ATOM TONE – live electronic concert using sonification of atomic data

Jiří Suchánek

Janáček Academy of Music and Performing arts,
Ph.D. candidate of Composition and Theory of Composition,
HF JAMU, Komenského nám. 6, 662 15 Brno,
Czech republic
jiri.suchanek@hf.jamu.cz

ABSTRACT

Project *Atom Tone* explores aesthetic possibilities of sonification of atomic data and using generated complex waveforms in live electronic music. The result is 30min concert. Sonification is done in max/msp patch that I've programmed for this project during Visegrad residency at A4 Bratislava 2015. Now I am continuing in development of the patch as a part of specific research during my Ph.D. studies at JAMU.

The sonification has two parts: synthesis and modulation. Synthesis uses atomic spectroscopic data as a source for additive synthesis technique – each oscillator is tuned to recalculated exact frequency of the atomic emission spectral line. Each element has unique list of spectral line frequencies (Figure 1). This atomic "fingerprint" is audificated into the complex chord that is further modulated. Modulation is done only with numbers taken from Mendeleev periodic table related to selected element. Numbers can be routed to several parameters. This routing method is open to many possibilities.

The goal of the project is to discover possible new aesthetic qualities for the contemporary electronic music with this specific sonification technique.

1. INTRODUCTION

In this paper I will describe the basic concept of my max/msp sonification patch that I use for the live electronic concert. Also I will describe all optimal technical requirements for the concert realization. I will not talk too much about the atomic spectroscopy itself because it is well and deeply documented in lot of scientific texts, books or web pages [1]. I must mention that I am not physicist but musician/sound/media artist so still I have to learn lot of about the atoms. This project is interdisciplinary and I consult it with Department of Chemistry MU [2] for relevant results.

2. SYNTHESIS – AUDIFICATION OF SPECTROSCOPIC ATOMIC DATA

I synthesize the waveform of the one element. Sonification of molecules, or even reactions is something I am still working on and it looks like long term research. I use NIST spectroscopic database [3] as a source of light emission / absorption frequencies.

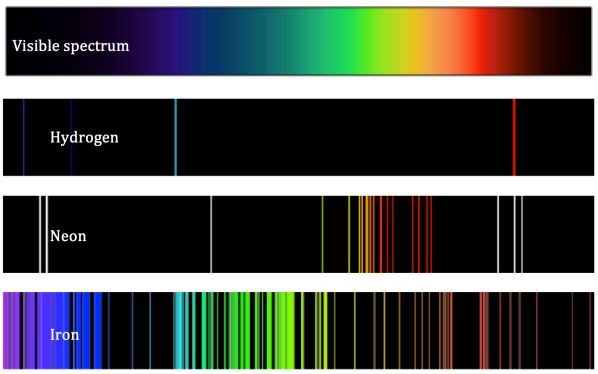

Figure 1: The visible light spectrum is displayed at the top and example of atomic spectra lines for three elements (hydrogen, neon, iron) are below.
Image © Neon spectrum: Deo Favente

I've formatted this database into the files compatible to coll object in max/msp. Each element has from ten to thousands of exactly described lines. The parameters of each line that I selected for audification is wavelength (nm) and relative energy [4].

The core of the audification synthesis can be described simply: each line means one sine oscillator (that can be alternatively set to saw, tri, tan, etc.). Frequency of the oscillator is counted from the line frequency simply by division (from Thz light range into the Hz audible range). The division number can be adjusted for the "best" musical result. The volume of each oscillator is logarithmic value of the relative energy of the line. I decided to use all measurable lines in vacuum. So I use the lines from visible light range and also in ultraviolet (Lyman series) and infrared (Paschen series) range (Figure 2).

I decided to select only the lines with higher relative energy to eliminate huge number of oscillators (I have to use CNMAT sinusoids~ or oscillators~ objects to be able to use several hundreds of osc. The poly~ in max/msp is quite inefficient with more than 50 voices…). I plan to rewrite the code with Supercollider for even better efficiency. With maximum of 100 oscillators the results are already clear and highly usable for the musical performance.

There are five index states of each element in database. I use all of them, so every element can be heard in 5 different states – the differences are clearly audible.
With this method I can audificate all elements described in the NIST database. That means elements with proton number from 1 (Hydrogenium) till 99 (Einsteinium). Elements with

higher proton numbers are not included in the database – probably they exist so short time for needed measurements.

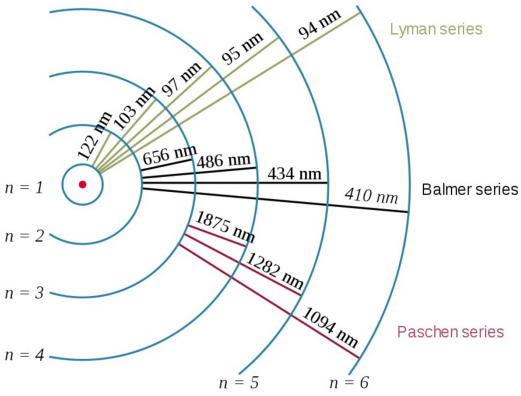

Figure 2: The relation between the lines wavelength, atom orbitals and energy state of the atom [5]

3. "MENDELEEV" MODULATION

Generated pure sound described above can be modified with several techniques. I use waveshaping, multiple frequency shifting, buffering and than modifying with 2d.wave~, fir filtering. This processing is conceptually more open than the exactly described synthesis. The goal of this processing is to find the musically most suitable result and to have many options to play with.

The data used for the modulation/processing parameters are taken from Mendeleev periodic table. As a source data I use: atom number, atom weight, electronegativity, density, ionization energy, atomic radius, constant radius and period. The sources and parameter destinations are connected in matrix so it is very easy to change the routing and find the most interesting settings. I know this does not suite to the one of the sonification definition written by Thomas Hermann - especially in the context of the concert where I sometimes change the routing. *"The transformation is systematic. This means that there are precise definition provided of how the data (and optional interactions) cause the sound change."* [6]

This is sort of collision between exact scientific sonification technique where listener has clear cue for analysis and artistic approach. For me the sonic result is more important than strictly respected method during the whole concert. I know my method very well but when music needs it I violate its rules. So for me the aesthetic decision stands above the purity of sonification method. I understand described sonification tool as great source for discovering new aesthetic territories for sound arts/music with kind of rich metaphoric and symbolic meanings.

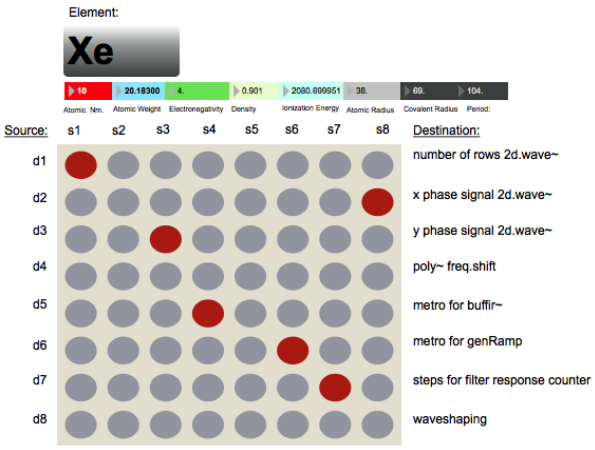

Figure 3: The view of routing matrix in the *Atom Tone* max/msp patch

4. ELEMENT MIXING AND PARAMETER CONTROLING

Actual version of the *Atom Tone* max/msp patch offers synthesis of two elements at once. So I can fade from one element into another and that is basically the compositional concept of the performance: slowly evolving changes and fading from one element into another. I control the patch with mapped midi controller. I've sorted the sounds into the categories like bass, complex, high frequency, metallic, disturbing and I mix them usually in a contrast way. Now I am working on a patch where molecules and even chemical processes can be sonificated and synthesized. I can imagine concert as a chemical reaction.

5. CONCERT FORM

Concert takes aprox. 30 minutes. It consists from prepared parts (beginning and the end) and improvised parts where I react on the mood of the audience and myself. One part of the concert is also video projection where actual sonificated atomic lines are projected. I play with laptop and midi controller. Sometimes I played with friend who processed my signal in analog modular synthesizer (Figure 4). I understand the concert as an exploration specific kind of aesthetic deeply hidden in a matter. That is what interests me the most – hidden music inside the matter. I feel something fundamental in this musical approach what keeps me continuing this research. I am trying to bring the artistic experience of the atoms – kind of impersonal reality that is here regardless on us.

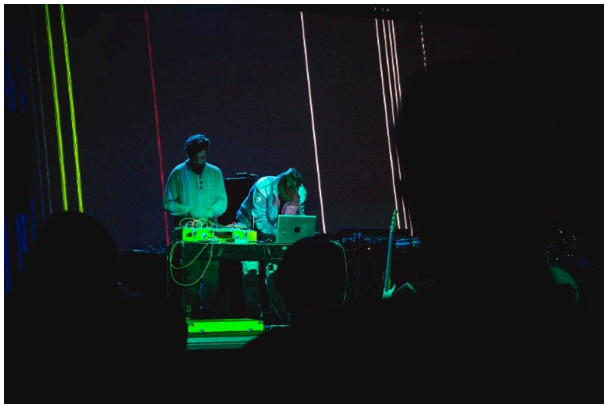

Figure 4: concert of *Atom Tone* at NEXT festival at Bratislava, 2015 [7]

6. LINKS WITH ONLINE MEDIA CONTENT

Here are links with the content related to this project:
Description of the project on my personal web page – including sound examples:
http://www.jiri-suchanek.net/en/project/atom-tone/

video documentary from premiere of the *Atom Tone* at NEXT festival:
https://vimeo.com/149558954

my personal web page with my other projects:
http://www.jiri-suchanek.net/en/

7. REFERENCES

[1] http://www.thespectroscopynet.eu/
[2] https://www.muni.cz/en/about-us/organizational-structure/prirodovedecka-fakulta/313010-ustav-chemie
[3] http://physics.nist.gov/PhysRefData/ASD/lines_form.html
[4] http://physics.nist.gov/PhysRefData/ASD/Html/lineshelp.html#OUTRELINT
[5] http://www.thespectroscopynet.eu/?Physical_Background:Atomic_Emission:Line_Spectra
[6] T. Hermann, *"Taxonomy and definitions for sonification and auditory display",* in *Proc. of the 14th Int. Conf. on Auditory Display*, Paris, France June 24 - 27, 2008, pp. ICAD08-2
[7] http://2015.nextfestival.sk/atom-tone/?lang=en