Cloud Chamber: A Performance with Real Time Two-Way Interaction between Subatomic Particles and Violinist

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Abstract

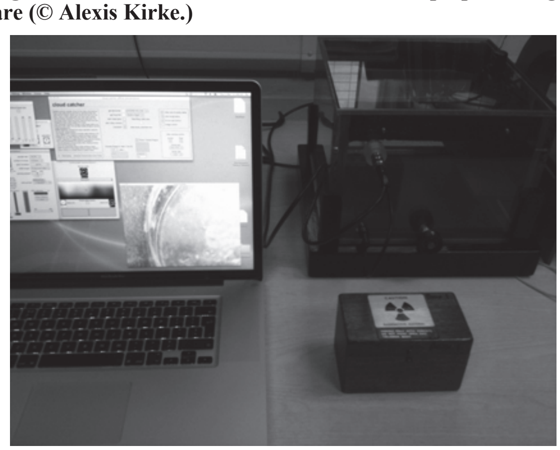
'Cloud Chamber' - a composition by Alexis Kirke, Antonino Chiaramonte, and Anna Troisi - is a live performance in which the invisible quantum world becomes visible as a violinist and subatomic particle tracks interact together. An electronic instrument was developed which can be "played" live by radioactive atomic particles. Electronic circuitry was developed enabling a violin to create a physical force field that directly affects the ions generated by cosmic radiation particles. This enabled the violinist and the ions to influence each other musically in real time. A glass cloud chamber was used onstage to make radioactivity visible in bright white tracks moving within, with the tracks projected onto a large screen.

There have been a number of performances inspired by particle physics and quantum mechanics [1]. Music has also been used to create an offline audible display or sonification of particle interactions at CERN [2]. The equations of quantum mechanics have been used to create sound [3,4]. Brody [5] used recordings of Geiger Count clicks to build music. What has been less common has been the live utilization of particle physics experiments for sonification or for artistic use [6]. There has been no practical work at developing two-way live interactive performances – where not only do the particles influence and create music/sound, but where any accompanying music/sound influences the particles in real-time on a physical level. Cloud Chamber is an attempt to move performance into this area of application. This is done by utilizing tools which make atomic particles visible in real time, visual recognition methods, granular synthesis and electrical field generation from musical instruments.

Cloud Chambers

The diffusion cloud chamber creates a volume of supersaturated alcohol vapor that condenses on ions left in the wake of charged particles. This is accomplished by establishing a steep vertical temperature gradient with liquid nitrogen. Alcohol evaporates from the warm top side and diffuses toward the cold bottom. The gravitationally stable temperature distribution permits a layer of supersaturation near the chamber bottom. Charged particles passing through the supersaturated air at close to the speed of light leave behind numerous ions along each centimeter traversed. In the absence of a radioactive source, most events observed in the cloud chamber are cosmic rays [7]. About two-thirds of sea level cosmic rays are muons, one-sixth are electrons, and most of the remaining one-sixth are neutrons. Neutrons cannot be directly observed, because they will not ionize air within the chamber. Low energy (<100keV) electrons can be identified from the convoluted character of the tracks. Higher energy electrons and muons form straighter tracks.

Fig. 1. On the right is the Cloud Chamber, on the left is a laptop running the Cloud Catcher software (© Alexis Kirke.)



Cloud Catcher

The Cloud Catcher is a MAX/MSP/Jitter patch developed at the Interdisciplinary Centre for Computer Music Research (ICCMR) by Antonino Chiaramonte and Anna Troisi (known collectively as Electroshop), with Eduardo Miranda, which provides a real-time audio input granulation [8] driven by live video colour tracking. The patch section which carries out the video colour tracking mainly exploits the features of a Jitter object called jit.findbounds, calculating bounding dimensions for a range of values.

A frame of video is represented in Jitter as a two-dimensional matrix, with each cell representing a pixel of the frame and each cell containing four values representing alpha, red, green, and blue on a scale from 0 to 255 (RGB standard) [9]. The jit.findbounds object scans a matrix for values in the range [min, max] and outputs the minimum and maximum points that contain values in the range [min, max] within the matrix [10]. The bounding region is a rectangle, so jit.findbounds will output the indices for the left-top and bottom-right cells of the region in which it finds the specified values.

Cloud Catcher provides the ability to define the colour range by means of the colorange subpatch. In this way focusing on a suitable range is quite intuitive, precise and immediate. Therefore every time a colour in the chosen range appears in the video, it will produce as output two coordinates related to the region boundaries (otherwise it will have no output). These two coordinates are used as input for the live_cloudy_grain subpatch. Furthermore the live_cloudy_grain subpatch will also take as input the slope of the segment bounded by the two coordinates to effect the real-time audio sample granulation.

The live_cloudy_grain subpatch is the audio processing section of Cloud Catcher. As mentioned above, live_cloudy_grain uses as input the following values:

1. Top-left boundary x coordinate (x_{LT})
2. Top-left boundary y coordinate (y_{LT})
3. Bottom-right boundary x coordinate (x_{BR})
4. Bottom-right boundary y coordinate (y_{BR}) .
5. Slope (Delta) of the segment bounded by the top-left and bottom-right coordinates.

The video input for the Cloud Catcher is taken from a camera above the glass cloud chamber, and the Catcher is tuned to pick up the ions created by the radioactive particles. The audio input to the Cloud Catcher is taken from an acoustic violin. So all the audio content of the performance will come from the violin (a suggestion by the premiere's violinist, John Matthias), although some may be unrecognizable as coming from an acoustic instrument due to periods of more extreme grain transformations, which are partially parameterized by the ion tracks picked up in the chamber.

Fig. 2. Left to right: John Matthias, Alexis Kirke, cloud chamber, Atomolin, Catherine McCabe. Above: cloud chamber projection (© Plymouth University.)

Atomolin and Composition

The "Atomolin" is a device developed with Nick Fry and Cathy McCabe of Plymouth University, which enables a musician to use an acoustic instrument live to create a physical force field that directly affects the ions generated by radioactive particles. The violin can be converted into an electrical audio signal using a microphone. In the Atomolin the signal is used to modulate a high voltage power supply, with output adjustable between 1.5 and 3 kV. This connects to a projection field electrode installed in the cloud chamber. Thus the violin playing modulates a positive potential in the chamber top. Applying a varying positive potential to the chamber top will directly change the particle tracks appearing in the chamber. Thus the Atomolin allows the violin playing to directly affect subatomic particle tracks in the chamber during performance.

Cloud Chamber is a semideterministic piece of music, given that the particles are generating sounds and the particle production rate is based on non-deterministic quantum principles. At the heart of the structure is the ability of the particle track's sound to influence the violinist musically, and the ability of the violinist to influence the particle tracks physically (which can lead to changes in the sounds they make). However it also draws on quantum physics for inspiration in its pre-scored structure elements, specifically by what is known in physics as the Standard Model [11].

There are types of particles which are made up of 3 smaller particles called quarks of types called Up, Down, Charm, Strange, Top, and Bottom. Based on this the 15 minute performance is divided into 3 sections, the violin parts of which are named after the six quarktypes. The actual motif pitches used to build up the pre-scored elements of the score are partially generated algorithmically using the quark structure of observable Baryons. This is done in Matlab code through the Matlab MIDI toolbox [12] (using a simple mapping system and constrained by the physical properties of the violin). Some other small-scale structures in the violin score are generated from data provided by project partner ISIS Neutron and Muon Source, from their experiment shining neutrons through liquid crystals [13].

Parallel with this violin score is an electronics parametric score. The purpose of this score is, for each of the sections, to set the broad parameters for the granulation system. Within each subsection itself, the subatomic particle tracks will be allowed to freely influence granulation sound (though they are influenced by the Atomolin). There are some improvised subsections, during which the violinist is free to interact with the particles and the particle sounds as they see fit.

It should be noted that the use of this approach to generating musical material is not argued as being a meaningful expression of the Standard Model or of quarks. It was mainly used as a framework around which the composer could construct the piece.

Performance

"Cloud Chamber" was commissioned by Peninsula Arts and premiered at the 2011 Peninsula Arts Contemporary Music Festival [14] with John Matthias on violin and Alexis Kirke on electronics. Radioactive safety was supervised by Miranda Keith-Richards. Liquid nitrogen was provided by Nicholas Fry, and ethanol by the Centre for Chemistry at Plymouth University. It was then performed at ISIS Neutron and Muon Source, at the Rutherford-Appleton Laboratories, UK. Cloud Chamber was developed at the ICCMR and part-funded by the Roland Levinsky Memorial Fund. More details can be found at <http://www.cloudchambersound.com>.

References and Notes

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