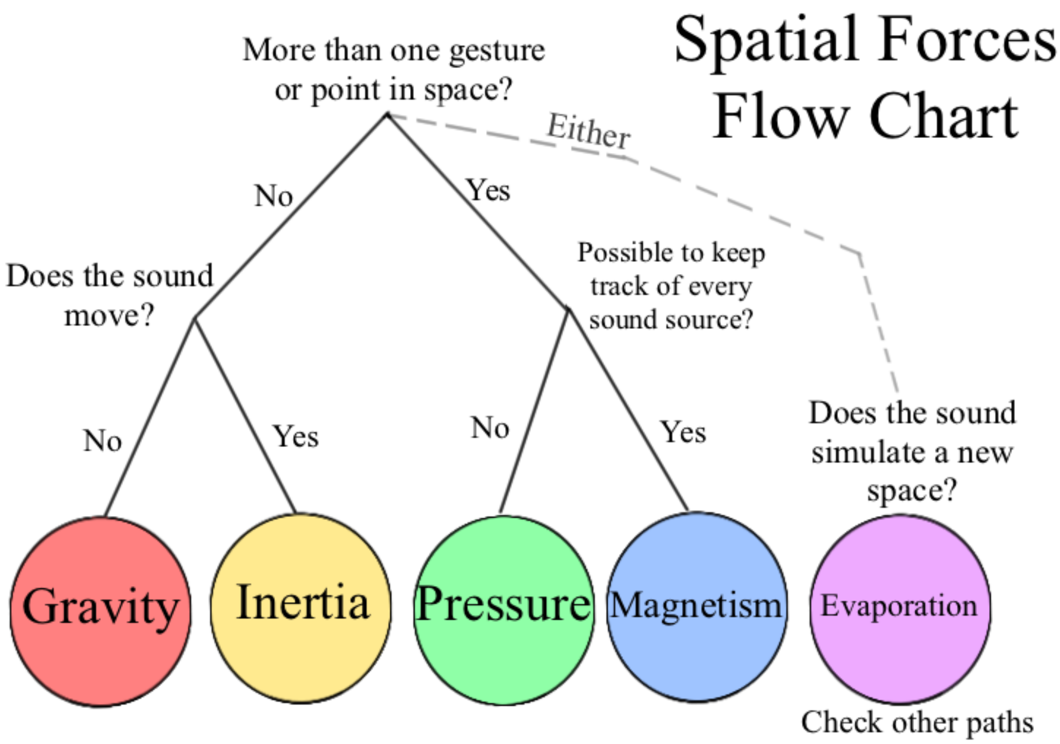

Figure 11: Flow chart guide for spatial forces

41 In acoustic music, it can describe when a performer changes acoustic environments in a performance. This might occur if an outdoor performer moves behind a building while still being audible.

42 The malleability is also a strength because I believe it is helpful for early analytical tools for spatialization to be open to unheard possibilities. New technologies or aesthetics trends can easily change what is popularly composed with musical space, so flexible tools will be more able to adapt than rigid ones.

In pieces of spatial music there is almost always more than one spatial force present. Or put another way, some spatial gestures are best described using a combination of forces. When many forces work together, they form a virtual world of sound that operates on its own unique spatial logic. This can be eloquently described by Hatten's idea of a virtual environment. Hatten uses the term to describe how humans imagine non-existent entities interacting with energy and intention when they listen to music, such as a melody being drawn to tonic.[43] The virtual environment of a spatial piece of music is therefore a summary of the forces present and how they influence or are influenced by other musical elements.

A good example of a virtual environment would be Joo Won Park's electroacoustic piece *Beft*. The title and concept are taken from a line in a Dr. Seuss book which talks about creatures named "Beft" that go to the left. Consequently, all the sounds in the piece move to the left. If constructing a virtual environment to define the use of space, magnetism is a very important element since all the sound are attracted to one side of the stereo field.[44] Gravity is less important, since very few sounds ever stay still or fixed in place before succumbing to the magnetic force. Because each musical object in the piece moves to the left at a different rate of speed, inertia is also a fundamental part of the virtual environment. The entire piece could be described only using the force of inertia, since all spatial movement boils down to simply sliding leftwards. But describing the left side as having a magnetic force personifies the location and

[43] Robert Hatten, & Maria Paschoal, & Cristina Gerling, & Flavio Pereira, & Diósnio Neto, & Guilherme Barros, & Paulo-de-Tarso Salles, "A Conversation with Robert Hatten about A Theory of Virtual Agency for Western Art Music," (August 20, 2020), Accessed July 15, 2023. https://doi.org/10.52930/mt.v5i2.165.

[44] Magnetism often is used to discuss how two sound sources attract or repel but can also describe how one sound is attracted or repelled from a certain place in a spatial field. This happens when enough attention is brought to a specific point that it can be heard as having agency in warping the virtual environment.

gives it agency that can't be described simply using inertia.[45] To summarize the piece's virtual environment, it can be said that all of the gestures are drawn magnetically from the right side of the sound field to the left, but each unique timbre is affected by the magnetism unequally, resulting in deferring rates of inertia. In Figure 12, the dashed lines represent how short percussive gestures repeat over time so that the listener can track their movement. The grunt sounds in green are pulled the quickest to the left, followed by the drums in red and lastly by the "noisy whine" sound in blue. It is as if the quicker the sound is pulled to the left, the lighter it is, and the magnetic force is the one revealing this physical mass. In the piece *Beft*, in can be seen how virtual environments create new physical laws exclusive to individual compositions.

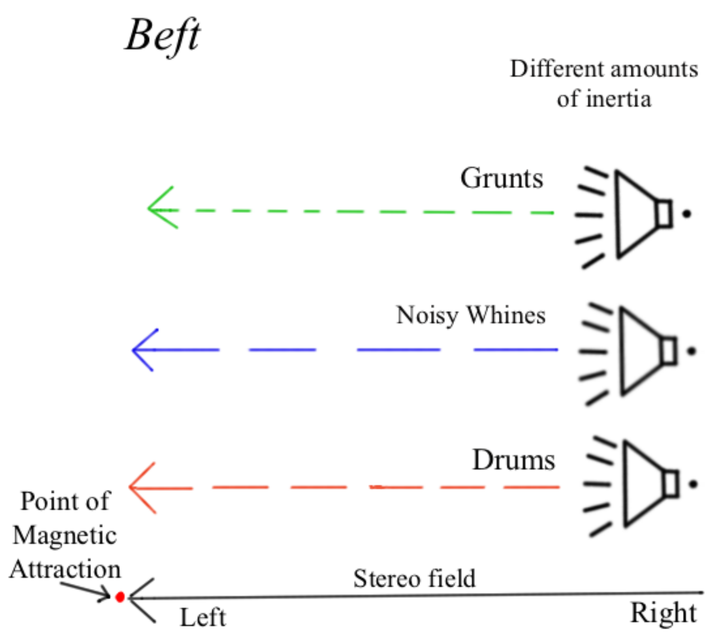

Figure 12: A representation of the virtual environment from Joo Won Park's *Beft*. Sounds move to the left in a stereo field with different types of inertia.

[45] Magnetism is useful to describe the relationship between two things, while inertia generally describes the trajectory of a sound. The terms do, of course, overlap when magnetism creates a long-term pattern. A good example of this could be the afore mentioned spatial hocket in Figure 8. Since both sound sources avoid happening in the same space, it can be said they are magnetically repelled. But the pattern can also be described as having spatial inertia due to its consistency.

CHAPTER III

ANALYSES OF SPATIAL VIRTUAL ENVIRONMENTS

Gravity and Agency in Michel Chion's Sanctus

A piece of music that exemplifies how spatialization can be a primary element in a composition is Michel Chion's *Requiem* for fixed-media. This is a seventy-minute-long work (premiered 1973 in stereo) that uses the spoken text of a requiem mass as its foremost sound source.[46] The sound world of the piece is split between vocal recordings of singing, coughing, laughing, snarling, and speaking contrasted with purely mechanical sounds created by synthesizers. Some of the spoken samples are manipulated, being cut off short, pitch-shifted, or spaced throughout the stereo field as if they are actors on a stage.

One of the middle movements, the "Sanctus", exhibits how an agential desire can work against the spatial force of gravity for dramatic effect. The movement opens by establishing a reverberant setting with many reflections across the entire stereo spectrum, suggesting to the listener that they are in a large hall with stone floors. Outside of this space in a less reverberant place, a voice enters muttering the word "sanctus" (holy) over and over again. This voice is stuck to the center-right of the stereo field, held in place by gravity (Figure 13). The timbre of the voice is altered (either by the voice actor or through electronic means, or both) to sound pinched, nasal, and otherworldly, a demon perhaps. The demon begins chanting Sanctus repeatedly, growing faster and more frantic with every repetition and increasing in pitch. This frantic activity

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[46] Sarah Jacobs and Paul Rudy, "Noise, Dissonance, and the Twentieth-Century Spiritual Crisis: Synchresis in Chion's Requiem," (Proc. of The 2006 International Computer Music Conference, New Orleans, Louisiana, USA, November 6-11, 2006) accessed November 8, 2021, http://hdl.handle.net/2027/spo.bbp2372.2006.048.

does nothing to affect the gravity holding it in place, making the creature sound stuck or imprisoned. Suddenly, when the demon reaches the top of its lungs the space changes to a dry one bringing the sound right in front of the listener. The lack of reverberations makes it sound much closer and no longer stuck in a faraway world.

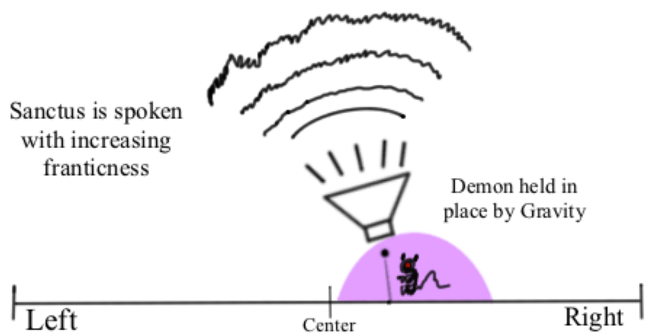

Figure 13: The spoken work part is held in place by gravity

This marks a formal change in the movement and the spatialization of the piece. The little creature has gained newfound agency within the virtual environment and is now able to break free from the force of gravity holding it in place. The demon then unexpectedly appears on the far left of the sound field and hisses its favorite word (Sanctus) before immediately hissing it again on the right side of the stereo image.[47] The force of spatial pressure begins to increase as the original voice gains a following and several other demons join in, growing the number of

[47] Because recorded samples can be copied endlessly in electronic music, it is unclear if the second hiss should be attributed to the original character or a new character. This uncertainty seems to be intentional, because it raises the question of "how fast can the original character move from the left side to the right?" The question is never answered because additional voices join and hide the original, so the lasting uncertainty about the original's speed serves to make it seem more alien and mysterious.

sound sources. Each start hissing at different fixed places in the virtual space, panned to the far left and right ends of the stereo field in contrast to how the original voice began stuck in the middle. The hisses begin noticeably moving from side to side but each voice magnetically repels the others. The demons seem to want to stay spread out in the sound field, as though they can't stand each other or perhaps are hunting something as a pack. With one final outburst, the original demon ends up in the center again and gurgles a long-drawn-out utterance of "Sanctus" that is panned rapidly between the right and left channels. Each side of the stereo field at that moment magnetically repels the original voice, as though both sides of heaven and hell have rejected the creature's final plea.

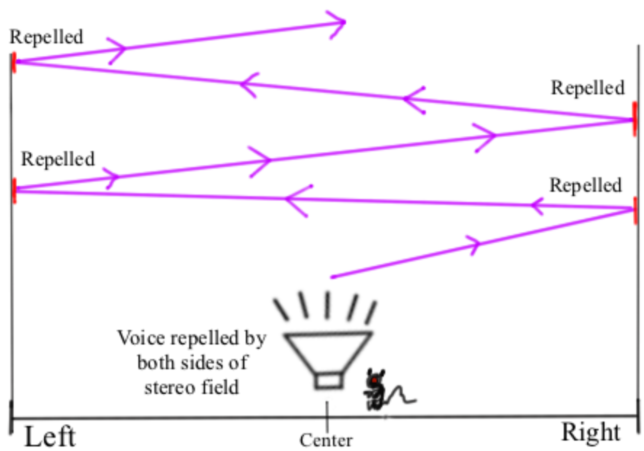

Figure 14: The demon is magnetically repelled by both ends of the stereo field

After a short interlude of synthesized sounds, the voice returns (1:16) with a sudden cough in the center of the sound field. The cough wakes up another slew of demons that were absent from the first revelry, as new guttural voices (pitch-shifted down) begin chanting

“Sanctus” as well. The voice that coughed is apparently sick and fatigued enough to be caught in another field of gravity and begins sobbing in the center of the stereo image where it arrived. Many of the new voices are gravitationally stuck as well, but a couple of the low-pitched and imposing voices freely move about the space and add momentum and inertia to the cacophony. As the demons continue their ambiguous celebration/dirge, new voices, child-like and distinct in timbre and space from the demons, begin singing the rest of the text to the Sanctus. This quasi-angelic choir enters at the exact same center-right point of the stereo field where the very first demon spoke and becomes subjected to the same force of gravity. Unlike how the demons magnetically repelled each other, this new voice multiplies into several pitch-shifted instances that all stay magnetically clumped together. They sing and bless the demons but will not walk among them or leave the safety of their group. The larger demon that was moving around freely has started being tossed from side to side, magnetically repelled and banished from either end of the stereo field in contrast to the choir’s stable location. All the voices then become subsumed by the entrance of synthesized electronic drones and the new sounds create a force of spatial pressure to crush and flood out the demons. In one last act of desperation, a demon breaks out of the newly imposed electronic sounds and dryly yelps “Sanctus” right in front of the listener; panning slightly to the left in final defiance of the virtual gravity before falling silent.

Forces of Attraction in Monk’s *Hocket*

In the acoustic realm, one piece that demonstrates the forces of spatial magnetism and inertia is *Hocket* by Meredith Monk from her album *Facing North*. This work is for two singers and the performance being analyzed includes a low and a high voice. There is no published score for this work, so the main document being looked at is a video of a performance from 1991 and uploaded to YouTube in 2013. In this performance, both singers start on opposite sides of the stage and sing back and forth to create a compound melody that hockets between them. As the pattern changes, the singers walk closer and closer together (figure 15) until a climatic iteration of the melody results in them repelling each other, finishing the piece in the opposite corners from where they started. Unfortunately, most likely due to the video's age, the youtube recording exists in mono and not stereo, so the audio contains no spatialization at all. The recording available on her album has each singer panned slightly to the side of each other but doesn't digitally mimic the movement of the singers from the performance. As noted in its inclusion in a valentine's day themed article on New Music Box written by Ellen McSweeney, the work suggests: "either the rhythmic call-and-response of lovemaking or a couple in a lifelong repetitive conversation. Or both."[48] If using that perspective, the magnetic force of attraction mirrors the idea of a romantic attraction between the musical characters. Space in this piece could therefore be interpreted as a metaphor for intimacy.

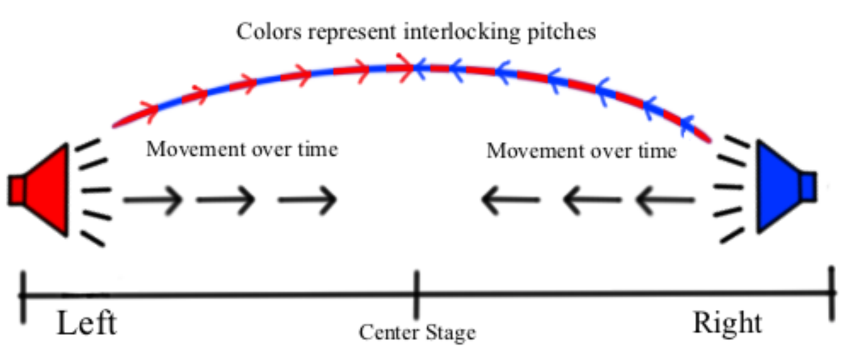

Figure 15: Two vocalists being magnetically attracted in Monk's *Hocket*

[48] Ellen McSweeney, "Very Modern Love Songs: Your Weird, Steamy Playlist for V-Day," NewMusicBox (February 14, 2014), accessed July 15, 2023, https://newmusicusa.org/nmbx/very-modern-love-songs-your-weird-steamy-playlist-for-v-day/#.

Beginning with an ostinato in a lower vocal tessitura, each singer begins adding higher notes to grow the minimalistic pattern. After the frequency of these higher notes increases (around 30 seconds into the piece) the singers start becoming magnetically attracted to each other and each take a couple steps forward. Their conversation has intensified, causing them to get closer together both physical and metaphorically. The higher voice breaks the hocketting pattern briefly by stealing five notes in a row for herself, which then triggers another couple steps forward. After a cadence in which both vocalists pause and take a short break, the ostinato pattern restarts with renewed vigor and introduces new notes. They slide a few steps closer and resume where they left off. The two performers arrive at their closest and final position after both musical lines start sliding notes up and down. They have been magnetically pulled together in space in response to melodic developments. The clear pattern of moving together emphasizes the changes in the melodic pattern and creates a sense of inertia, with the audience predicting from the start that the two singers will arrive together eventually.

While still standing close together, the melody speeds up, reaches a climax, and then pauses. The hocket starts up again, slower this time, and now the magnetic force between the two singers is reversed. They begin walking backwards as they repel each other, gliding away in a relatively short time span compared to how long it took to meet in the middle. Once they reach the farthest edges of the stage, both voice parts introduce the highest and lowest notes in the piece. These high and low notes create a “pitch space” metaphor to compliment the spatial reality; they are now both physically and musically as far away from each other as possible. Each voice slowly peters out as the hocketing melody gets slower, losing its inertia in response to the loss of spatial inertia. Both singers are fixed in place and there is no longer an expectation of movement.

Since there is no published score or written directions, it is unclear how important this particular spatialization is to the piece *Hocket*. Because the composer was performing her own work, it might have been a spatial decision made for the individual hall it was performed it. The name "hocket" does imply a concept with space and multiple voices, but it could be spatialized in other fulfilling ways too. The digital recording also doesn't mimic the use of space from this performance when it could have, raising questions. But, regardless of how critical the spatial chorography is to the composer's conception of the piece, this performance is a clear example of how magnetism and inertia can be found even in acoustic music.

Spatial Teamwork in Park's *Singaporean Crosswalk*

Another piece that contains an interesting use of spatial forces is *Singapore Crosswalk* by Joo Won Park. This is a work for laptop ensemble in which several people walk around a venue while playing sound from their computers and following choregraphed instructions that appear on their screens. There is no upper limit to how many performers can play the piece at once, but there were originally parts for four computers, implying a minimum number.[49] These instructions tell the performers to either walk in a direction of their choosing or to periodically stop and choose a new direction. The instructions for the piece also ask that performers seek out areas in their environment that might have unusual acoustical properties, such as a reflective wall that creates echoes.[50] This direction causes there to be a magnetic force that draws performers to spots of their choosing. The magnetic force is therefore created by giving the performers agency to choose where to wander based on their own sonic interests. If *Singaporean Crosswalk* didn't

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[49] In my opinion, the greater the number of people performing, the more effective the spatialization of the piece.
[50] I've performed this piece both outside and in a concert hall. It works well in both settings, provided there's no rain and no leaky roof respectfully.

ask performers to listen for any interesting acoustic properties around them, they might choose to walk around randomly and not listen to their surroundings, nullifying the magnetic force.

The sonic material of the piece, which consists of varying rhythmic patterns using a limited pitch set, also creates a magnetic force that attracts the performers to each other. Each rhythmic loop can last for about 30 seconds and consists of one pitch or single chord repeating itself (Figure 16). Each person (unless people are doubling up on parts) has their own unique pitch/chord and tempo (Figure 17). On their own, each individual part is rather bland, especially after 30 seconds of it. But this blandness is a key mechanic of the piece because the rhythmic loops only reach their full musical potential when combined into polyrhythms (Figure 18). Since each performer is moving independently, the polyrhythms can only be heard when players go near each other. Thus, the force of magnetism is created by rewarding players with new combinations of polyrhythms that result from being in close proximity to another sound source.

Figure 16: The sound of one computer part from *Singaporean Crosswalk*. Similar sections can last up to about 30 seconds

Figure 17: A second section from *Singaporean Crosswalk* with a new pitch and tempo

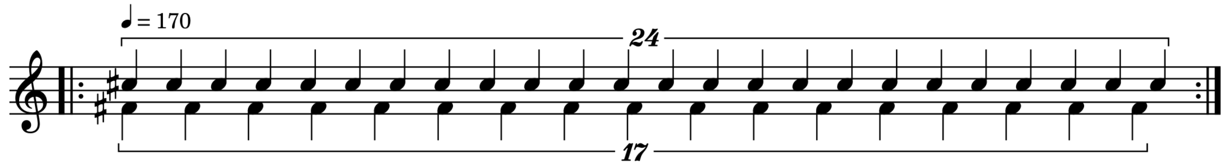

Figure 18: A resultant polyrhythm from combining the music from Figures 15 and 16.

The spatial force of evaporation is also an element of this piece. Since each pitch repeats over and over, the color will change from wet to dry depending on what else is in the physical environment that can cause reflections or dampens them. Each sound will constantly be changing its state due to where the performer chooses to walk. The beeping sound might become much more reverberant under an overhanging roof than in an open field for example.

The virtual environment of this piece therefore becomes a system where simplistic sounds are colored differently depending on their location and musical interest is created by the magnetic attraction between performers seeking out more complex and unique polyrhythms. One of the important aesthetic concerns of electroacoustic music is sonic awareness, or encouraging people to find beauty in the sound that exists around them. Since *Singapore Crosswalk* literally requests that the performers listen to the acoustic characteristics in the space around them, it clearly shares and espouses this aesthetic ideal. And because this ideal is what causes performers to be magnetically drawn to certain locations, it becomes a factor of the virtual environment as well. *Singapore Crosswalk* is therefore an example of how a composer can use spatialization to promote beliefs they find aesthetically pleasing or beautiful. Composers always use various musical elements to promote their own aesthetic beliefs, and some elements are used more than others depending on the era.[51] But *Singapore Crosswalk* is a somewhat unique example of spatialization being the principal musical element used to make a complex aesthetic statement.

A final characteristic of *Singapore Crosswalk*'s virtual environment is that it celebrates teamwork. Because people are sonically rewarded by complex polyrhythms when they are near each other, the work celebrates a system where people are interdependent on one another. If one person attempts to perform this piece solo, the force of magnetism breaks down and the virtual environment along with it.[52] If *Singapore Crosswalk* is read as a social commentary, it concludes that people need each other to have any sort of purpose or success, musical or otherwise.[53]

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[51] Such as how harmony was used as a primary aesthetic dividing line at the turn of the 20th century.
[52] I've tried performing it alone and the piece was not as effective.

CHAPTER IV

DEVELOPMENT OF SPATIAL FORCES IN MOVEMENT I OF *WITH PARADISE ABOVE*

Like many of my pieces, *With Paradise Above* references a multitude of musical and extra-musical topics but tries never to communicate an easily understood message about any of them, forming a cloudy nebula of meaning and ideas. As an artist, I like to present listeners with sonic abstractions, give them a couple handholds, and then leave them room to ascribe their own meaning and understanding to the sounds. The result is akin to a sandbox videogame, where abstract puzzles/goals are presented that could be solved in a variety of ways. If I stepped in and tried to tell audiences what I thought my own compositions are about, I fear it would spoil the purpose of the music. By analyzing my own piece, I hope to reveal insights into how *With Paradise Above* engages with the concept of space, but not dictate any "correct" way of hearing, analyzing, or interpreting the work.

Cosmic Dissipation

The opening movement, titled "Cosmic Dissipation," is loosely inspired by a cosmology model that describes the timeline of the universe, from the beginning to its heat death. The model consists of the Big Bang, the formation of planets and stars, celestial bodies collapsing into black holes, and the Dark Era where all matter slowly freezes to absolute zero. While I'm not sure if such a model is still in fashion among those studying the physical fate of our universe, it is a concept that I found inspiring for writing a piece of music about space and spatial forces.

Following the model, the music is divided into four main sections with each being defined by a unique virtual environment of spatial characteristics.

To differentiate between them, I've named each virtual environment below in Table 2. At the three seams where one virtual environment changes to the next, I tried to mimic three modulation strategies found in tonal music. I did this to highlight how the change of a composition's virtual environment could be heard as similar to a change of pitch center. The first seam copies the idea of a "pivot chord" modulation, where a chord found in both the new and the old key center is used as a link to help listeners smoothly adjust to hearing new tones. In my piece, instead of pivoting on harmony the melodic content is kept the same while the spatial pattern in the electronics changes behind it. Keeping one element of the musical material the same makes the transition smooth rather than abrupt. The second seam is similar in that it is an elision of material akin to a common tone modulation.[54] Here, many spatial patterns in the electronics change but both the old and new virtual environments share drones that are gravitationally stuck, providing a clear commonality from one area to another. The last seam takes after a direct modulation, which is an abrupt change from one key signature to another. When translated to a modulation between virtual environments, the transition is abrupt with no commonality between the old and new spatial environment. Musically, I do eventually include similar melodic material in the saxophones and callbacks to spatial patterns found earlier in the piece, but the moment of transition itself (mm. 123-124) only focuses on the differences between the old and new virtual environments.

[54] A common tone modulation is when one note that is common to both the original and destination key is held over and recontextualized in the new key.

Table 2: Virtual Environments in Cosmic Dissipation

Sections of "Cosmic Dissipation"	Main Sounds and Gestures Used	Virtual Environment and Relevant Spatial Forces
Section I mm. 1-42	1) Explosions 2) Particle with short bell-like attack 3) Airy Drones	**A) Particle Expansion:** 2) and 3) Magnetically attracted and repelled particle gestures and drones. 1) Explosions gradually move from the center of the spatial field to an edge.
Section II mm. 43-80	1) Bell formations/chords 2) Thick Drones 3) Pitched Percussive Ostinato 4) Synth Melody	**B) Celestial Formation:** 1) Bells sounds move in gravitationally held clumps. 3) Percussive ostinato circles with varying amounts of inertia with drones 2) and 4) Melodies and drones are gravitationally held in four corners
Section III mm. 81-123	1) Static, Popping 2) Noisy Distorted Drones 3) Unpitched Percussive Ostinato	**C) Gravitational Collapse:** 1) Static gains inertia before collapsing into a corner 2) Drones are gravitationally stuck. Particles try to escape event horizon but are sucked back in 3) Percussive ostinato spins at an increasing rate
Section IV mm. 124-end	1) Shimmering Chords 2) Noisy Drones 3) Percussive Ostinato	**D) Unstable Drones:** 1) Shimmering chords expand and contract with spatial pressure 2) Noisy drones are magnetically attracted with varying amounts of inertia 3)Previously hear percussive ostinatos are evaporated to different locations with reverb

One of the large-scale concepts for the movement “Cosmic Dissipation” is that most of the musical material played by the saxophones is used throughout the entire piece but gets continually recontextualized by the different spatial virtual environments around it. The material is often developed to the point where it is heard as unique in each of the four sections, though its DNA is traceable to earlier iterations of itself. In the first virtual environment labeled “Particle Expansion” melodic motives slowly emerge from collections of trilled notes. These motives link up into a canonic structure in the “Celestial Formation” environment before being pulled and stretched into drones during the third section labeled “Gravitational Collapse.” The fourth virtual environment, “Unstable Drones,” presents snippets and fragments of all the previous melodies and spatial gestures, as though all matter in the universe is slowly being stretched thin. By using the same motific ideas in the acoustic piece throughout, I hoped to draw attention to the spatial changes occurring in the electronics. One of my favorite composition techniques is to keep one musical element unchanging and static to draw attention to a more active musical element. While melody is not “static” in this movement per se, the uniformity of material helps accentuate each of spatial environments.

Section I: Particle Expansion

The first section begins with a spatially immersive explosion in the electronics and crunchy tremolo patterns in the saxophone parts. During this opening section, I’m trying to creatively interpret the beginning of the universe when matter started densely pack together before spreading out. Musically, quick high-pitched “particle” gestures in the electronics are attracted to the same point in the spatial field through the force of magnetism, as though elementary particles are crashing together and forming new elements (Figure 19). The sound of the opening explosion engulfs the listener from all sides of the room in a flurry of activity. But when the same sound happens subsequently, the explosions drift off to different sides of the room as though the first bang flung the listener away from the center of action (Figure 20).

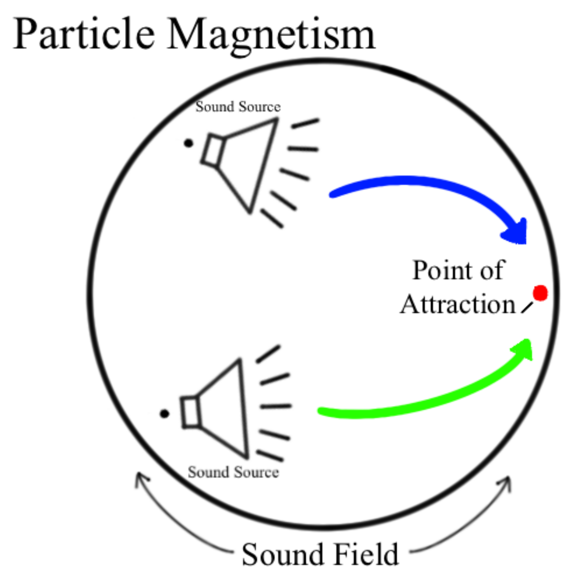

Figure 19: Multiple gestures move to the same point in the sound field

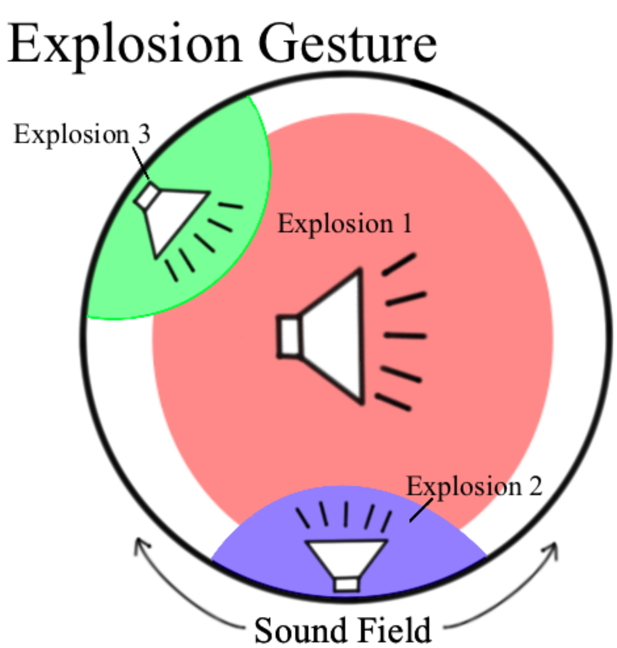

Figure 20: Locations of the first three explosion sounds

For this movement, the saxophones are set up in a semicircle in the front of the venue, so the sound of the whole group comes from a central location. The opening pitch content of the tremolo starts with the notes C, D, Eb, and F. But over time the notes morph up and down by step to new harmonies with only the root note C staying constant. Other harmonies throughout the work follow a similar pattern, being tetrachords with a constant root pitch and variable chord members.

Figure 21: The root C4 used in four different tetrachords found in mm. 1-6.

The same four pitches occur in the electronics as the pitch material for the "particles" that are magnetically attracted to each other. Spatially, since these moving particles are from the same pitch collection as the chord in the saxophone part, it sounds like they are being emitted from the middle of the room outward, as though a dense clump of matter is gradually diffusing into a vacuum.

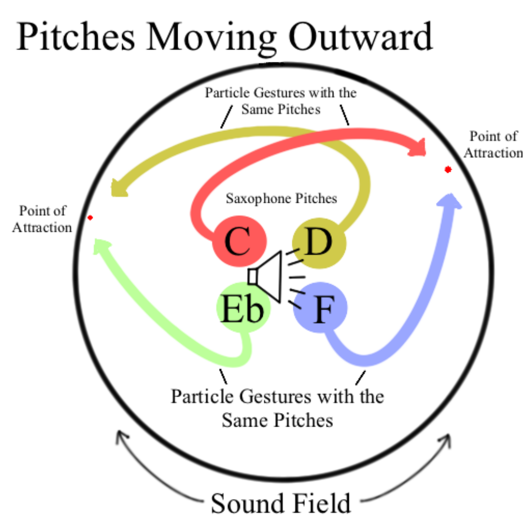

Figure 22: The same pitches from the stationary saxophones move to magnetic points

From m. 1 to m. 15 the electronic part contains shimmering drones that are gravitationally stuck in the four corners of the room. At m. 15 the acoustic material becomes more clearly melodic. To demark that structural change, the stuck drones break loose and begin to be magnetically attracted to each other (Figure 23). At the same time the quick "particle" gestures flip polarity and repeal one another; the spatial equivalent to a motif being intervallically inverted.

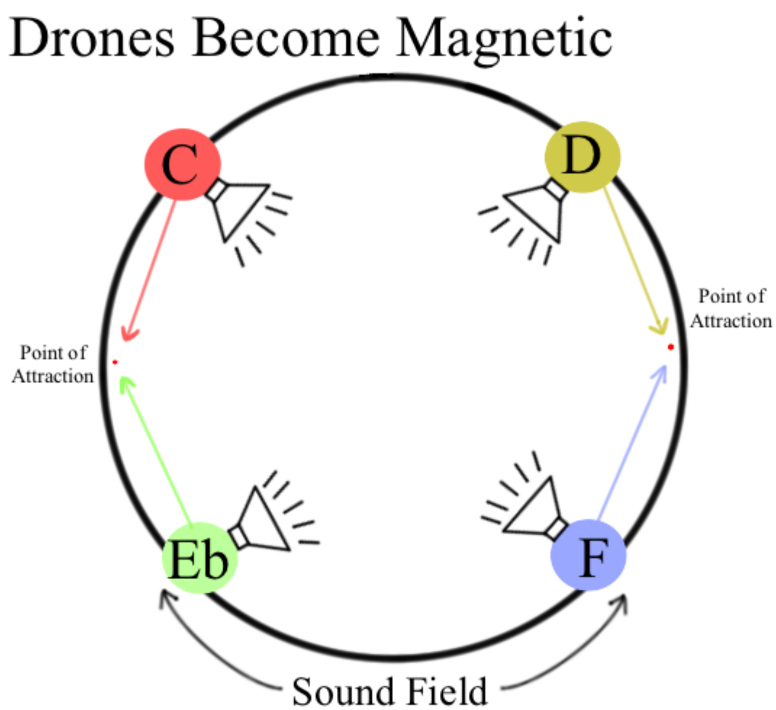

Figure 23: Drones overcome the force of gravity. They began to be magnetically drawn towards the same points in the sound field.

In summation, the virtual environment labeled "Particle Expansion" can be described as spatial forces pulling particles magnetically together and apart amongst static drones and sporadic explosions. As acoustic melodies begin to form in the saxophones, magnetic relationships between electronic samples change to emphasize the new melodic developments.

Section II: Celestial Formation

"Particle Expansion" ends with the same melody that the virtual environment "Celestial Formation" begins with, allowing the two sections to smoothly pivot from one to the next. This next virtual environment is characterized by electronic sounds clumping together and building up inertia. The sharp particle samples with short attacks[55] are transformed into bell-like sounds clumped together and moving in a group. These groups occur on the edges of the sound field, alternating between the left and right in new transpositions of the original tetrachords found in Figure 21. The newly formed clumps of chordal samples drift along, pushed by a slow force of inertia derived from the collision's leftover energy (Figure 25).

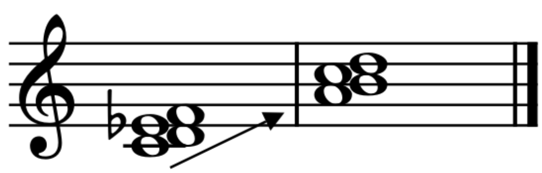

Figure 24: Transposed tetrachord

[55] An attack here refers to ADSR musical envelopes. The parts of a sonic gesture can be broken down into four parts: the Attack, Decay, Sustain, and Release. These refer to how quick the onset of the sound is, how much the sound decreases from the onset, if pitch is sustained, and how quickly the sound disappears when it stops being played. A sharp attack would be sound happening suddenly, and a slow attack would have a dynamic crescendo signaling the onset of the sound

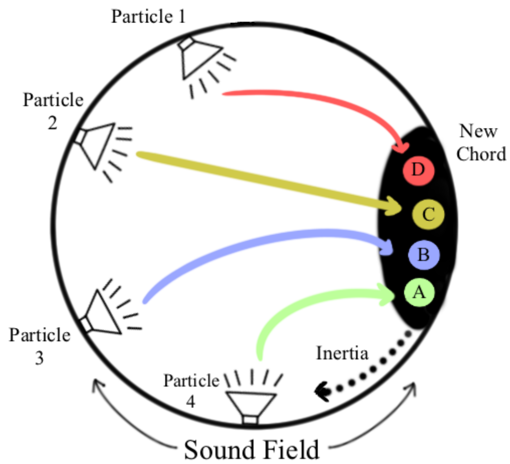

Figure 25: Particles colliding and forming new chords. The chords gain inertia from the leftover energy of the collision.

While these bell clumps are forming, the saxophone parts have coalesced into a four-part canon. To add musical energy and a contrasting metric structure to this canon, the electronics introduce a pulsing percussive ostinato in the lower register. The percussive sounds consist of four different timbres and each are pulled by inertia around the saxophonists. The four separate sounds all travel at a different rate, forming clouds of sparkling colors like planetary rings.

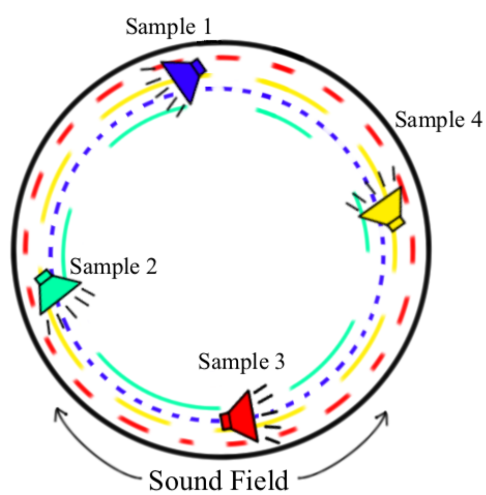

Figure 26: Four parts of the ostinato moving in a ring. Each color represents one of the four percussion samples. A higher number of dashed lines represent faster movement.

A last spatial element of this virtual environment starts at m. 67 in the electronics. At this measure, the canon in the saxophone part has now transferred to the electronics in a modified form. To copy the number of saxophone parts, each of the four corners of the spatial field adds one voice to the canon, accompanied by a synth droning along in its respective corner. Over time, even more electronic voices join the throng, and the sound field accumulates greater spatial pressure from the number of canonic voices until they all drop out at m. 81. The only remaining sounds are the drones that were gravitationally stuck in each corner which now elide into the following virtual environment.

Section III: Gravitational Collapse

The third virtual environment opens in m. 81 with the saxophones and electronics all droning on the pitch "A." In the same way the first movement uses similar material throughout its duration to draw attention to its spatial gestures, this third section uses an extremely limited palette of pitches to draw attention to where the pitches are coming from. The electronic drones on "A" begin in the four corners of the room, as though rising from the ashes of where the canonic melodies used to exist. Over time these drones of various colors spread throughout the spatial field, fading in and out of one another to create a kaleidoscope of shifting timbres and spatial configurations.

The saxophone material alternates between long drones and chant-like fragments of melody in counterpoint with one another. These two acoustic parts grow longer in duration after each cycle while the electronics maintain the pitch of the drone. Each time an instance of the melodic chant cadences, the next drone begins on a different pitch (Figure 27). To accentuate the change in texture between drones and melodies, each chant is accompanied by a crackling gesture in the electronics. These crackling gestures appear on different sides of the spatial field and flow into corners where they become gravitationally stuck, like light being sucked into a blackhole.

Figure 27: Melodic cadence ushering in a new droned note

At m. 93 a new percussive ostinato begins to form, with accumulating electronic samples occurring on more divisions of the meter after each iteration of the pattern. This entire beat is carried in a slow circle by inertia but flips direction every time a new melody appears in the saxophone part, mapping another spatial gesture to these moments of structural change.

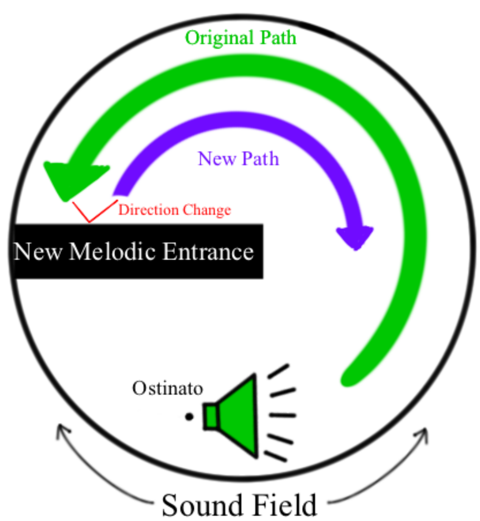

Figure 28: Ostinato changing direction in response to new melodic entrances

Section IV: Unstable Drones

When the percussive ostinato from the previous section builds up to its climax in m.124, the virtual environment suddenly changes into the last spatial area. The fourth environment is labeled "Unstable Drones" and is characterized through the use of spatial pressure and evaporation. Harmonies shimmer throughout the entire spatial field as the four pitches from the original tetrachord (Figure 21) rapidly flicker on and off. The effect is like a gentle audio "strobe light." The four different pitches in the gesture have staggered entrances and exits, causing an accumulation of spatial pressure followed by a decrease in pressure (Figure 29).

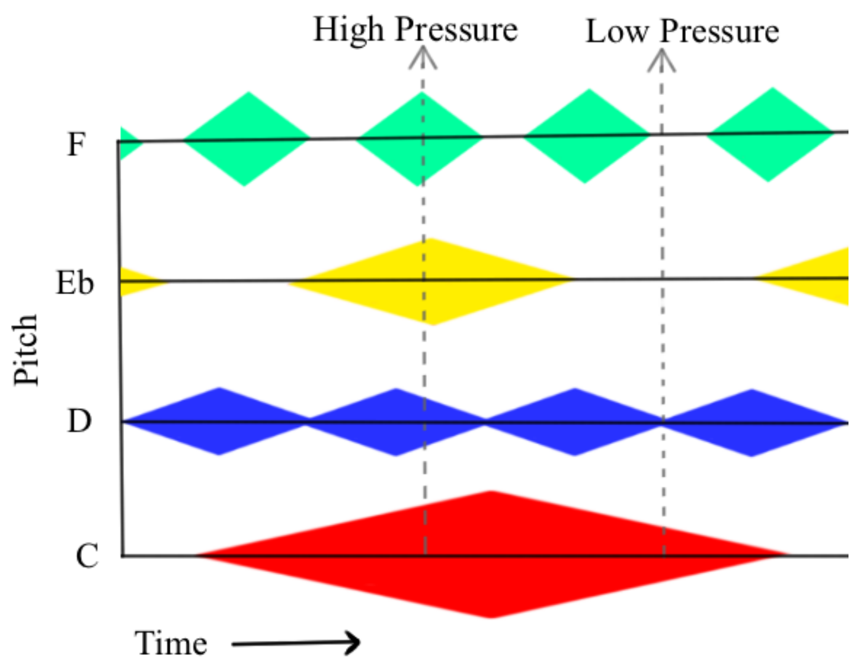

Figure 29: Moments of high and low pressure. The more notes at once, the higher the pressure.

In the acoustic part, the saxophones are given boxed notation and instructions to play bits and pieces of previous melodic motives without coordinating with each other. In each section their boxes contain more elaborate gestures, and they are instructed to create increasingly dense musical textures amongst themselves. This accumulation of denser acoustic textures mirrors the accumulation of more spatial pressure in the electronics, forming a relationship between musical texture and space. As the section continues into m. 127, disembodied percussive material from the two previous ostinato patterns appear scattered sporadically in the audio field. Each of these samples are heard multiple times in a fixed location and every occurrence has a new reverb tail applied to it. This causes the sample to sound like it is changing locations and existing either nearer or farther away from the listener while still being gravitationally stuck in place. Distorted drone gestures from the third section also make a reappearance, but this time they start out gravitationally stuck before splitting into three EQ bands (the highs, mids, and lows) that float away in different directions. The dissipation of the drones suggests a universe that is slowly breaking down into particles and cooling to absolute zero.

Concluding Remarks

While I do not expect any listeners to follow exactly how I'm connecting these four virtual environments to different stages of a cosmology model, I do hope that the spatial contrasts between the sections is musically compelling. Or provides enough evocative spatial ideas that a listener might feel inclined to come up with their own personal narrative through which to hear the piece. In writing this work, I used my own terminology of spatial forces to organize and come up with the spatial patterns. Overall, I found them to be a useful composition tool that helped me create a variety of sonic environments and think up spatial ideas I may not have considered otherwise. In my previous work (especially with electronics) I've included space as part of my compositional rhetoric, but I often found myself simply moving sounds around a spatial field without much thought other than to create a variety of gestures. Using my own terminology helped me to categorize ideas and see how some might be thematically grouped together or highlight musical relationships between them. And I'm excited to see if other composers besides myself might find this terminology useful in their own compositional processes.

CHAPTER V

RECAPITULATION

I once had a composition teacher who believed that the use of space was the defining aspect of electronic music. Not electricity, not technology, not a computer, but space. His reason for this was because when sound is stored digitally or electronically, you must choose where to place a speaker to hear it (be it monitors or headphones). This definition fascinated me and was what caused me to start thinking about space as a fundamental part of music composition. Besides electronic music, I believe that the use of space will also become more and more relevant to acoustic music as well, since performance practices nowadays frequently incorporate speakers. And if more performers of acoustic instruments start listening for how music can be spatialized, I imagine many of them would be interested in incorporating those ideas into concerts and recitals. Perhaps in a solo recital a lament could be played from behind the audience, invoking an Orpheus-like concept of not being able to look back. Or a duet recital could have the different performers play from across the concert hall or between the floor and a balcony. There are endless possibilities, but at the very least I hope that by creating terminology to talk about space, acoustic musicians (and concert attendees) will start to wonder if there are more interesting ways to perform music beyond the convention of standing still in the middle of the stage. Rejecting convention is at the heart of being a musician and an artist, and to me musical space is an avenue for challenging norms.

Potential Pedagogical Uses for Spatial Forces

A further application of spatial terminology is to employ them as pedagogical tools in music classrooms. I believe they would prove especially useful to music technology and composition intro classes because they focus on creating original work. This would allow students in those classes to make new music while organizing their spatial ideas into categories of inertia, gravity, or magnetism. But even aside from classes the focus on compositional work, I can also imagine them being used in music theory, music appreciation, and music production courses as well. In the Spring of 2023, I taught an intro to music technology class I decided to test the effectiveness of my terms by seeing how my own students would use them. This class covered basic music software was offered to a wide variety of music majors, making it perfect for seeing how a diverse group of musicians might use spatial descriptors. At the time, they were working on a project that required them to add different types of automation, such as panning, to MIDI instruments in Logic. When I introduced them to the idea of spatial forces, I gave several examples of how space could be used and encouraged them to think about creating their own virtual environment. The results were exciting. Only a few students really explored the concepts (It was not a requirement because students new to DAWs[56] already had enough topics to learn.), but those that did started building (and therefore hearing) spatial relationships in their stereo field. These folks were also drawing in automation lines so that their sounds moved around in zigzagging patterns and included spatial variations in tandem with motivic variation. This was a marked improvement from the previous semester (who weren't give spatial terminology) where most students simply moved a couple sounds to different sides of the stereo field while many did no panning at all. For future class in music technology, I hope to include lessons about ways to

[56] Digital Audio Workstations

talk about space earlier on in the semester to see how students play with the concept over an entire semester of projects.

Future Avenues for Research

I view one of the main benefits of describing spatial gestures with physical metaphors is that it forces any analysis to be somewhat subjective rather than objective. If a sound is moving from the left to the right, my terminology can't determine if it is moving because of its own inertia or because it is being magnetically attracted to the right side of the room. It would be up to whoever is doing the analysis to decide. While the movement of this example is objectively going from one side to another, I believe terms which allow a multitude of interpretations of this gesture simply create more ways to listen to the same music. And I would contend that is a good thing. With that in mind, the broadness and lack of specificity of my spatial forces is a feature, not a bug. Of course, there are downsides to this as well. Composers who want to use analytical tools about space to aid their creative work may desire a system with more robust descriptions of spatial gestures. A composition that plays back a sequence of 12 notes from different speakers may be more accurately talked about using terms for serial music, as opposed to saying: "the sequence has 12 points of spatial gravity." It could also be the case that as people listen to spatial music more often, certain gestures become culturally dominant and any lingo for describing it would only need to cover the gesture in fashion. Thus, there is plenty of room for future research into musical space to create systems of greater specificity. But until we reach the point where spatialization is afforded the same attention as other musical elements, I believe that my terminology of spatial forces will succeed in helping a variety of musicians, composers, and listeners take the first step towards hearing space.

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APPENDIX A

SCORE TO *WITH PARADISE ABOVE*

Daniel Karcher

With Paradise Above

for Saxophone Quartet and Electronics

July 2023

Movement I
Cosmic Dissipation

Circa 10’

Performance Notes and Instructions

- Multiphonics should be treated as an abrasive effect with the pitch content being a secondary concern. If the multiphonic notated is not feasible on your saxophone, it can be substituted with another. Each multiphonic references the Weiss book for fingering.

- Microtones are always inflections of neighboring tones and are notated using arrows that show whether to tune a note up or down a quartertone.

Electronics

- The piece uses an accompanying max/MSP patch to trigger fixed-media samples. The patch will need to be formatted for each specific performance venue to accurately playback the ambisonics files. Contact the composer at karchercomposer@gmail.com for the max/MSP patch.

- One saxophonist should use a pedal to trigger the fixed-media tracks from the provided max/MSP patch. Rehearsal numbers in the full score indicate when to trigger each track.

Improv Section

- Measure 125 onward is an unmetered improvisation. Several sections are divided with repeat signs and are preceded by a rehearsal number indicating an new electronic cue. The performer triggering the cue should signal the start of each new section of the improv, letting each last about 20 seconds. A stopwatch can be used to help keep track.

- Players should repeat each section until the next cue is given.

- Each section is unmetered and the tempo at measure 125 is only a guideline. Gestures can be drawn out or speed up in time if the performer believes doing so will create an interesting texture.

- Performers should gradually increase the density of the improv texture until measure 128 and then gradually decrease it until the end. Sparser textures can be achieved by pausing longer in between gestures and holding sustained tones longer. Do the opposite to create denser textures.

Cosmic Dissipation

transposing score

Daniel Karcher


S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
2+3
2
explosion
clearing up to drones and sparks


bring out
S. Sax.
A. Sax.
(measured)
T. Sax.
(measured)
Bar. Sax.
Elc.
3
bring out
(measured)


S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
cascading particles
Elc.
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


31
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
bring out
34


37
4
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
41
5
closed spacing, darker
bell formations


44
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
open spacing, lighter
Elc.
47
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


50
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
52
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


54
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


56
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


59
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
ff
f
mf
63
6
mf
f
melodic canon


67
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
70
percussive
slap tongue
percussive
slap tongue

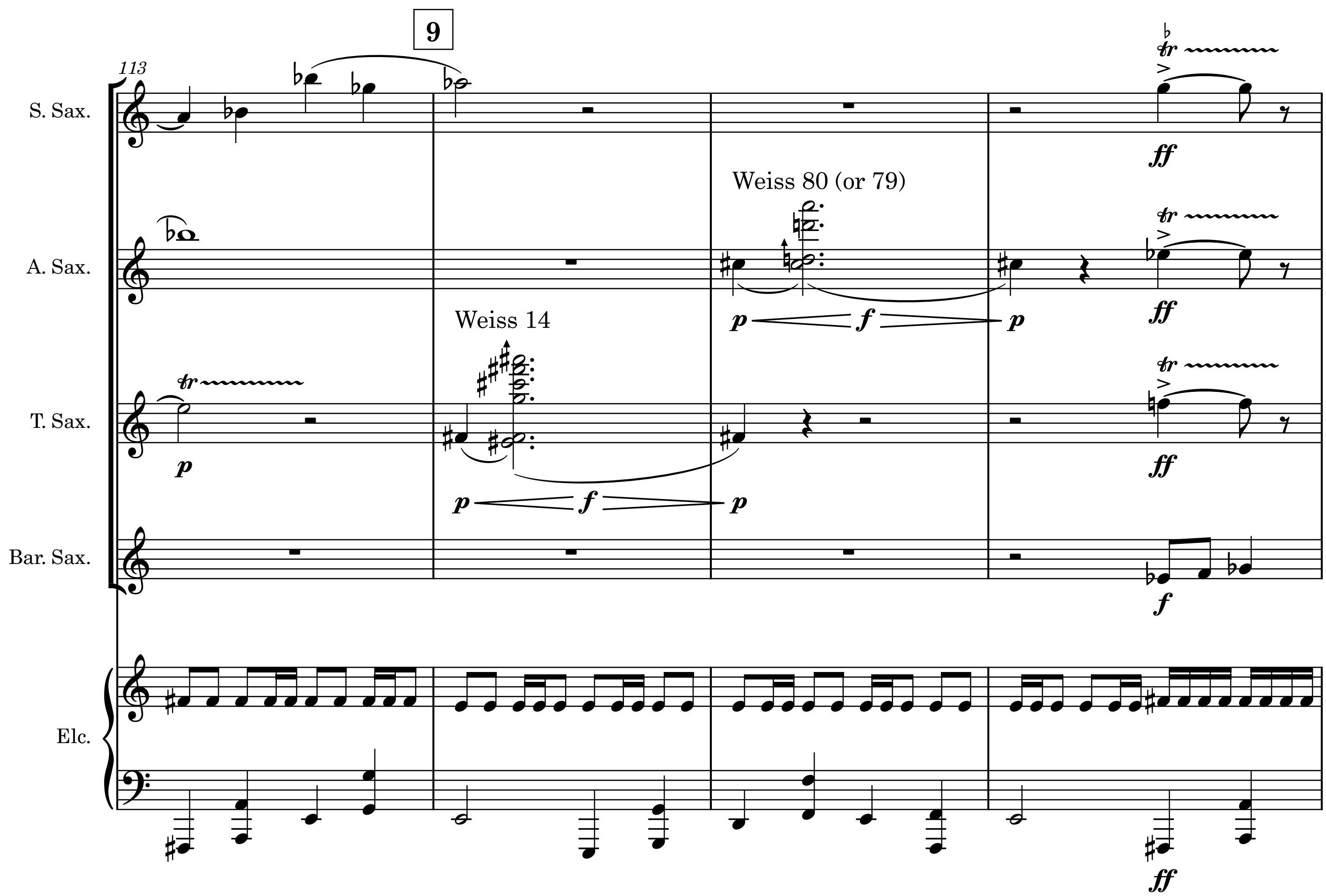

73
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
sim.
sim.
78
3+2
3+2
3+2
3+2
♩= 60
7
bell formations
static and crackling


84
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
static and crackling
89
8
trill with accel.
static and crackling
drone
percussive sounds
quasi-pitched


trill with accel.
94
S. Sax.
A. Sax.
trill with accel.
T. Sax.
Bar. Sax.
Elc.
98
trill with accel.
trill with accel.
Timbre trill with accel.
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.

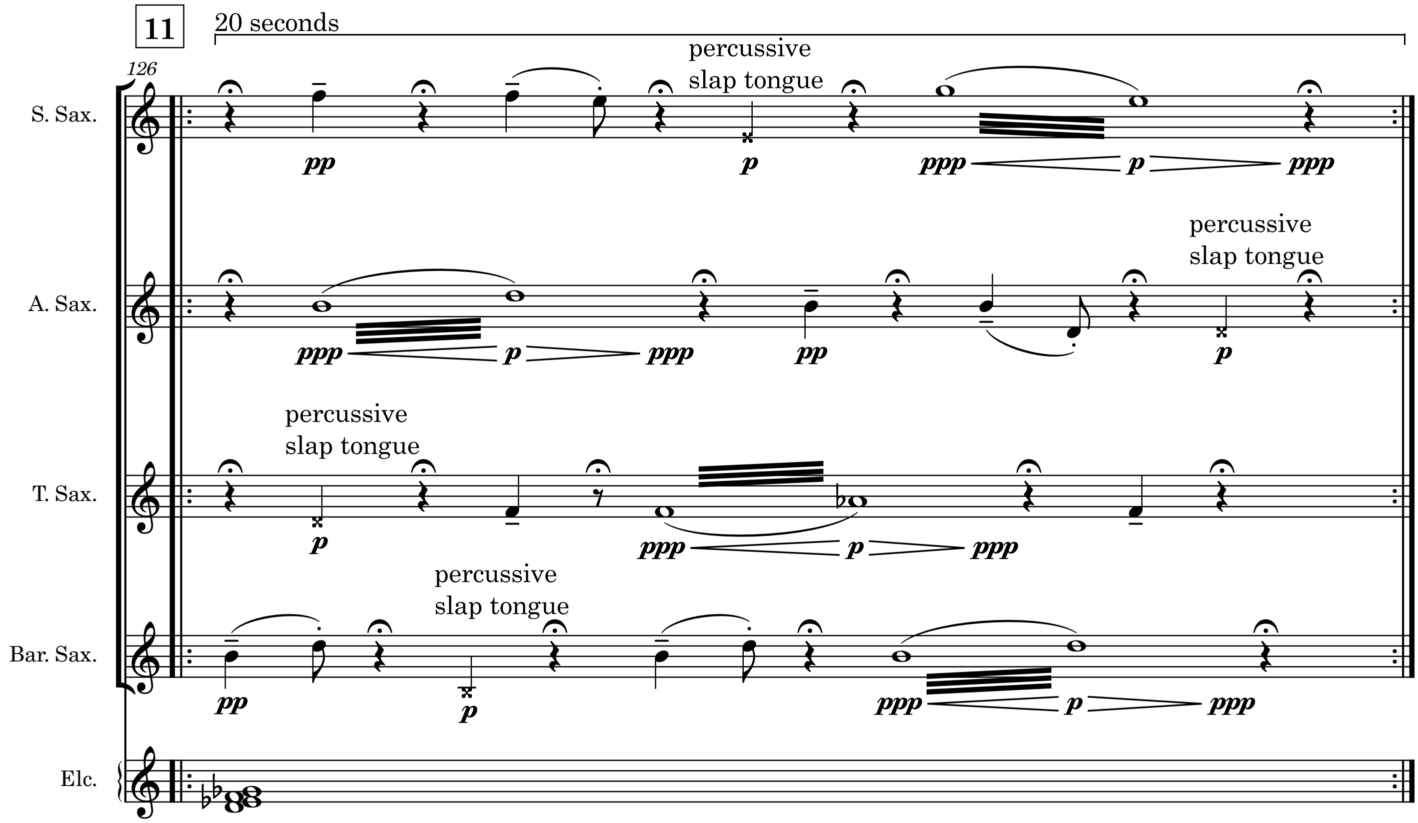

102
S. Sax.
A. Sax.
gliss.
trill with
accel.
T. Sax.
3
gliss
Bar. Sax.
Elc.
timbre trill
with accel.
106
Weiss 80 (or 79)
p < mf > p
Weiss 14
timbre trill
with accel.
p


110
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


113
9
S. Sax.
A. Sax.
Weiss 80 (or 79)
T. Sax.
Weiss 14
Bar. Sax.
Elc.

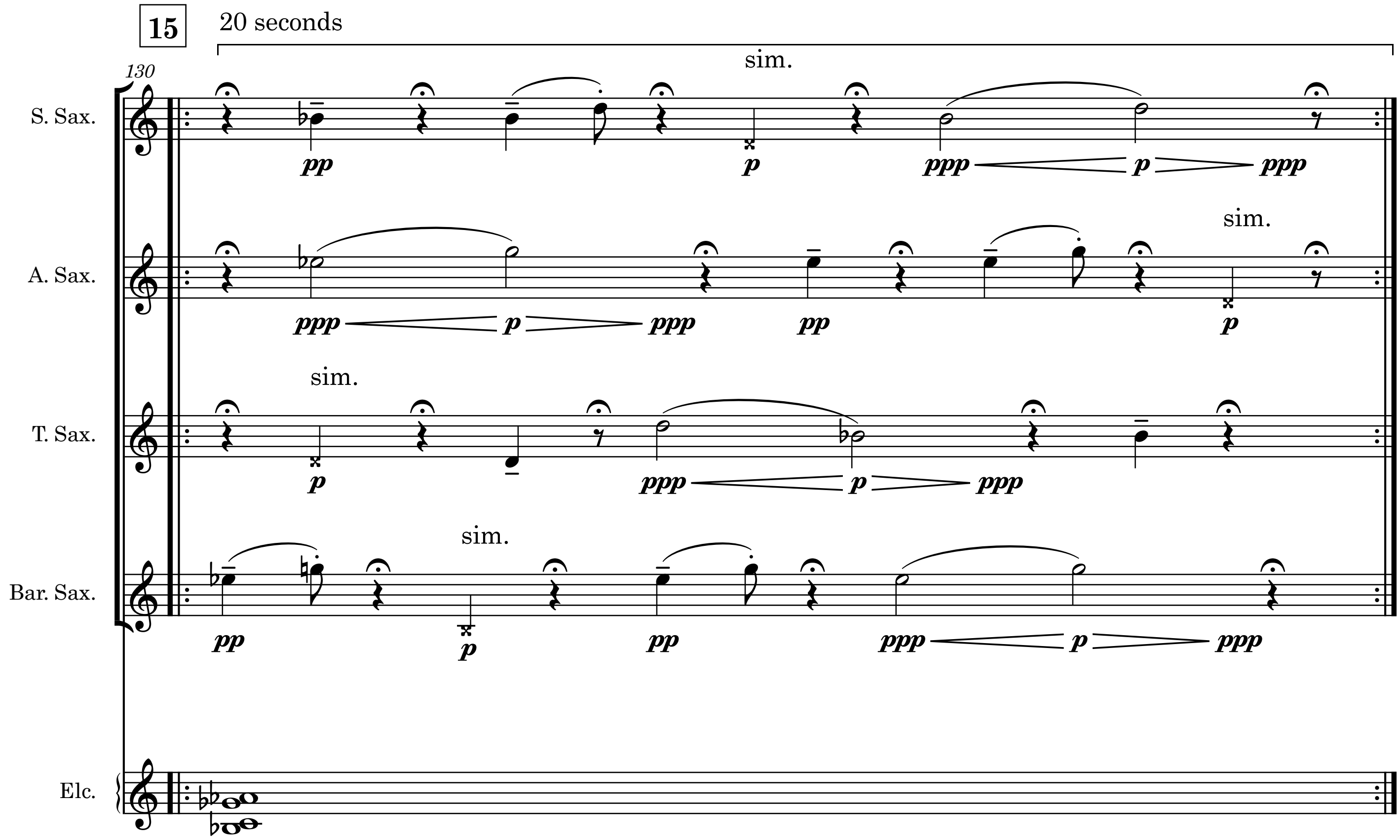

117
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
119
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.

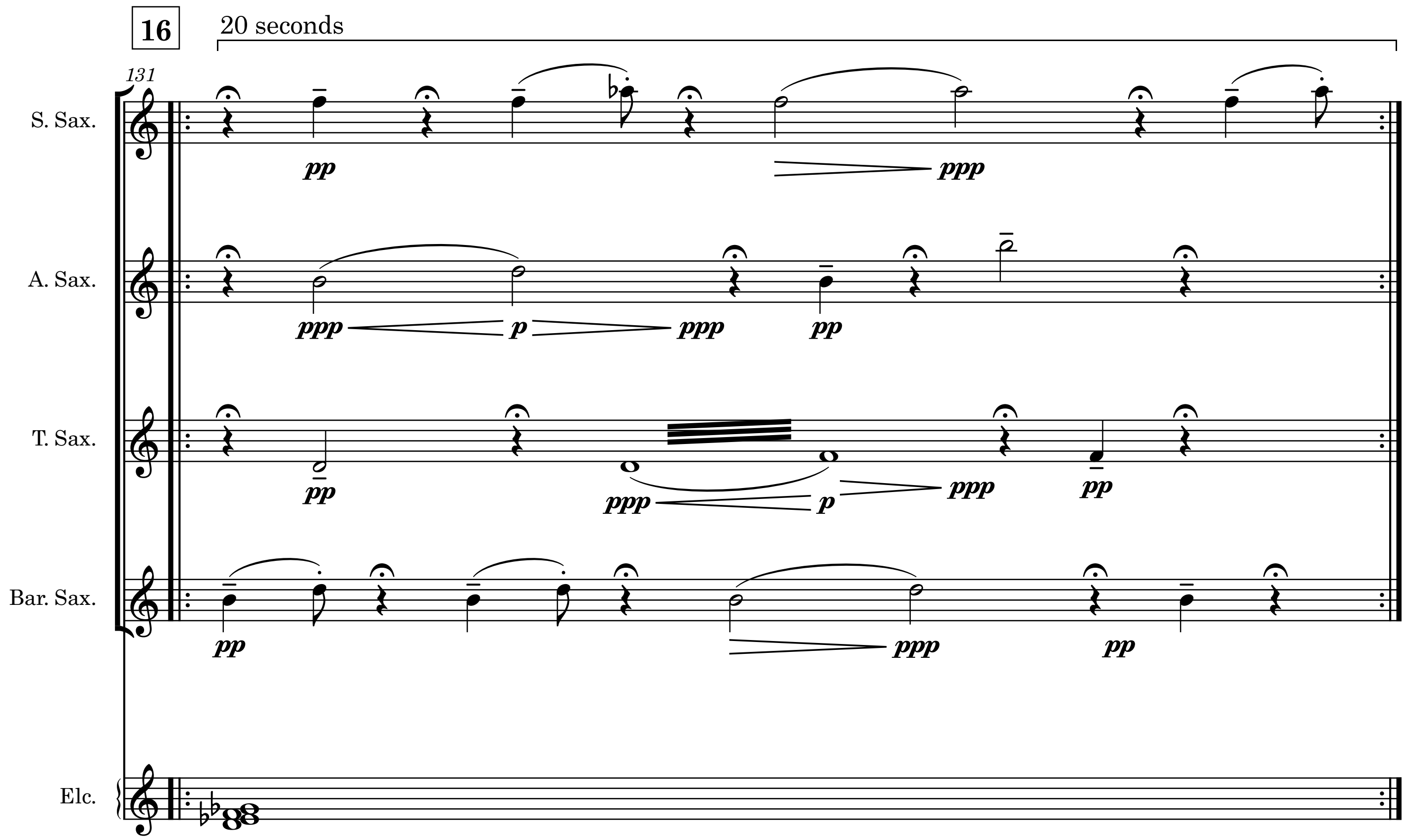

121
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
124
♩= 80
10
20 seconds
pp
ppp
p

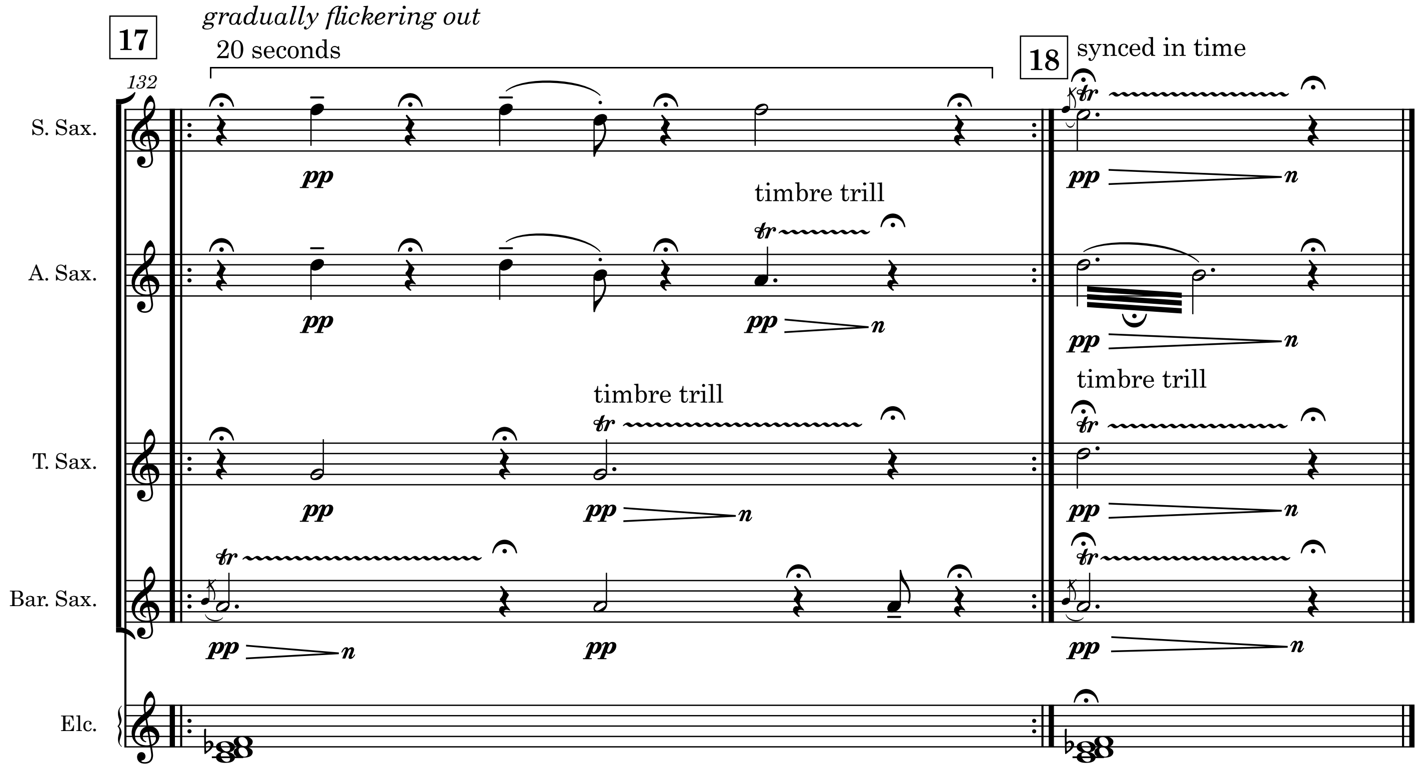

11
20 seconds
126
S. Sax.
percussive
slap tongue
pp
p
ppp
p
ppp
A. Sax.
percussive
slap tongue
ppp
p
ppp
pp
p
T. Sax.
percussive
slap tongue
p
ppp
p
ppp
Bar. Sax.
percussive
slap tongue
pp
p
ppp
p
ppp
Elc.


12
20 seconds
127
S. Sax.
p
mf
p
mf
mf
p
A. Sax.
p
mf
T. Sax.
p
p
mf
f
Bar. Sax.
tr
mf
p
p
mf
Elc.


13
20 seconds
128
Weiss 51
sim.
Weiss 71
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
14
20 seconds
129
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.


15
20 seconds
130
sim.
S. Sax.
pp
p
ppp
p
ppp
A. Sax.
sim.
ppp
p
ppp
pp
p
T. Sax.
sim.
p
ppp
p
ppp
Bar. Sax.
sim.
pp
p
pp
ppp
p
ppp
Elc.


16
20 seconds
131
S. Sax.
pp
ppp
A. Sax.
ppp
p
ppp
pp
T. Sax.
pp
ppp
p
ppp
pp
Bar. Sax.
pp
ppp
pp
Elc.


17
gradually flickering out
20 seconds
132
S. Sax.
A. Sax.
T. Sax.
Bar. Sax.
Elc.
pp
timbre trill
18
synced in time
n