Coronium 3500: A Solarsonic Installation for Caramoor

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ABSTRACT

This paper describes the development, creation, and deployment of a sound installation entitled *Coronium 3500 (Lucie's Halo)*, commissioned by the Caramoor Center for Music and the Arts. The piece, a 12-channel immersive sound installation driven by solar power, was exhibited as part of the exhibition *In the Garden of Sonic Delights* from June 7 to November 4, 2014, and again for similar duration in 2015. Herein I describe the aesthetic and technical details of the piece and its ultimate deployment, as well as reflecting on the results and the implications for future work.

Author Keywords

NIME, sound installation, soundscape composition, interactive arts, solarsonics

ACM Classification

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing, J.5 [Arts and Humanities] Fine Arts.

1. INTRODUCTION

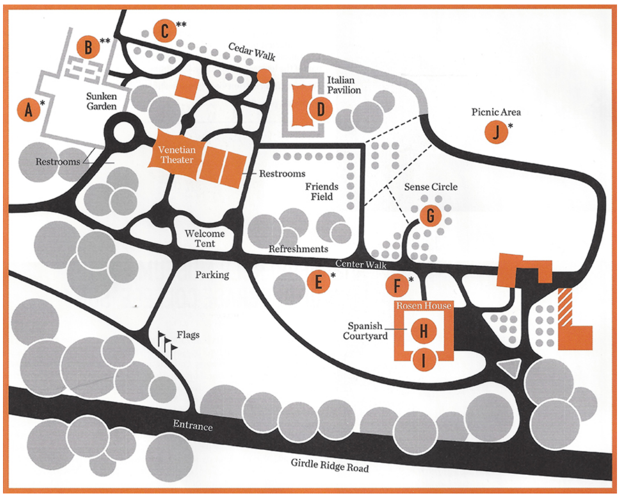

Figure 1. Caramoor Exhibition Overview

In 2013, I was approached about developing a site-specific sound installation for a group exhibition entitled *In the Garden of Sonic Delights*, curated by Stephan Moore and produced by the Caramoor Center for Music and the Arts. The concept was for each artist to visit the beautiful Caramoor estate, which includes incredible landscaped gardens, lawns, walks, and forested areas, along with the historic house and performances spaces which are used for Caramoor's summer music program. Upon visiting the site, each artist was asked to choose a location for a new work, with the idea that each piece would be created specifically for that site. We were asked to use the opportunity to create a dialog with the site itself, and to understand that the piece would need to be available to listeners through its seven-month season from June 7 to November 4, 2014.

Given my current research and interest in *solarsonics*, that is, sounds dynamically powered and activated by light [1][2], this seemed like a good opportunity to work within the electronic medium through solar power and environmentally-activated situations. Furthermore, upon completing my site visit, I located a large grassy area (see Figure 1, location J, and Figure 2) that I felt would be an effective and interesting location, and it so happened that this space was not nearby to electrical infrastructure.

The resulting piece, a generative composition in multiple voices, is entitled *Coronium 3500 (Lucie's Halo)*. It's name references both the coin termed to identify previously unknown elements in the sun's corona, as well as the curly hair of the infamous Lucie Rosen, who with her husband was the owner and founder of the Caramoor estate, as well as being a champion and performer of the early electronic musical instrument, the theremin. Below I will describe the aesthetic position, technical creation, and successful deployment of the piece as an example of my continuing research in solarsonics. I will also discuss the piece in terms of environmental and human interaction, as well as the site-specific nature of the work. Finally, I will conclude with reflections about the outcomes of the work, and implications for future work.

2. CARAMOOR SITE VISIT

Figure 2. Coronium 3500 (Lucie's Halo)

It should be noted that my first visit to Caramoor, located in Westchester County outside of Katonah, NY (just north of New York City), was in July of 2008. It was during this year that the exhibition project was birthed, but financial difficulties and other priorities delayed the project until 2013. In the meantime, Perry Cook and I had been pondering the use of solar power in the context of the Princeton Laptop Orchestra [3], and so I was already thinking about solar power. Although the project was temporarily shelved at that time, I nevertheless began experimenting with solarsonics, producing several protype works and instruments during the next few years [1][2].

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When the project reemerged in 2013, I was much better prepared for embarking on a work of this scale, having been through a number of my own experiments as well as learning about works by other artists, including Craig Colorusso's *Sun Boxes* [4], Joe Jones's *Solar Music* [5], and Alvin Lucier's *Solar Sounder I* [6]. Lucier's work, in particular, rather piqued my interest due to the tension that emerged between his desire to reflect the seasons and the curator/producer's desire to facilitate user-interaction. In the case of the present work, I was certainly interested in visitor interaction, but I also wanted to ensure that the piece reflected the immediacy of weather and seasonal effects on sunlight.

During the first visit in 2008, and in subsequent visits in 2013, I mapped the grounds and made extensive notes about the pros and cons of various sites, as well as making field recordings of many locations on the site. Ultimately I settled upon the grassy area mentioned earlier (Figure 1 and 2), due in part to its sonic beauty and partial removal from some of the more active areas on the estate (it seemed more secluded and featured a quieter noise floor). I was also interested in the features afforded by the tree line that wrapped around the back and sides of the space, creating boundaries almost like the wings and back wall of a stage. This tree line also had the effect of creating a continuously moving light/shadow play across the grassy area. As the sun passed overhead, different areas of the lawn would be in shadow, and this would change as the seasons changed. This was an attractive situation since I hoped to make use of the sun both as power source and activator (explained in the next section).

3. CREATING THE WORK

In composing this piece, I worked to fulfill four objectives:

1. The piece should respond directly to the varying light levels in perceivable ways. It should *celebrate* full direct sunlight, whisper at dusk, and sleep at night.
2. The piece should have interactive components that could be discovered by visitors.
3. The piece should sound like it *belongs*, and should work with the natural soundscape of the site.
4. The piece should celebrate the life and art of Lucie Rosen.

3.1 Solarsonics Design

The first objective was informed by drawing upon the research I had conducted over the past few years. To summarize briefly: *solarsonics* is an invented term I use to define sounds that are created in direct response to sunlight. An aspect of this I have worked on is designing low-power circuits that can apply incoming voltages (from very small solar panels) to sound-making processes directly. The voltages produced by the solar panels are unbuffered (no batteries), thus no storage is happening – just usage as available.

In previous designs, I have utilized two different low-power technologies to achieve this: CMOS digital logic chips that can operate under extremely low-voltage conditions, and small programmable AVR chips that boot up very quickly when power threshold is achieved. The CMOS chips afford sounds that are basically either square-wave tones or insect-like modulated patterns, the frequency and amplitude of which will change in response to changes in voltage. These chips are widely used in the hardware hacking world for lo-fidelity audio sources [7]. The AVR chips allow for more sophisticated sounds, but are either on or off. They also require significantly more power.

These chips are then either connected to piezo buzzers or small amplified speakers. The sounds that result are relatively lo-fi, so I accepted from the beginning that I would be working with this specifically limited sonic space.

For this project I decided to combine sounds that used both kinds of technologies. I chose a 4093 chip (specifically the MC14093B chip by ON Semiconductor) for the insect-like sounds, and the ATMEL ATmega328 chips (widely used in Arduino products) for something more melodic, where I could define specific pitches and rhythms by coding simple algorithmic sounds on the chips. After much experimentation, I developed two different kinds of voices for the piece: *PVC peepers* and *birdhouse chanters*.

3.1.1 PVC Peepers

Before designing the first CMOS circuit, I first designed the sounding materials (the transducer and its housing). I knew that I would want to create several of these and scatter them around the lawn, so after trying several different ideas, I finally settled on a junction box for PVC conduit, which had a ¾" coupling 90 degrees outwards, which could be mounted on 1" PVC pipe. The coupling was a perfect fit for a 42 mm diameter piezo buzzer which, when mounted inside, created a wonderfully bright sound at the buzzer's resonant frequency of 3500 Hz. (thus the name *Coronium 3500*). This made the voice easy to scale with relatively inexpensive PVC electrical products, easily obtainable at hardware stores or in reuse centers (see Figure 3).

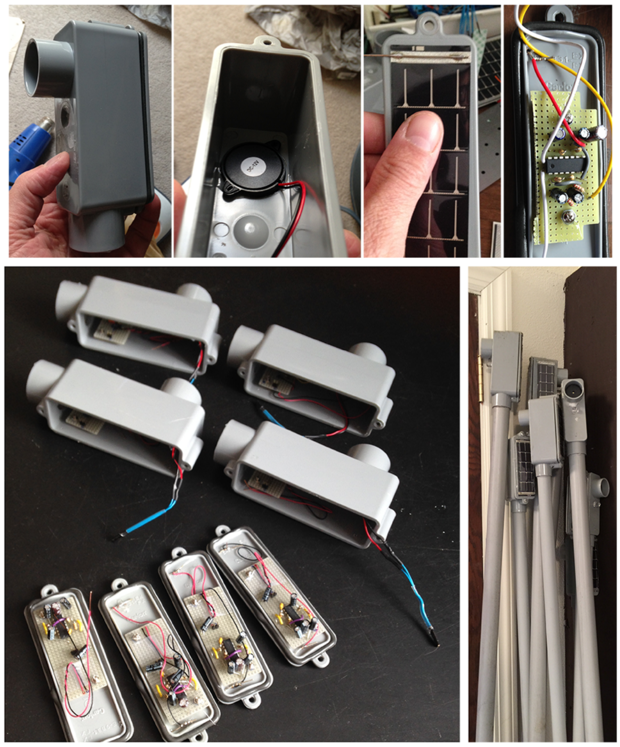

Figure 3. PVC Peepers

Once this problem was solved, I designed a basic circuit for the CMOS chip, using four oscillators to modulate each other in a daisy-chain way, resulting in a complex repetitive pattern. I simply varied the values of resistors/capacitors to get different frequencies until there were eight unique voices, each centered around a similar foundation. This was an arduous process, and took lots of trial and error to achieve patterns that worked at varying light levels in aesthetically interesting ways. The circuit is powered by a 3-volt, 50 mA solar strip by PowerFilm Solar Products, mounted to the side of the conduit junction.

3.1.2 Birdhouse Chanters

The AVR based circuits were similarly designed, starting with the speaker/housing. I located some surplus steel speaker housings that seemed like they would be a good size for fitting a speaker and all relevant electronics. Inside of these I mounted a 3.5" coaxial loudspeaker (Polk db351), leaving room below it for a small project box that would contain the audio amplifier and microprocessor. I sourced a 7-watt amplifier board from CanaKit based on the low power TDA2003 amplifier to power the speaker (see Figure 4).

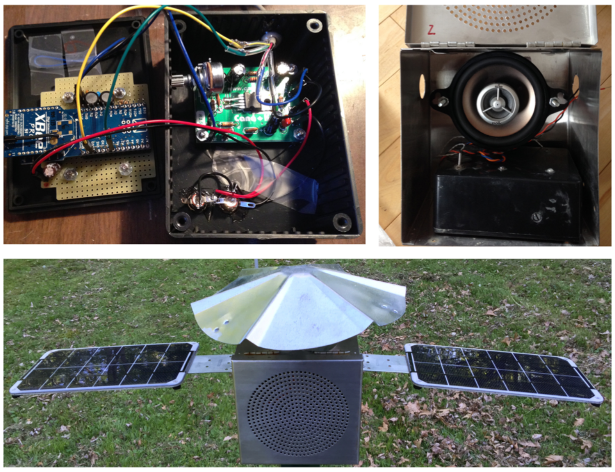

Figure 4. Birdhouses

For the AVR music, I used an Arduino-based system utilizing an ATMEL ATmega328 amp, which I had successfully used in some previous projects. During the process of composing this part of the piece, I began to realize the value of wireless updating, so that I could change the code while onsite, in addition to having some limited communication capabilities between the birdhouses, provided I could provide enough power. I therefore chose the Arduio Fio board with an XBee Pro S1 for radio serial communication. This turned out to be the perfect combination because of its small size and low power consumption. The entire system, including the amplifier, came in less than 5 watts. The system is powered by two 6V 3.4 watt solar panels by Votaic Systems.

In terms of software, a program was written for the chip (in the Arduino programming environment) that plays two audio streams, each a generative melodic pattern with a sinusoidal waveform. The synthesis system uses a simple accumulator and a tuning word which cycles through a sine wave table (one cycle in 256 points), driving the PWM (pulse-width-modulation) unit on one of the output pins, with a reference clock provided by one of the Arduino timers using an interrupt process. Some initial code was adapted from Martin Nawrath's Arduino DDS Sinewave Generator project [8] and modified to create two independent voices (pins 9 and 11). A pentatonic scale system was created from which a table of pitches was generated, based on 3500 Hz and its integer multiples. Another table of interval patterns was created for the voices to loop through. Essentially, the system choses a random interval pattern and loops through it for a specified amount of time before switching to a new pattern.

The tempo of the melodic pattern is also randomized, but constrained by the ambient light level via a photoresistor mounted on the back of the steel box (as the sun gets brighter, the tempos increase). Each melodic pattern loops for an initially short period of time (a few seconds), but that time increases proportional to the length of time the box has been alive. So, the longer the box is on, the longer the pattern will play before changing. If the birdhouses are on for ten minutes or more, they will suddenly lock together and play a short tune together, in rhythmic and melodic synchronization. This continues every ten minutes while the birdhouses are powered without interruption.

3.2 Interaction

The interactive nature of the installation is a matter of discovery. As visitors walk among the pieces and begin to understand that they are light reactive, they can interact with the pieces by blocking light with their hands.

The PVC peepers are the most dynamic, as they change dramatically as light levels change. Visitors can literally "play" them by placing their hands over the solar panel and moving it against and away from the panel. I witnessed many listeners with their ear to the transducer while fluttering their hand over the PV strip.

The birdhouses are interactive in two ways. The most obvious method is covering the two solar panels, which will cause the pieces to simply go silent. Upon receiving light again, they will start up their pattern. The threshold between the two can also be interesting. As mentioned above, the rate of change is proportional to the amount of time the birdhouses are active, so when they start up, they sound unsettled for a few seconds, and over time will settle into their patterns for longer and longer periods of time. This is a fun mode of interaction, especially on a sunny day. As visitors approach the piece in this state, it may be that the birdhouses have been active for awhile and are therefore in a state of stasis. As visitors discover that they can block the sun, the birdhouses are disturbed and become very dynamic, changing very rapidly.

The other less obvious interaction is via the photoresistor on the rear of the birdhouses. As mentioned above, the photoresistor determines the basic tempo of each birdhouse's chanting. If the photocell is covered, that birdhouse will slow down in a very noticeable way. This interaction is less obvious but can be easily discovered by the curious visitor.

3.3 Soundscape Composition

As mentioned above, one of my goals in creating the piece was to make something that worked with the site and the varieties of natural sounds that already exist. To achieve this, I spent lots of time listening to the field recordings I made on the site, some of which were made in July, and some earlier in the summer. I created the PVC peepers first, and as mentioned above, I discovered the pitch 3500 Hz was prominent due to the specific coupling of the piezo buzzer and the PVC junction box. The base circuit highlighted this pitch, and then I began the process of designing each circuit by improvising with electronic components (changing resistor/capacitor values) to create eight unique voices. I worked on the circuits while listening to the field recordings, intuitively locking the circuit into place once I found a quality that seemed to work well. Eventually I had eight very different but related voices and, thanks to having a sunny studio, was able to surround myself with them while listening to the field recordings on my studio monitors, tweaking them with circuit-bending techniques in order to finalize them.

Once these were completed and I felt good about the way they changed over the course of the day, I turned my attention to the birdhouses. I had already experimented with many ideas, but now settled on the pentatonic pitch system mentioned above, based on the same 3500 Hz base frequency. These pieces were designed to be celebratory, being most active and brightest when the full sun activates them. I imagined casino jackpot sounds, pinball, and other game sounds were influential. As mentioned above, each birdhouse features two voices in a sinusoidal timbre, for a total of eight voices. Each voice steps through a pattern that is randomly chosen from a table of 30 sets of eight interval classes, looping through the set at a randomized tempo (constrained by the photoresistor). So, the result is a complex web of sparkling pitches. The effect of the PWM did result in the slightest inclusion of the 32KHz sampling frequency and a submarmonic ripple, so I added a simple low-pass filter (some inductors and capacitors on the board) to roll off the high end at the hardware level.

The final touch was to create the periodic chime, to bring the birdhouses into a state of togetherness when the sun has been bright for awhile. To accomplish this, I simply wrote a routine on one of the birdhouses to keep track of accumulated time, signaling the other birdhouses every 10 minutes via the XBee radio network. Upon receiving that signal, all four birdhouses go silent, then play 3500 Hz for a few seconds, followed by their short tune, where they lock to a common tempo and play together for a few seconds, before reverting back to their individual patterns.

3.4 Lucie's Halo

The fourth and final objective was to find a subtle way to honor the legacy of Lucie Rosen. As mentioned above, Lucie and her husband Walter Rosen were the original owners of the Caramoor estate, and they founded the music program that exists today. During the 1930s, they met Léon Theremin who had come from Russia to work in New York with his new invention, the theremin. Lucie fell in love with the instrument and become a student, performing on the instrument throughout her life. As well, the Rosen's actually provided Theremin with his studio in New York, the infamous laboratory and residence on west 59th St. Lucie became a rather well known performer, and was once described in the press thusly: "She has a very curly blond hair which fuzzes out into a wide halo around her delicate and ethereal face" [9]. She performed on an instrument built for her by Theremin himself, which still resides in the historic house to this day.

In thinking about an homage, I searched for recordings of her, and found a very odd recording from 1949 called "Gigolette," performed by Elliot Lawrence and his orchestra. This whimsical tune features Lucie on theremin, and was the perfect fit for my purposes. I simply took a 4 bar section from the main theme and transcribed it for my birdhouse sinusoidal voices, and created an Easter egg. Essentially, when the birdhouses play their chime together, there is a 1:5 chance that, instead of their normal randomized song, they will play this snippet from "Gigolette." This proved to be a very effective choice, as it is quite startling to hear because it is so different from the normal character of the birdhouse sounds.

4. DEPLOYMENT

For the installation, my impulse from the beginning was to place the pieces in the center of the lawn in a circle – but I also wanted the pieces far enough apart so that they had a wide spatial sense upon approach. Luckily the install week had some sunny days, so I was able to position the pieces and test them in different configurations in multiple light conditions. I finally settled upon an arrangement that worked well with light/shadow mix, and ensured that they would be most active at noontime. We placed a large stump in the center, and spaced the four birdhouses at opposite poles around the stump about three meters from the center. Finally, we circumscribed a larger circle around the birdhouses and placed the eight PVC peepers at equal intervals. This arrangement created a central sweet-spot, but also created a kind of scattered appearance upon approach, encouraging visitors to wander among the pieces before finding the center.

5. REFLECTIONS AND FUTURE WORK

The experience of creating this work was extremely satisfying for a number of reasons. As a research stream, the solarsonics project has taken a great deal of my time and energy over the past few years, and has not always yielded very interesting results. In some ways, this piece represents the first manifestation of something I can feel good about as an aesthetic artwork, as well as a concept. The piece was favorably received and reviewed [10][11], and was even invited back for another year, which was also quite exciting. The second year gave me a chance to correct some small details that made the piece stronger (slightly more powerful solar panels, and some small changes in the code).

One of my original worries was that the heavy rain might be too much for the first generation of solar panels – and although they all survived intact, I did make a change to a different solar panel for the next year. I was also quite aware of the possibility that someone visiting the piece during cloudy or rainy weather would not experience the birdhouses, since they do not make a sound unless it is sunny. Luckily, the PVC peepers seemed to provide enough interest on their own, and when the sun did come out, the piece really blossomed and brought a smile to people's faces. Ultimately, I felt ok about this condition, accepting it in the same way that we accept not seeing the moon on a cloudy night.

This project has helped bring together several technologies and concepts into a satisfying artistic experience. Future work will involve an expansion of vocabulary, both in terms of software/hardware and in terms of fidelity. Given that photovoltaic and other solar technologies are coming down in price considerably, purchasing and experimenting with larger panels is becoming more feasible. With more power, I hope to find some interesting designs in the lower frequency ranges, as well as generally better quality audio at high volumes. But it is also interesting to work in the opposite direction, using less power to create quiet, almost whispering pieces that can function in a gallery setting, for example. Ultimately, solarsonics has become a really fun and challenging medium that I'm certain will continue to lead to some exciting artistic projects.

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