Prof. Eduardo Reck Miranda

Interdisciplinary Centre for Computer Music Research (ICCMR)
University of Plymouth, UK

https://www.plymouth.ac.uk/research/iccmr

- Ultra contemporary composer
- Working with AI since the 1980s
- Championed the development of Brain-Computer Music Interfaces
- Pioneered research into unconventional computing in music
- Pioneered the field of *Quantum Computer Music*

Some 30 years ago ...

era

Edinburgh Research Archive

Show simple item record

Sound design: an artificial intelligence approach

dc.contributor.author	Miranda, Eduardo Reck	en
dc.date.accessioned	2017-03-06T13:31:41Z	
dc.date.available	2017-03-06T13:31:41Z	
dc.date.issued	1995	
dc.identifier.uri	http://hdl.handle.net/1842/20692	
dc.description.abstract		en
dc.publisher	The University of Edinburgh	en
dc.relation.ispartof	Annexe Thesis Digitisation Project 2016 Block 8	en
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dc.title	Sound design: an artificial intelligence approach	en
dc.type	Thesis or Dissertation	en
dc.type.qualificationlevel	Doctoral	en
dc.type.qualificationname	PhD Doctor of Philosophy	en

I am interested in programming and using actual quantum computers to compose music.

I am ***not so interested*** *in music that is simply inspired by quantum concepts, nor am I looking for poetic or philosophical parallels between quantum mechanics and musical composition.*

For me, music serves primarily as a form of human communication, rather than a metaphorical exploration of quantum mechanics or vice versa.

I see quantum computers as unprecedented musical instruments.

My focus is on harnessing the unique computational power of quantum mechanics (e.g., qubits, qutrits, qudits, superposition, entanglement and interference) to develop methods and build systems for the composition and performance of music in ways that might not have been possible with classical digital computers alone.

BBC Concert Orchestra

Jarvis Cocker

Queen Elisabeth Hall, South Bank Centre, London

Peter Gabriel **Brian Eno**

Book launch at The Goethe Institute, London: https://www.goethe.de/prj/lqs/en/eve/sou.html

State of the art AI for music is great, but …

- One-shot interaction; click & generate
- Makes it easy to create.
- Does not make it easy to be creative.
- Text-to-music oriented.
- Unfaithful to the submitted prompt; add extra descriptors the system is tuned to respond to.
- Inhibit critical engagement with compositional practice; e.g., no support for contemplation.
- Can lead to overreliance on AI, promoting downfall of problem-solving skills.

Opportunity to improve

- AI systems do not necessarily need to BE creative. But SUPPORT ~~creative~~ compositional practices.
- Music-to-music oriented
- Small-data, ephemeral, volatile machine learning

Artificial Intelligence today

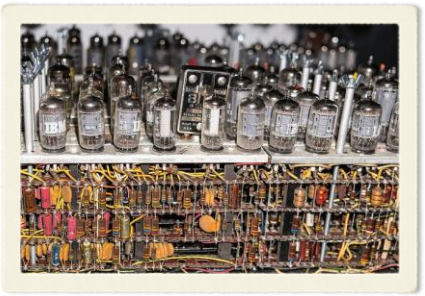
Bit
(Classical Computing)

0

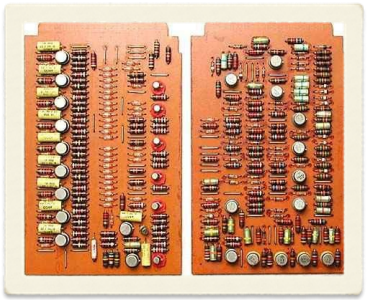
1

Represents 0 or 1 at a time

Relays



Vacuum tubes

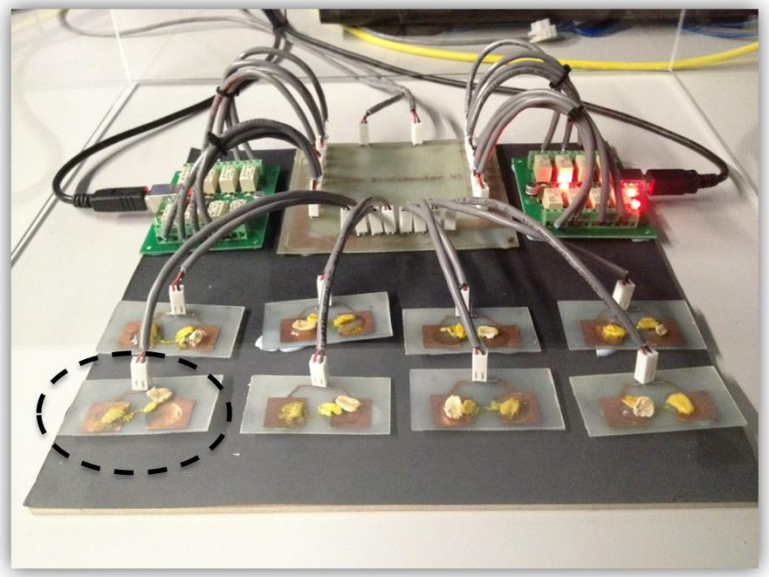


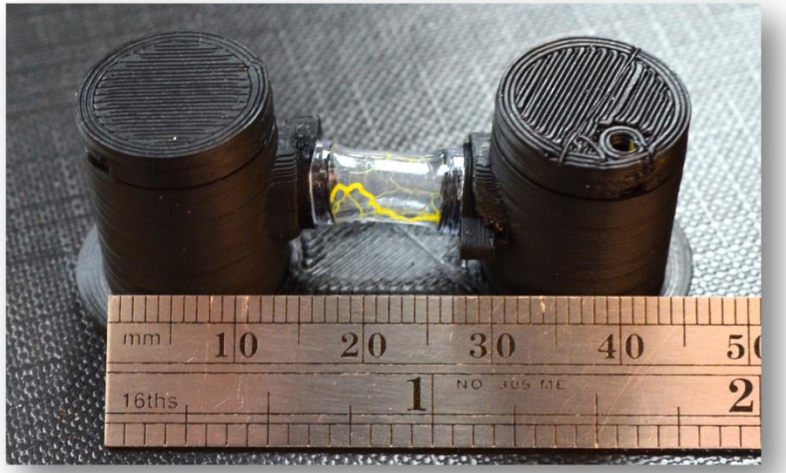
Transistors

Integrated Circuits

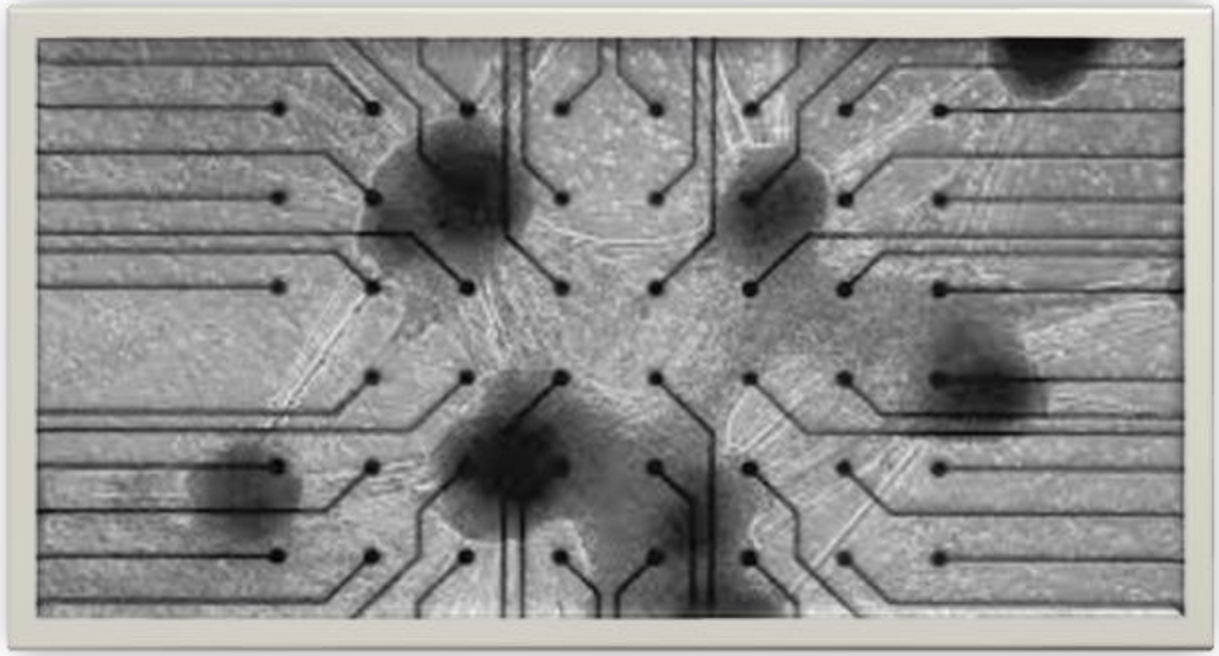
New kinds of hardware = New kinds of intelligence

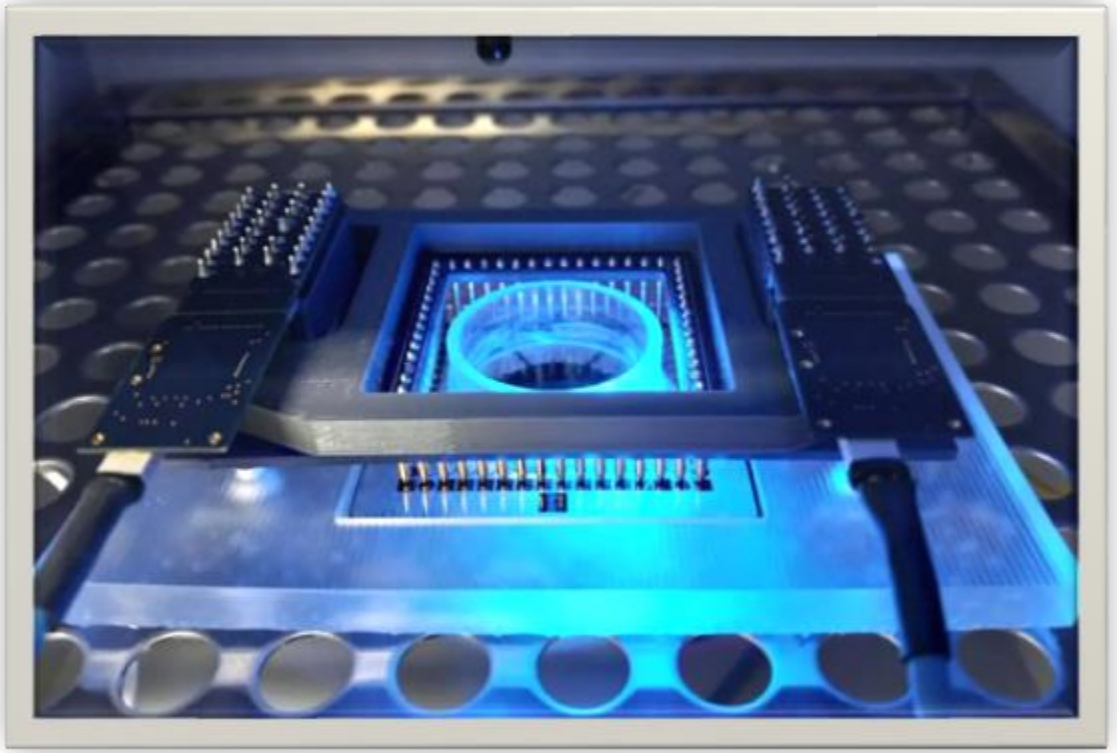
Exploring bio-computers ...





Neurons living on a silicon chip

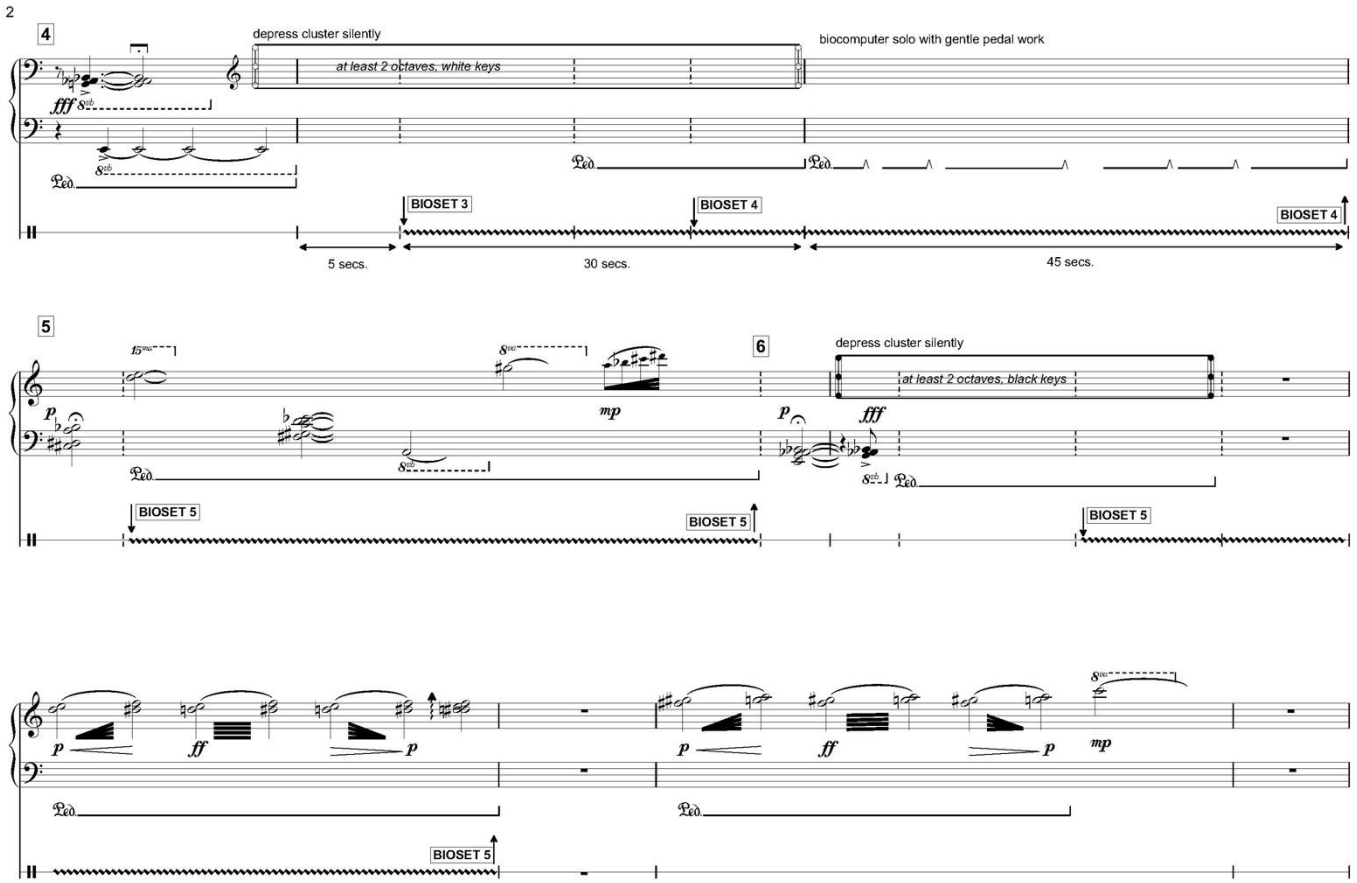




Biocomputer Rhythms

A one-piano duet between a pianist and the bio-computer.

The score for the pianist is fixed, but the responses generated by the bio-computer are unpredictable.



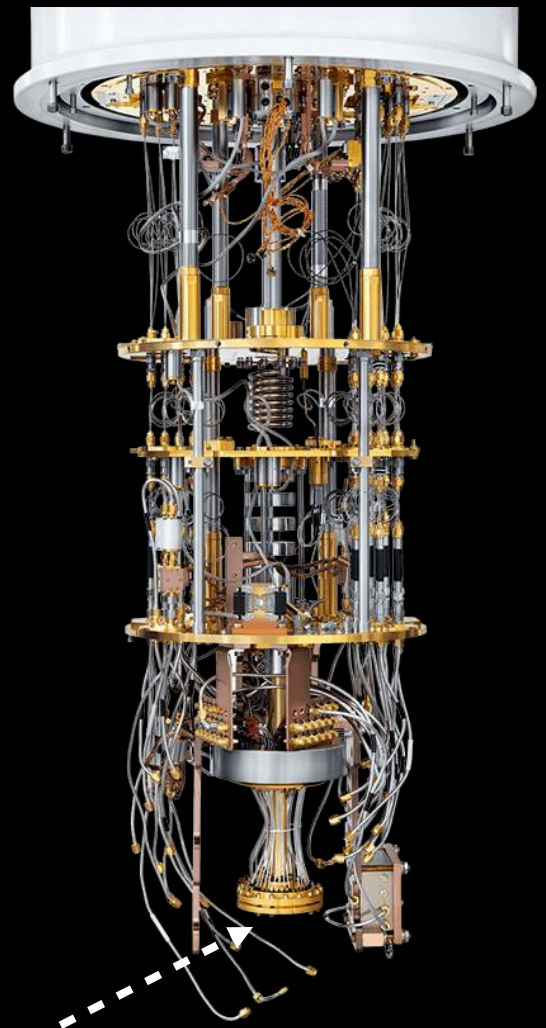
Biocomputer Rhythms

This is “machine” intelligence that is far different from the pedestrian AI as we know it!

https://youtu.be/fiOrhg1nKZs

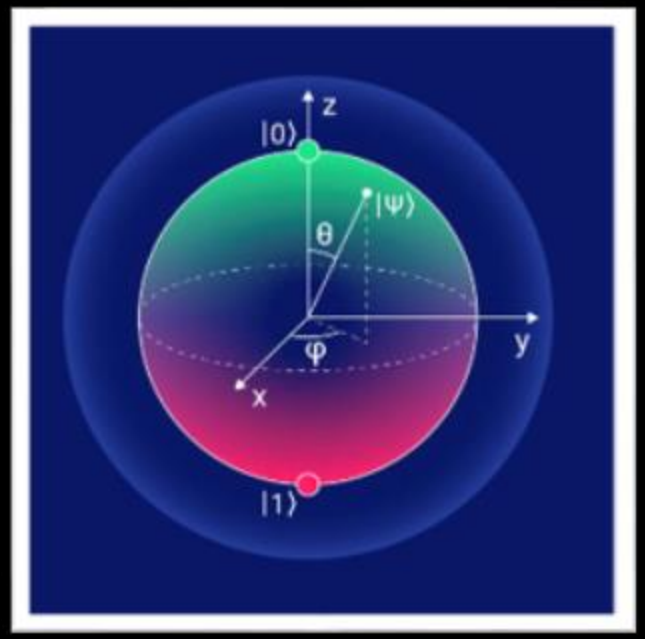
Quantum Computer

Rigetti



@ QuTech
Quantum Inspire

Is it be possible do design new kinds of AI with Quantum Computers?



- Using the principles of **quantum mechanics** to process information …
- Using **quantum bits**, or **qubits,** to represent data …

- Qubits can exist in a **superposition** of both 0 and 1 simultaneously
- Can be **entangled:** the state of one qubit can depend on the state of another.
- **Quantum interference**: Used to amplify correct results and cancel out incorrect ones. (Suitable for searching algorithms and logic problem solving.)

Bit
(Classical Computing)

0

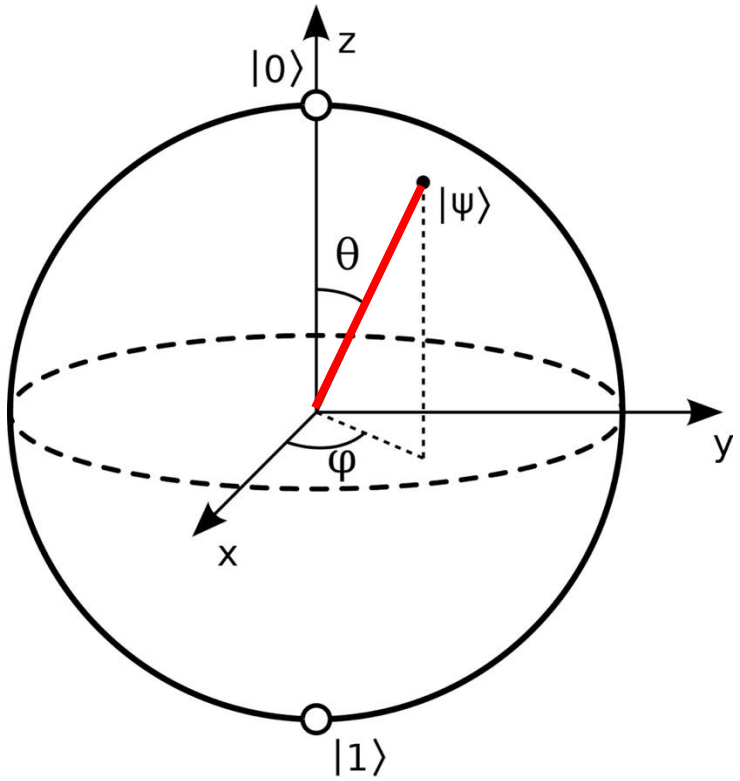
1

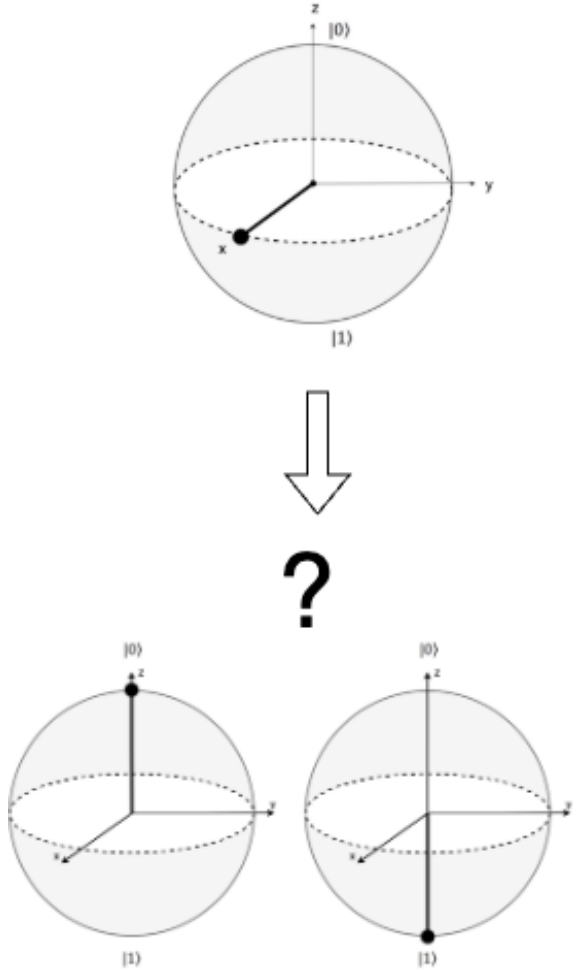
Qubit
(Quantum Computing)

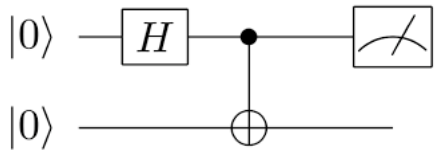
0

1

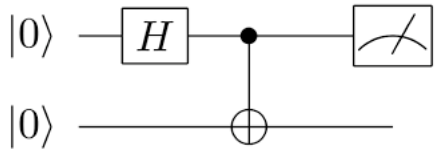
Quantum Superposition







Quantum Entanglement



Quantum Entanglement

qubit 1

qubit 2

Science & Tech Behind the Concert

Quantum Loops, Broken Symmetries

Dec. 3, 2025 6:00 PM – 7:00 PM, Salen, ZEB , Oslo

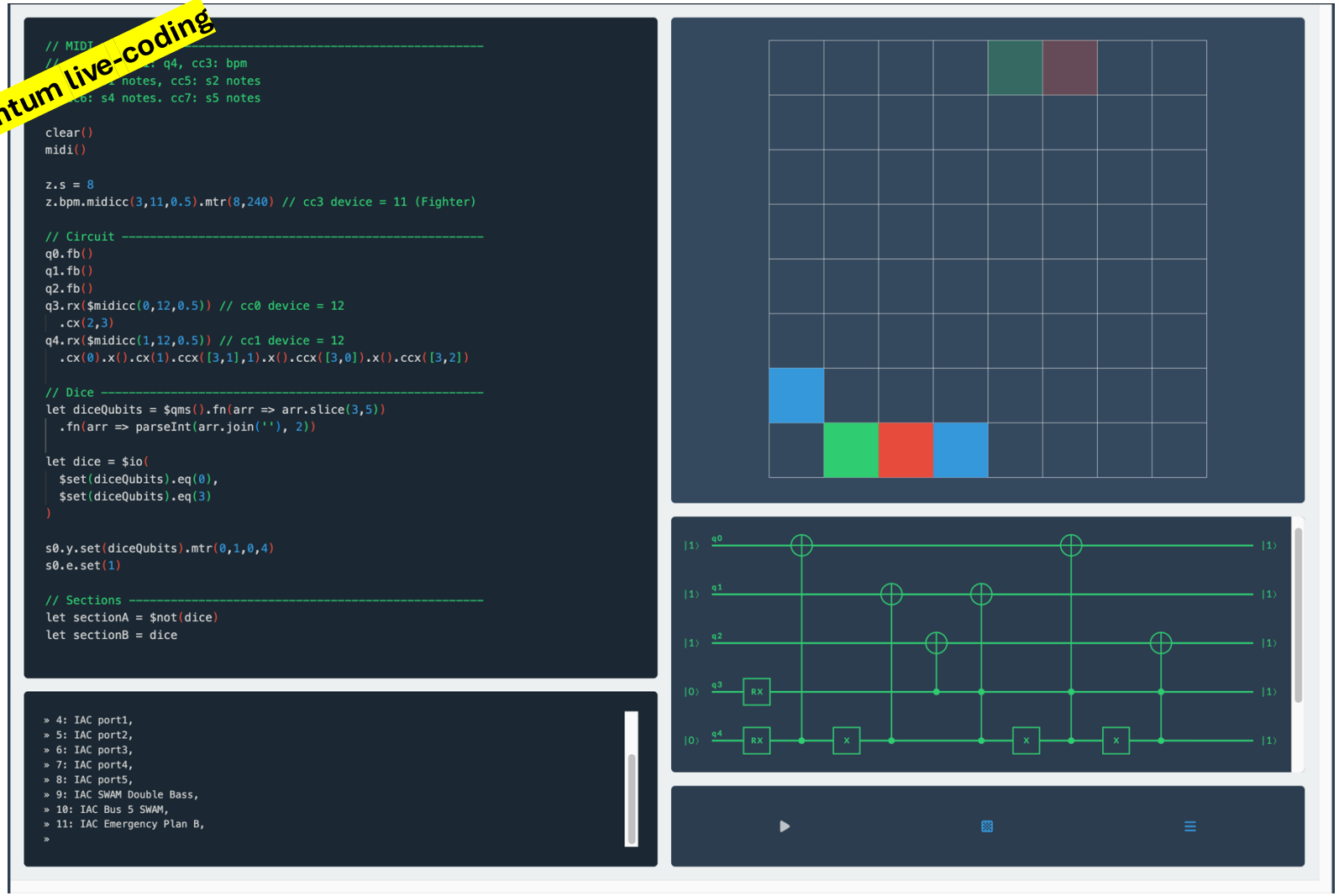
Read the programme notes here: https://www.uio.no/ritmo/english/news-and-events/events/artistic-performances/2025/quantum-music/

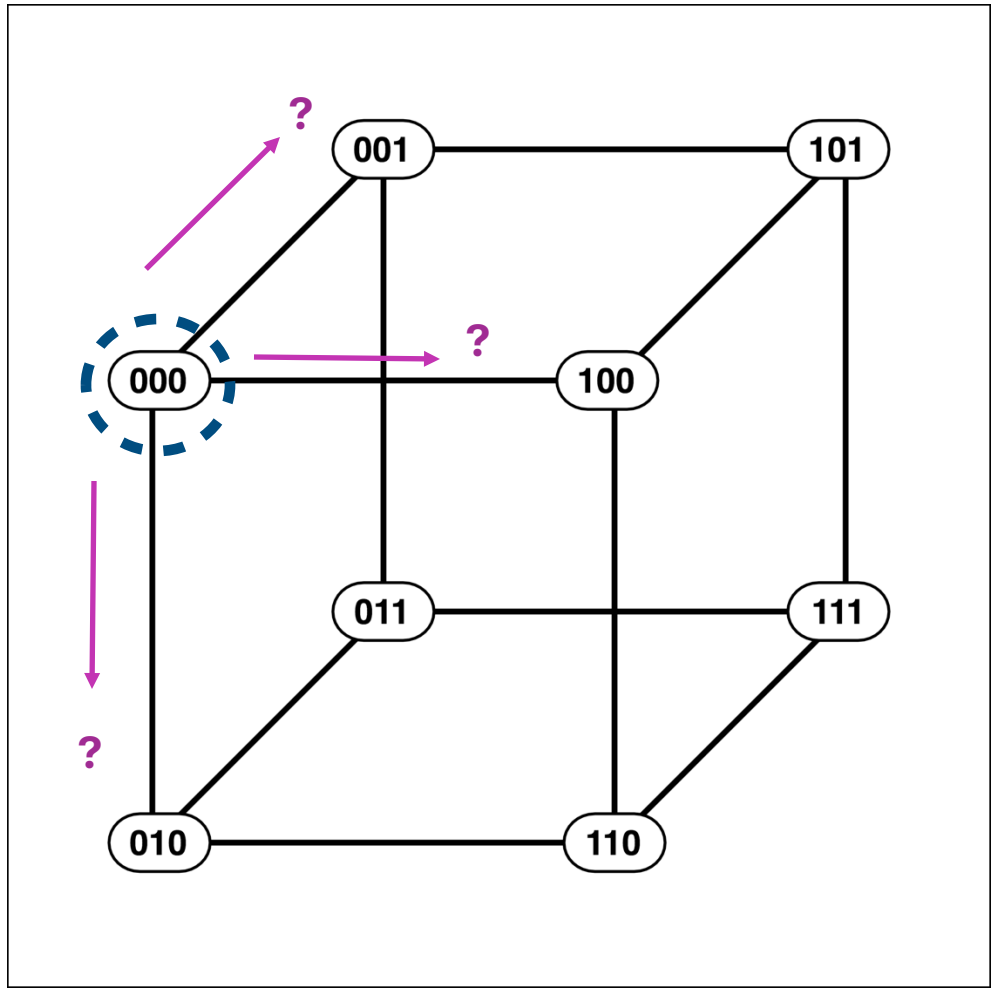
Scan the QR below for peer-reviewed papers detailing the quantum computing systems used in the compositions

Composition entitled: *Heisenberg's Hammer*

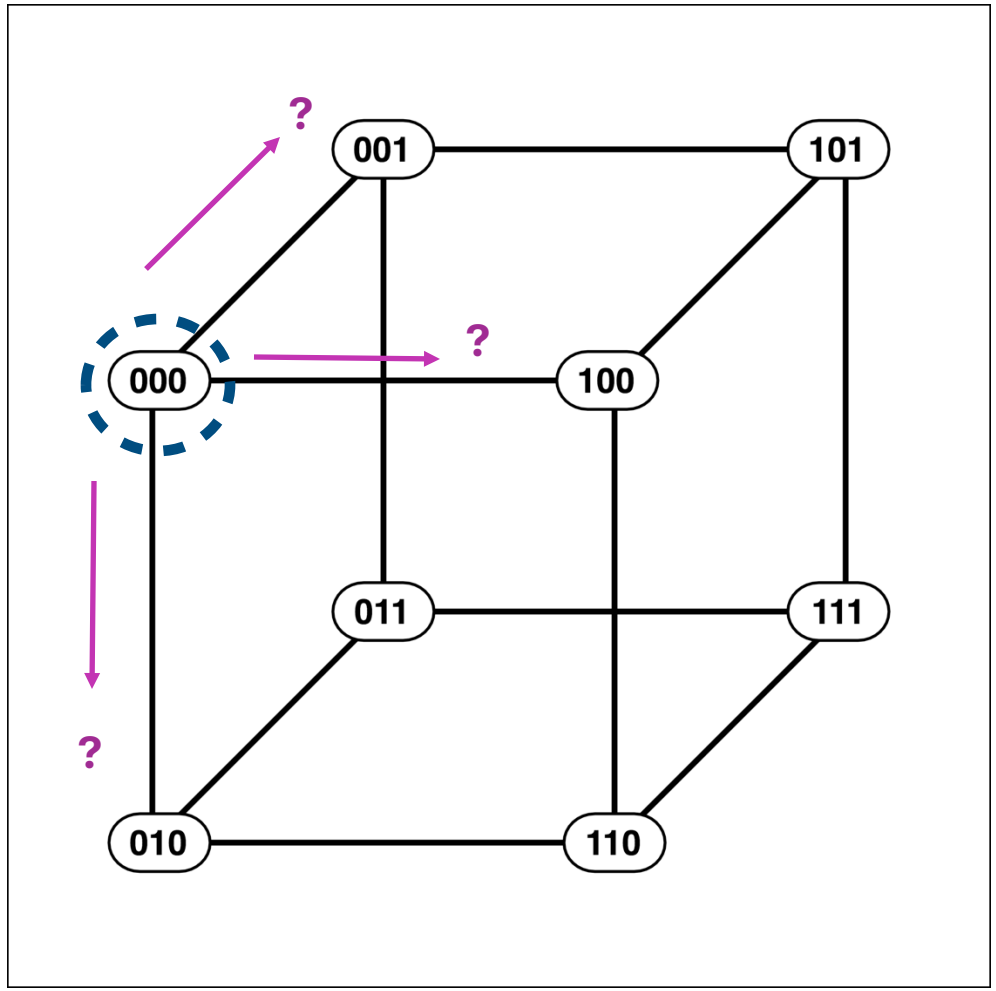
Quantum live-coding

```
// MIDI ----------------------------------------------------------
// cc0: q3, cc1: q4, cc3: bpm
// cc4: s1 notes, cc5: s2 notes
// cc6: s4 notes. cc7: s5 notes

clear()
midi()

z.s = 8
z.bpm.midicc(3,11,0.5).mtr(8,240) // cc3 device = 11 (Fighter)

// Circuit -------------------------------------------------------
q0.fb()
q1.fb()
q2.fb()
q3.rx($midicc(0,12,0.5)) // cc0 device = 12
  .cx(2,3)
q4.rx($midicc(1,12,0.5)) // cc1 device = 12
  .cx(0).x().cx(1).ccx([3,1],1).x().ccx([3,0]).x().ccx([3,2])

// Dice ----------------------------------------------------------
let diceQubits = $qms().fn(arr => arr.slice(3,5))
  .fn(arr => parseInt(arr.join(''), 2))

let dice = $io(
  $set(diceQubits).eq(0),
  $set(diceQubits).eq(3)
)

s0.y.set(diceQubits).mtr(0,1,0,4)
s0.e.set(1)

// Sections ------------------------------------------------------
let sectionA = $not(dice)
let sectionB = dice
```



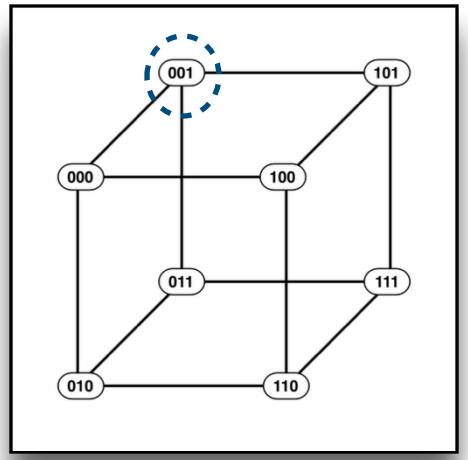


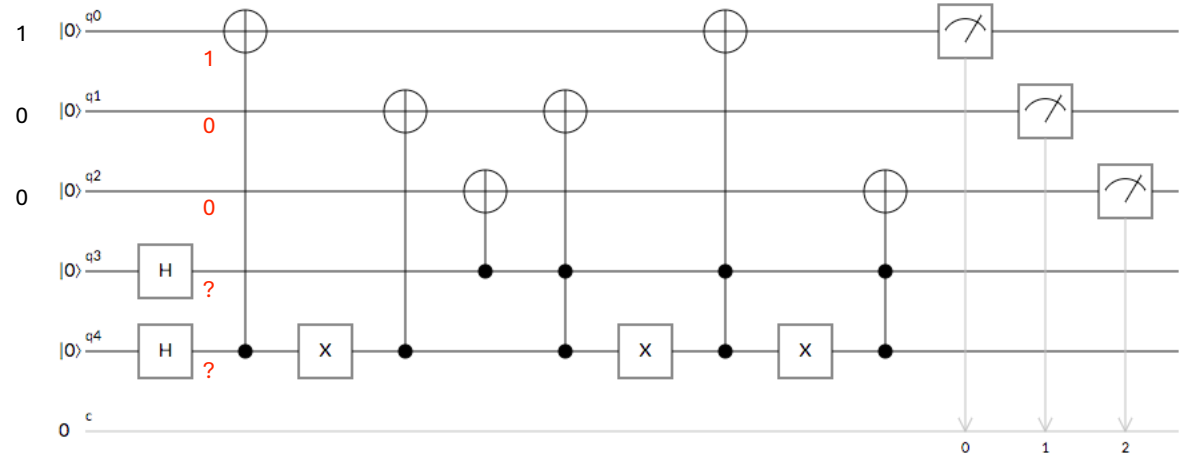

```
x = random_number (0,7);

if current_node = 000:
        if x = 1: then move_to_node(001)
                else if x = 4: then move_to_node (100)
                else if x = 2:  then move_to_node(010)

        else if current_node = 001:
                if x = 5: then move_to_node(101)
                        else if x = 3: then move_to_node(011)
                        else if x = 0:  then move_to_node(000)

        else if current_node = 001:
                if x = ...
                        ...
                        ...
```



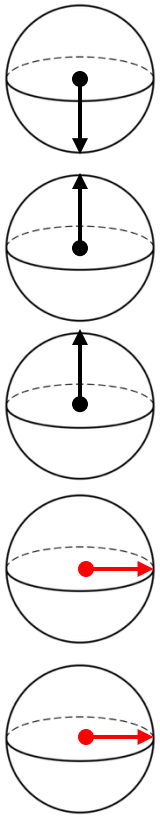
Standard sequential digital computing:

```
x = random_number (0,7);

if current_node = 000:
        if x = 1: then move_to_node(001)
                  = 4: then move_to_node (100)
                  = 2:  then move_to_node(010)

        else if current_node = 001:
                  = 5:  then move_to_node(101)
                        else if x = 3: then move_to_node(011)
                        else if x = 0:  then move_to_node(000)

        else if current_node = 010:
                  if x = ...
                            ...
```





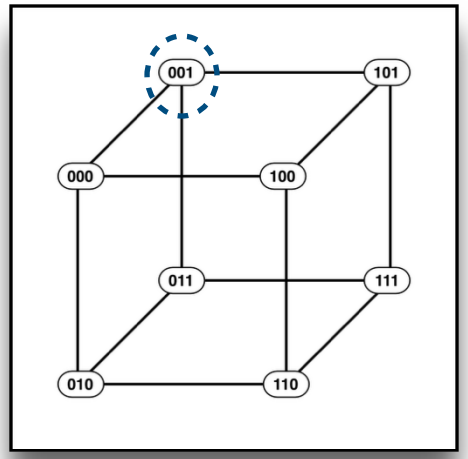
Quantum computing

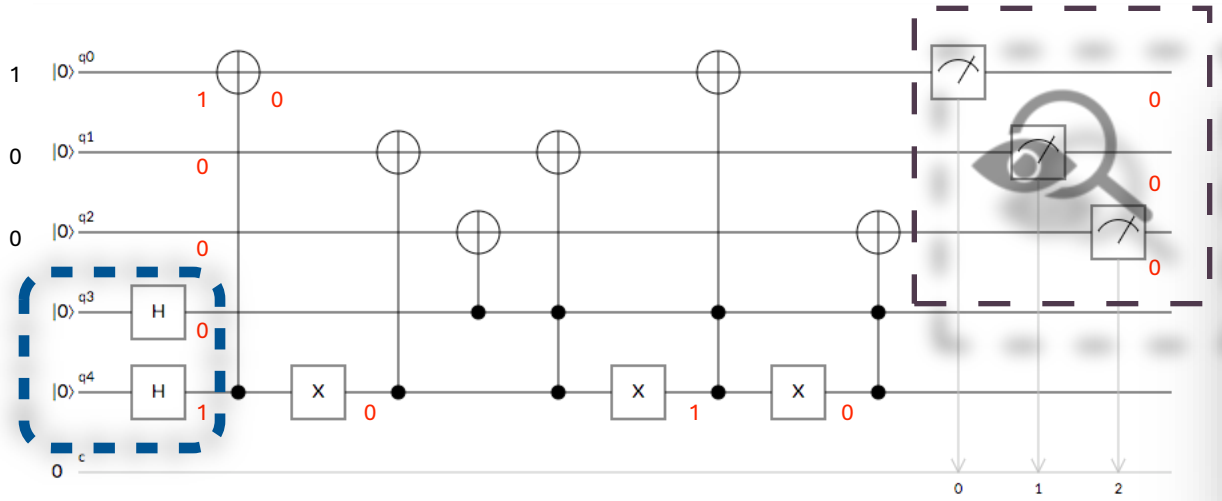


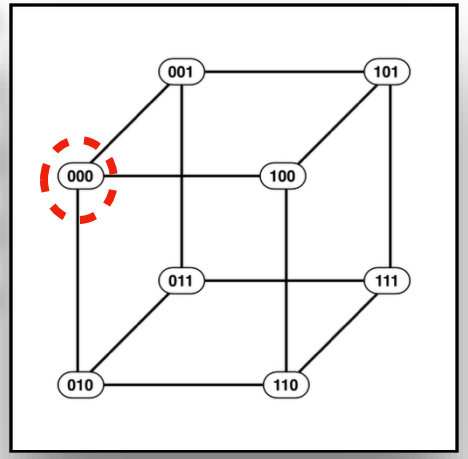
50% x 50%

50% x 50%

Superposition



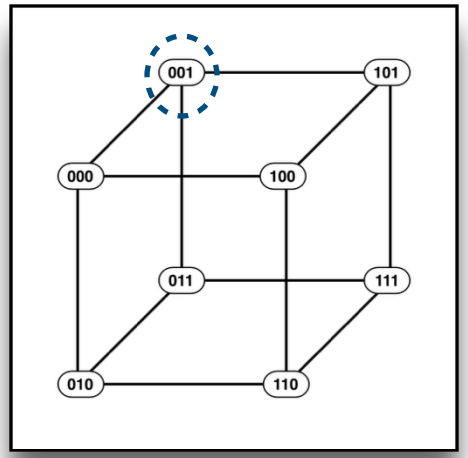




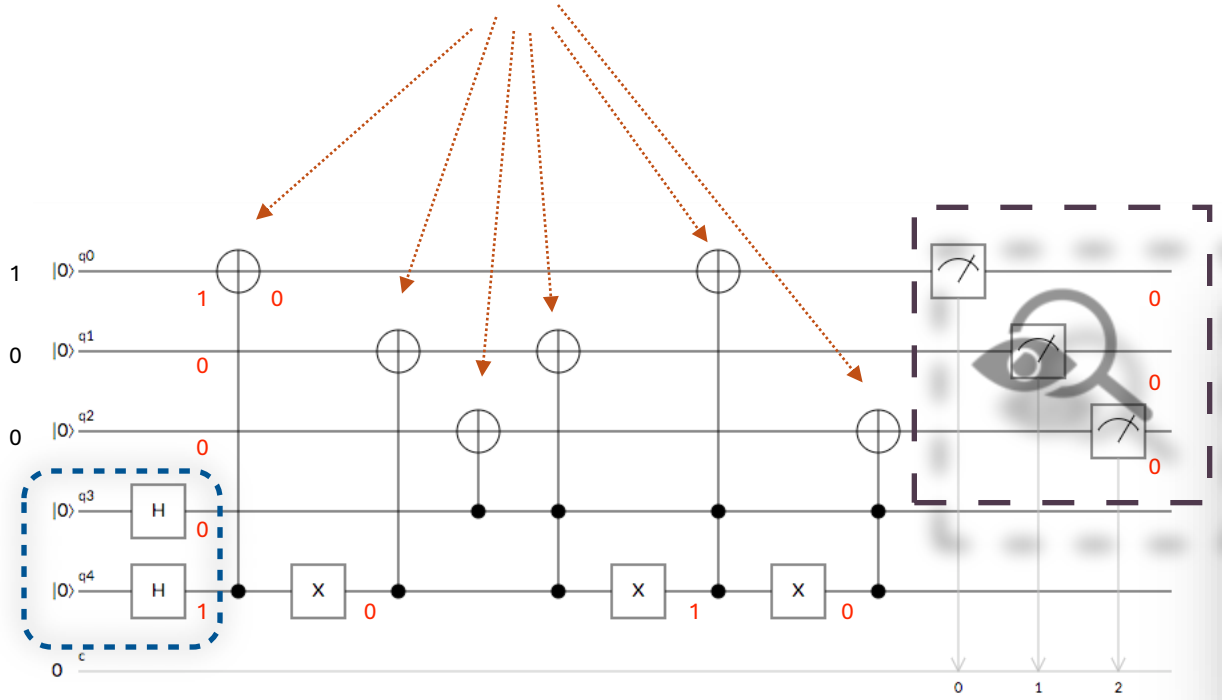
PROBLEM RULES

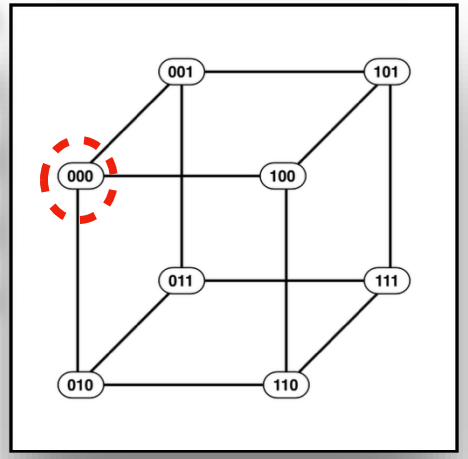
ENCODING FOR QUANTUM PROCESSING

RESULT



Entanglement

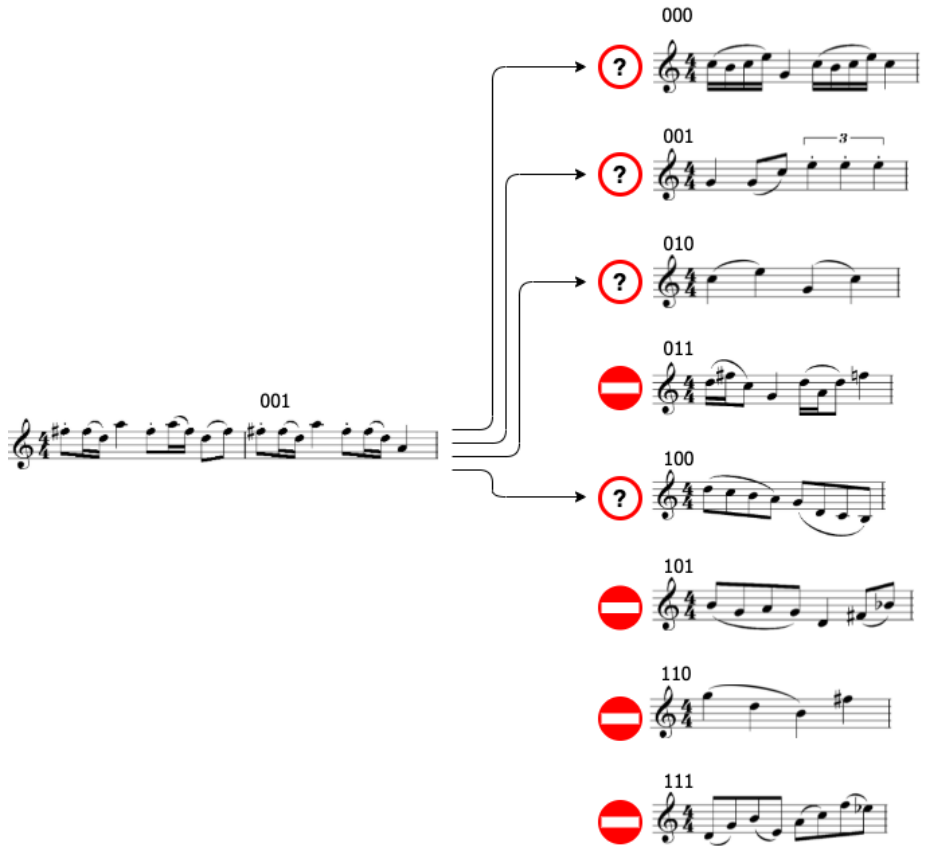




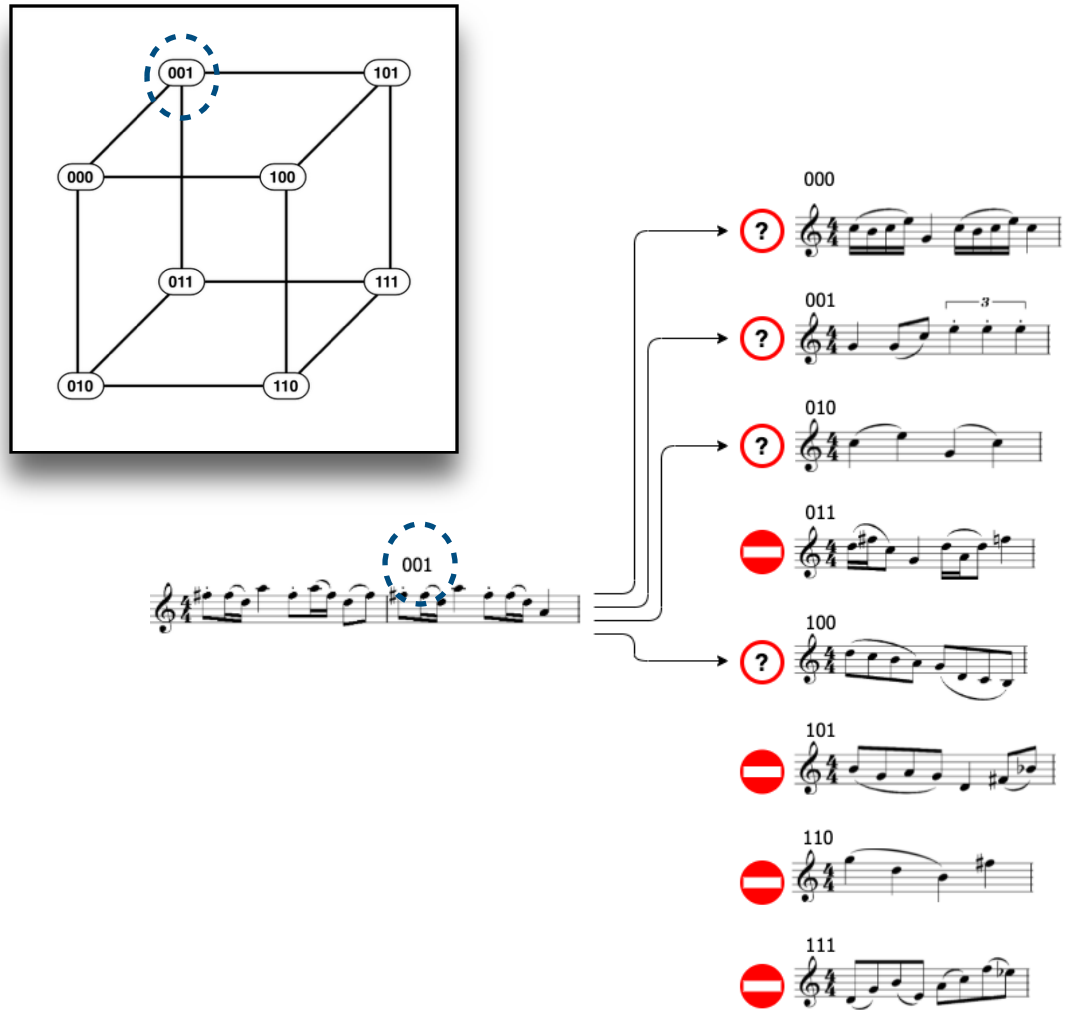
PROBLEM RULES

ENCODING FOR QUANTUM PROCESSING

RESULT



MUSIC RULES


001
101
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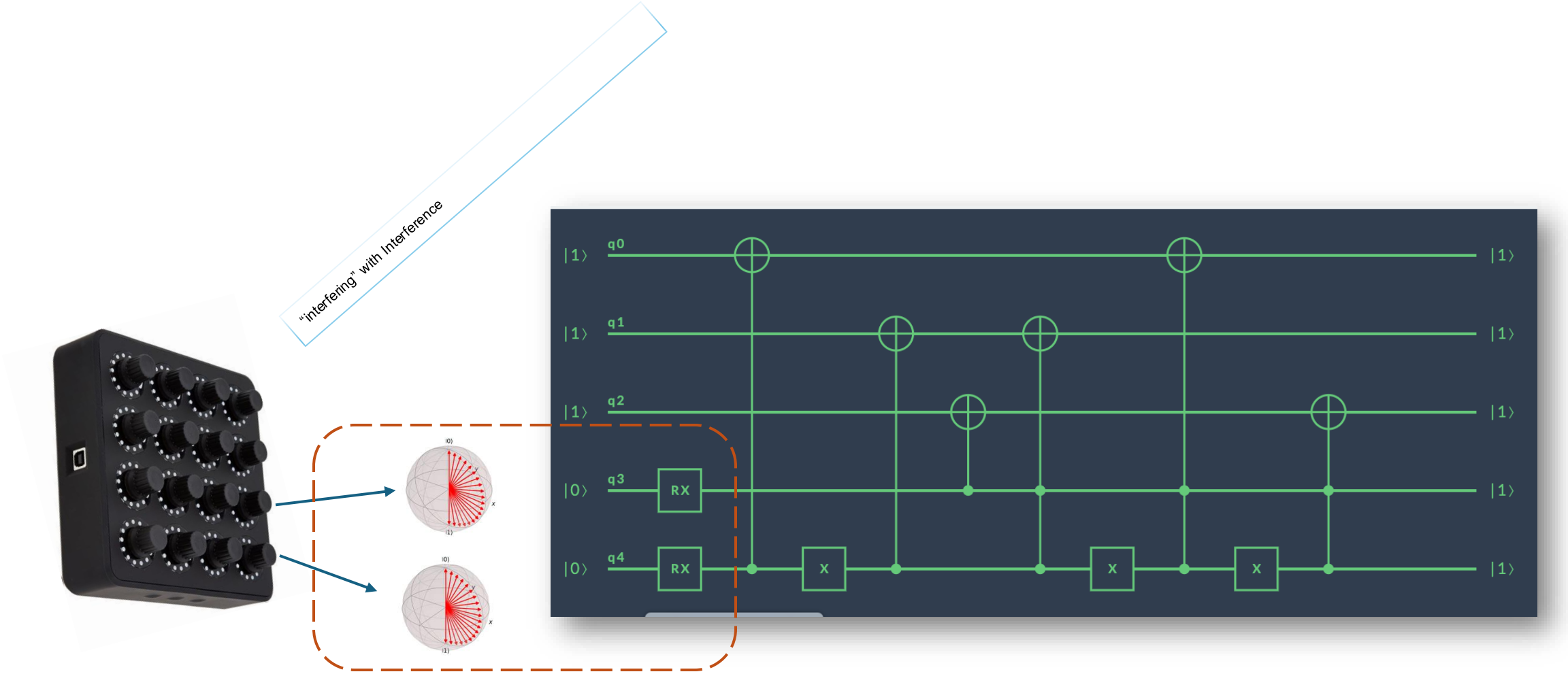
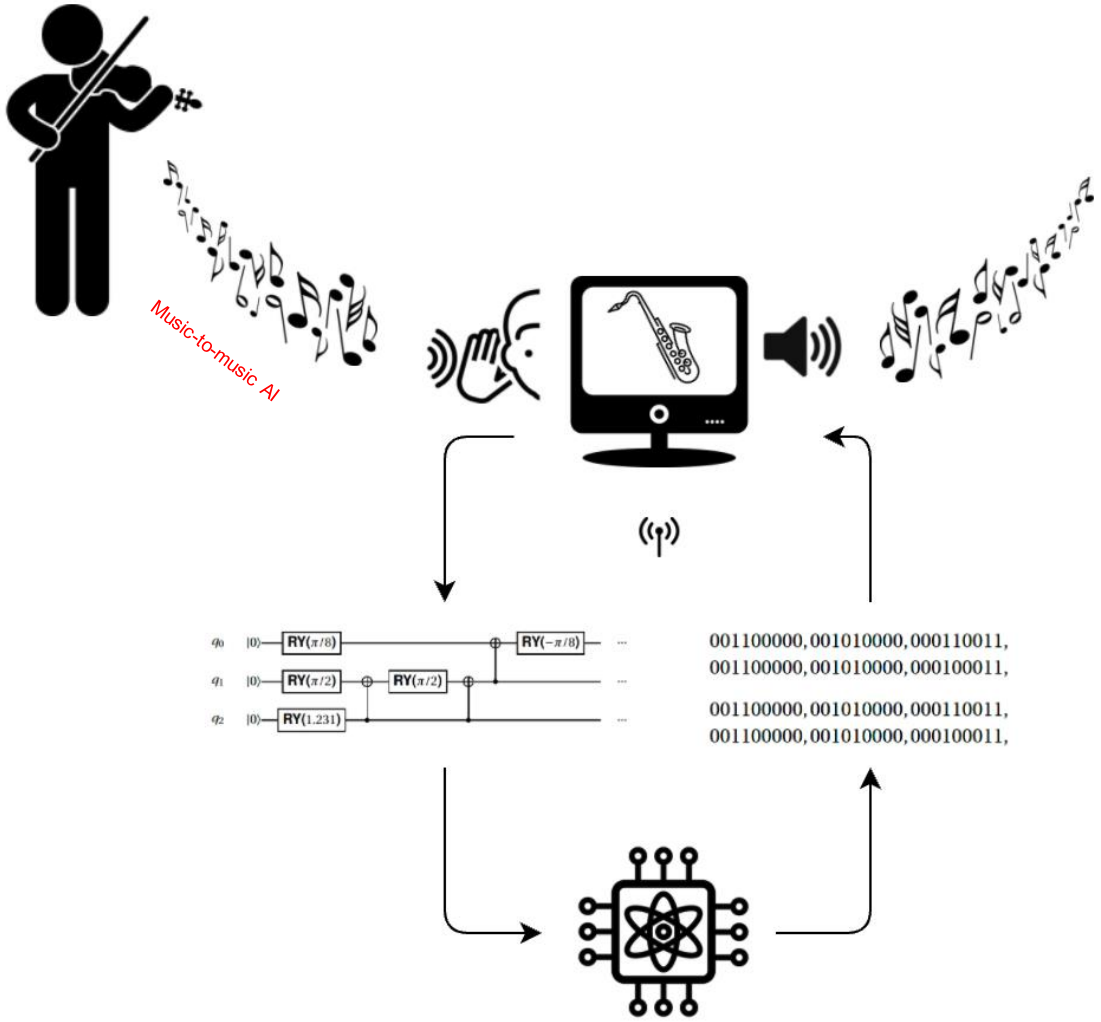
101
110
111


"interfering" with Interference
|1⟩ q0 |1⟩
|1⟩ q1 |1⟩
|1⟩ q2 |1⟩
|0⟩ q3 RX |1⟩
|0⟩ q4 RX X X X |1⟩

Composition entitled: I don't know how, but I will find a way



7-qubit superconducting quantum machine
@ QuTech, TU Delft, The Netherlands

$C_3 \Longrightarrow D_3(25\%) \vee G\sharp_3(25\%) \vee C_4(25\%) \vee D_4(25\%)$

$D_3 \Longrightarrow C_3(30\%) \vee E_3(70\%)$

$E_3 \Longrightarrow D_3(25\%) \vee F\sharp_3(25\%) \vee A\sharp_3(25\%) \vee C_4(5\%) \vee D_4(20\%)$

$F\sharp_3 \Longrightarrow E_3(100\%)$

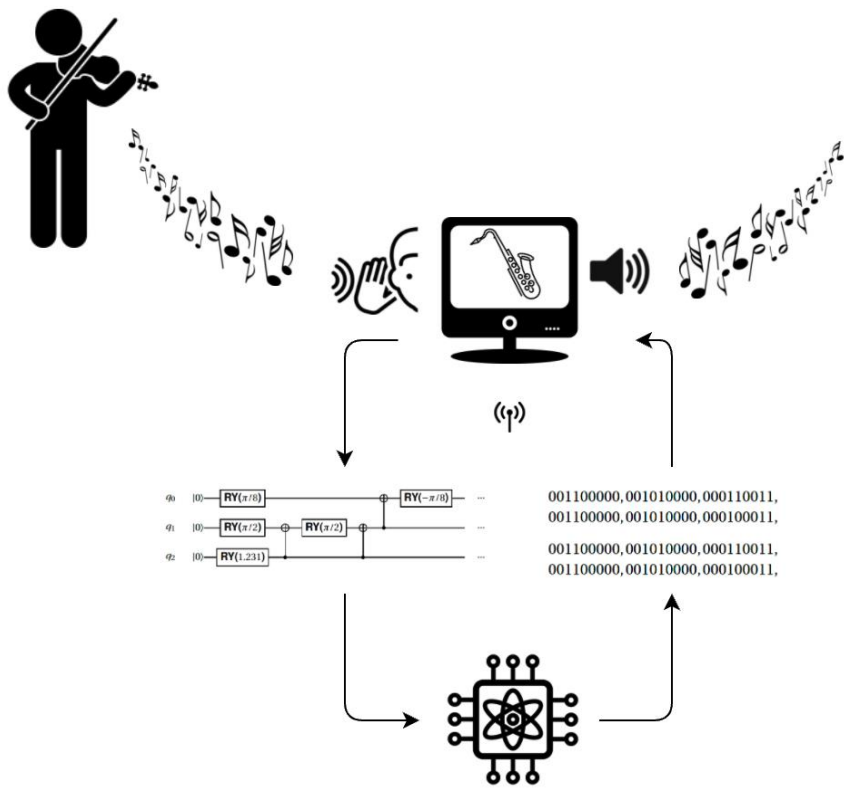
$G\sharp_3 \Longrightarrow C_3(30\%) \vee A\sharp_3(70\%)$

$A\sharp_3 \Longrightarrow E_3(33\%) \vee G\sharp_3(33\%) \vee C_4(34\%)$

$C_4 \Longrightarrow C_3(30\%) \vee A\sharp_3(70\%)$

$D_4 \Longrightarrow C_3(20\%) \vee E_3(80\%)$

MUSIC RULES



$C_3 \Longrightarrow D_3(25\%) \vee G\sharp_3(25\%) \vee C_4(25\%) \vee D_4(25\%)$

$D_3 \Longrightarrow C_3(30\%) \vee E_3(70\%)$

$E_3 \Longrightarrow D_3(25\%) \vee F\sharp_3(25\%) \vee A\sharp_3(25\%) \vee C_4(5\%) \vee D_4(20\%)$

$F\sharp_3 \Longrightarrow E_3(100\%)$

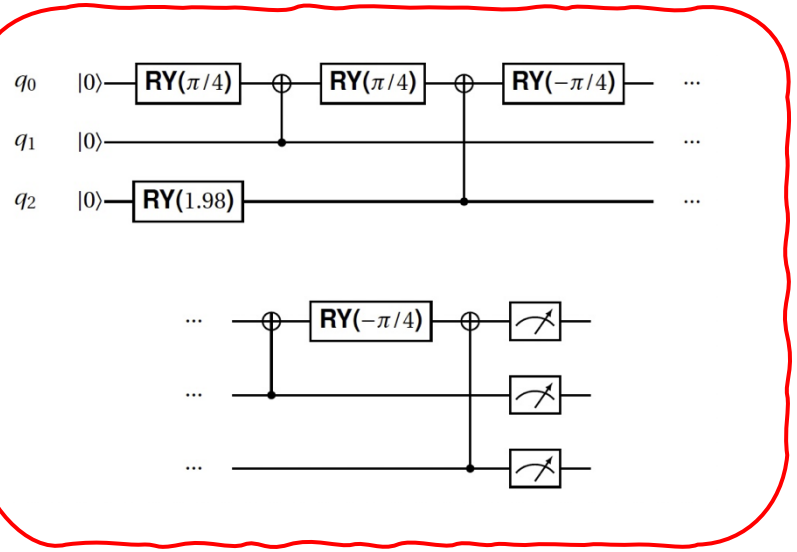
$G\sharp_3 \Longrightarrow C_3(30\%) \vee A\sharp_3(70\%)$

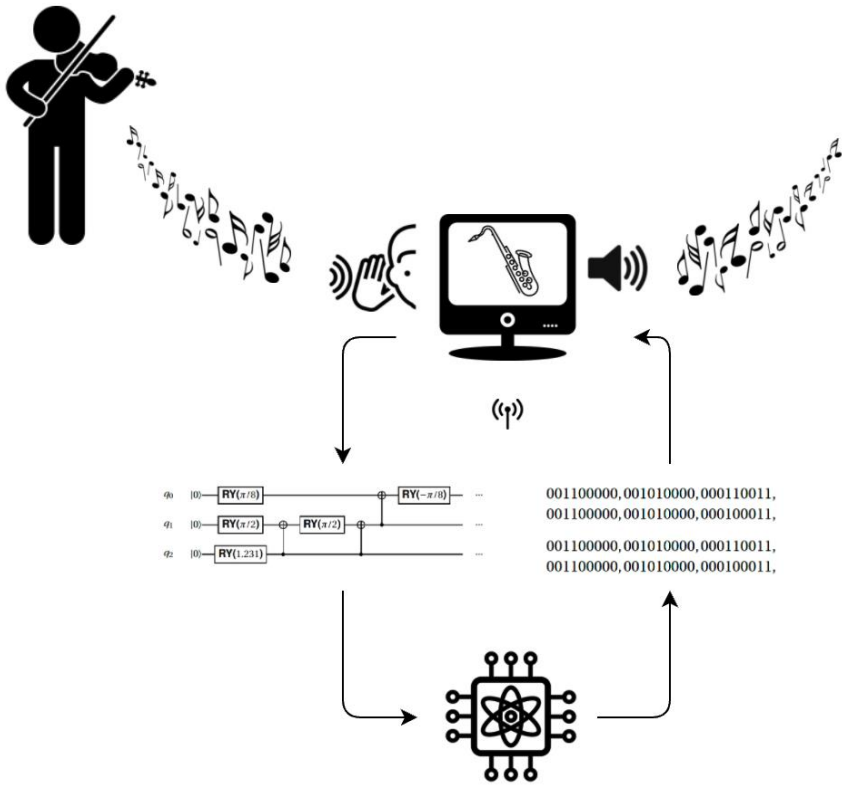
$A\sharp_3 \Longrightarrow E_3(33\%) \vee G\sharp_3(33\%) \vee C_4(34\%)$

$C_4 \Longrightarrow C_3(30\%) \vee A\sharp_3(70\%)$

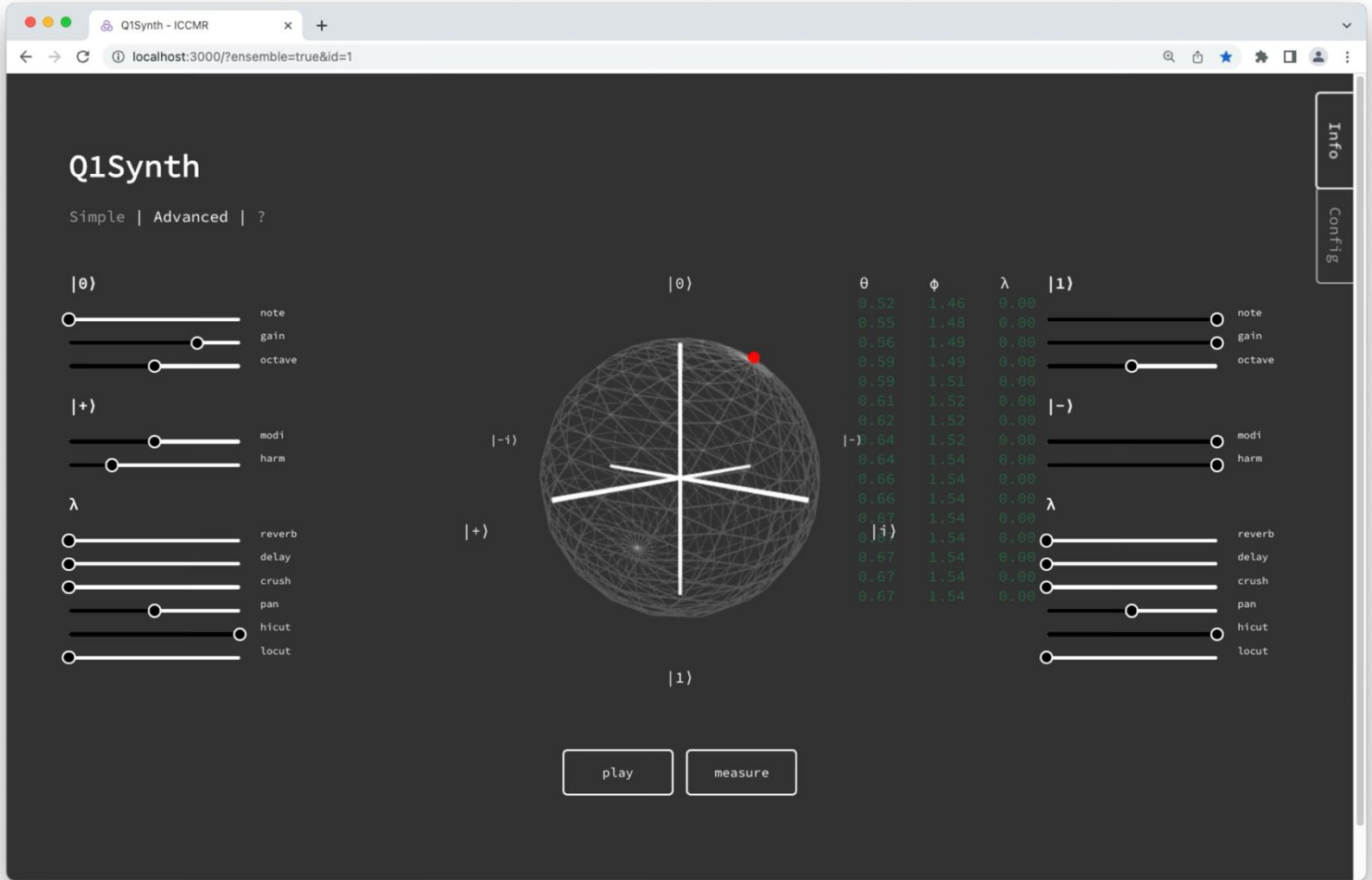
$D_4 \Longrightarrow C_3(20\%) \vee E_3(80\%)$

ENCODING FOR QUANTUM PROCESSING

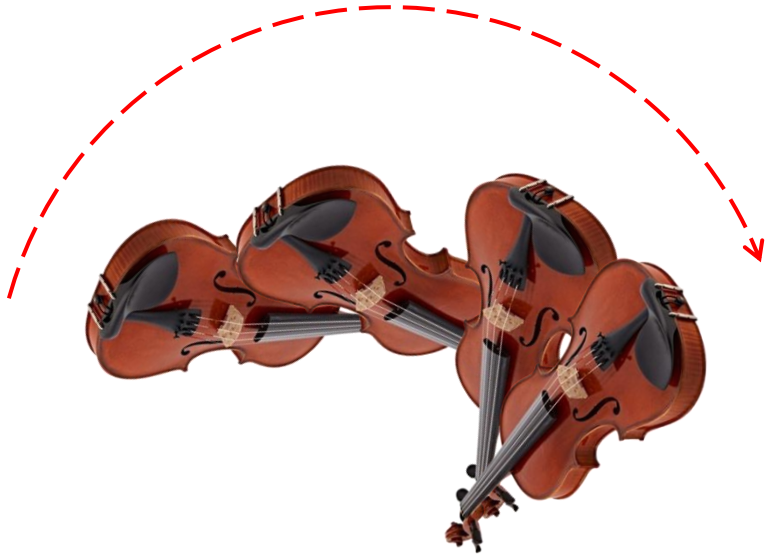


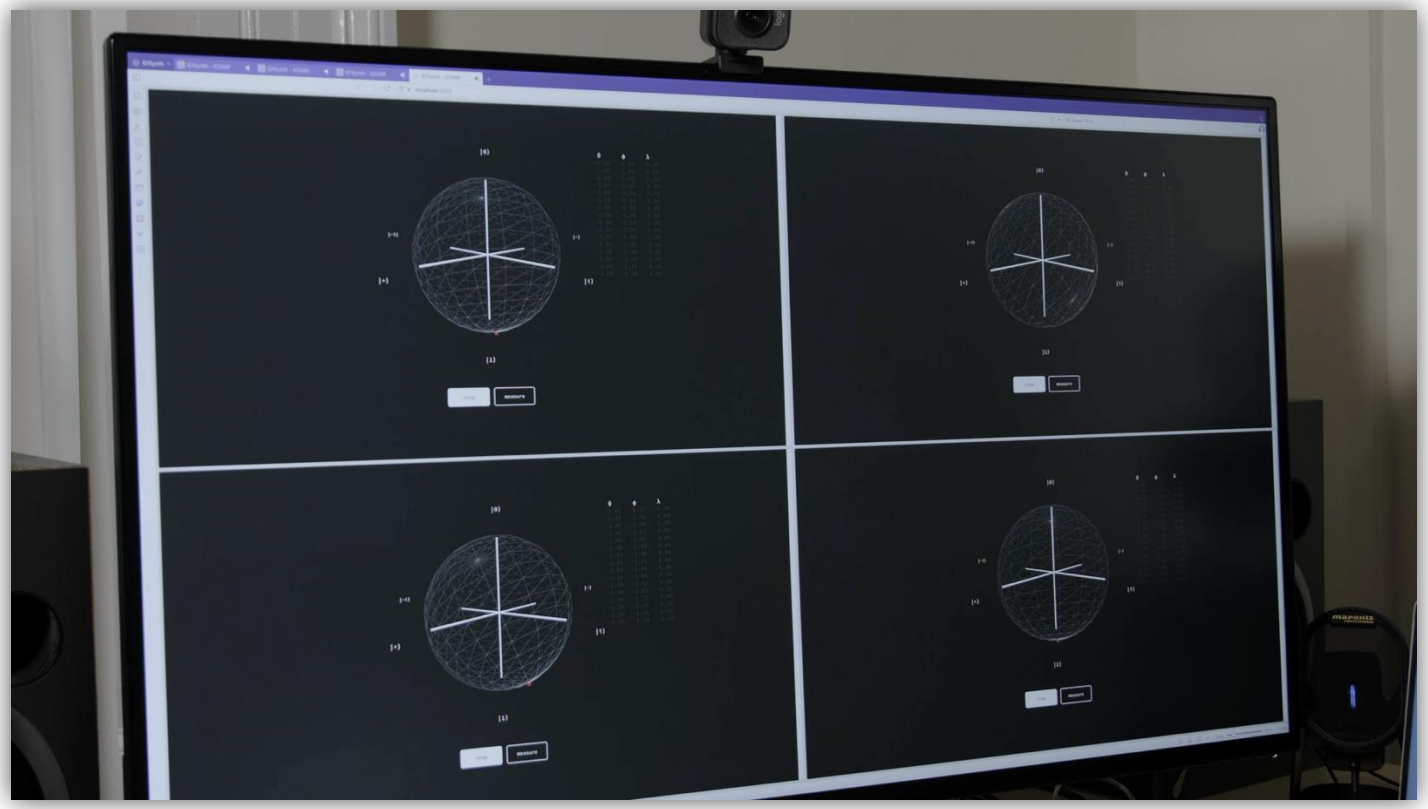


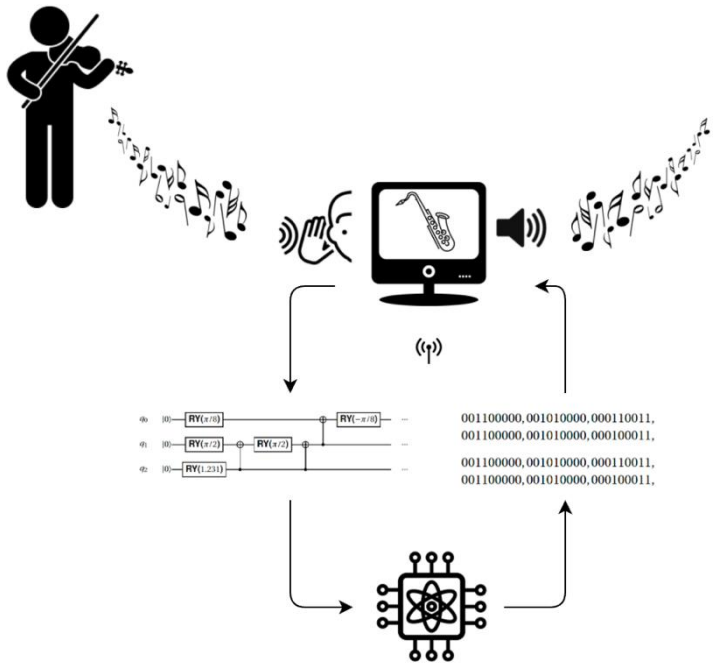
https://www.youtube.com/watch?v=DW9hgFQLeeE

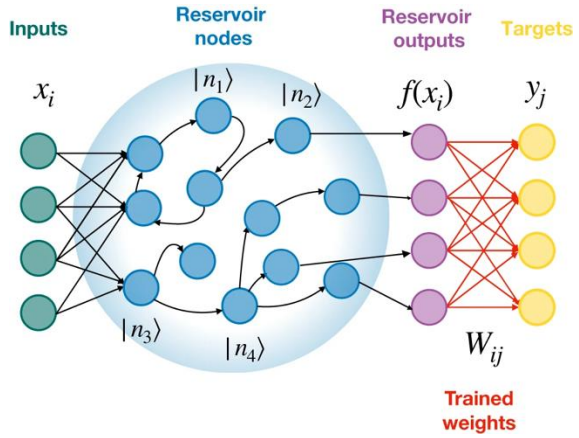


https://iccmr-q1synth-proto.cephasteom.co.uk/









Credit: https://doi.org/10.1038/s41534-023-00734-4

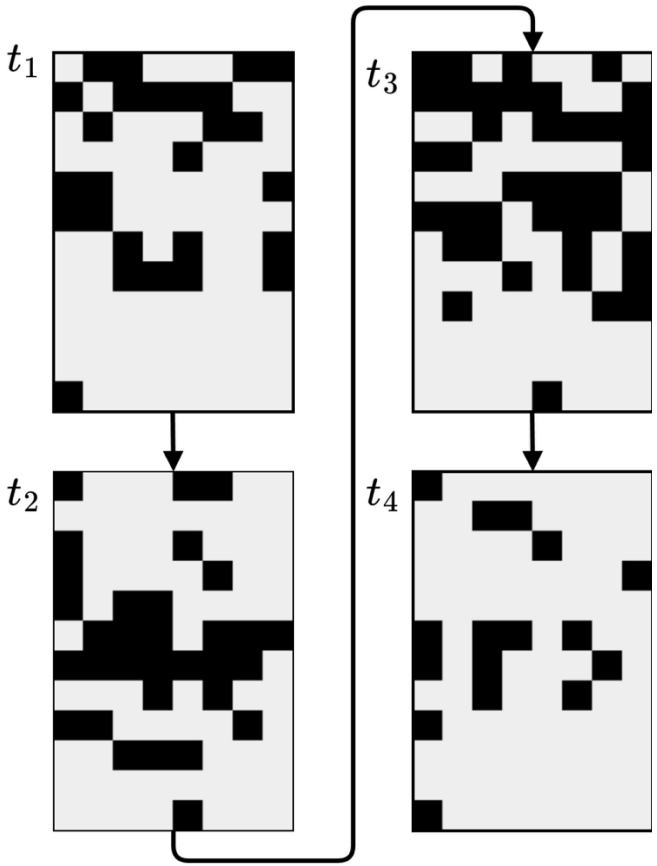
Composition entitled: Moment States

Quantum AI Method: Reservoir Computing

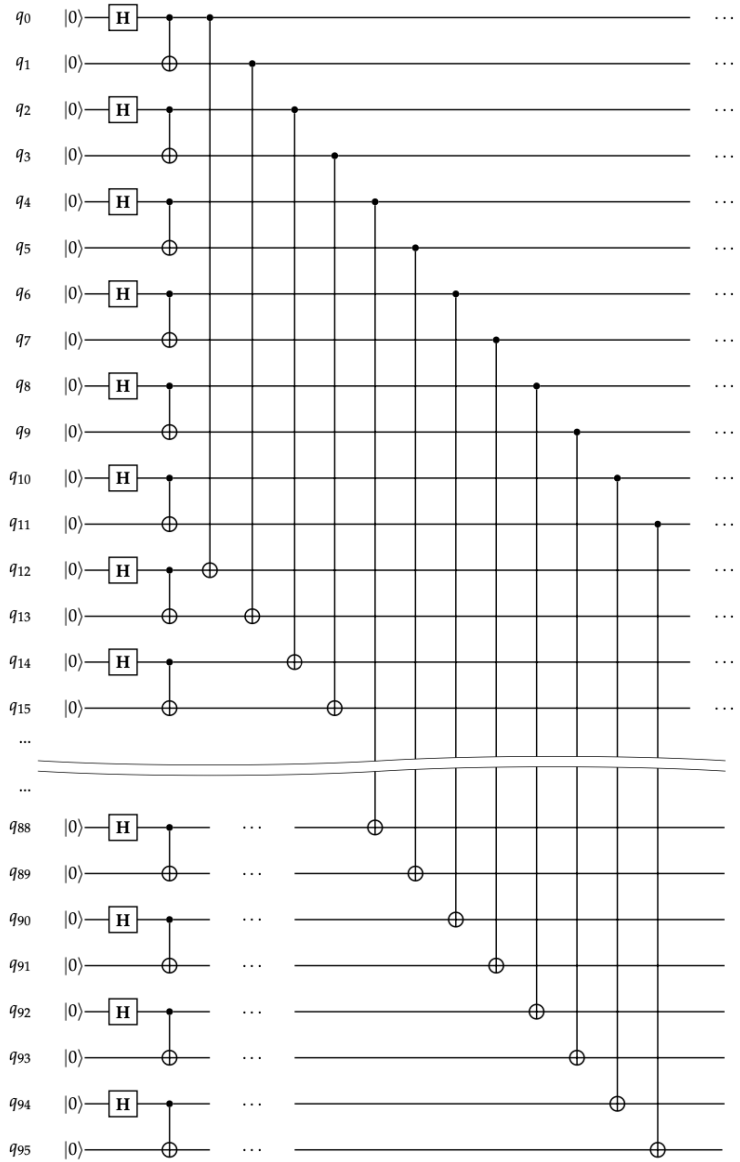
- Off-line batch processing with my own music for training the model (alter ego).
- On-line real-time interaction with the model for performing.
- Technically superior to the so-called RNN deep leaning.
- Not convinced. It produced good results, albeit in a rather convoluted fashion.

Procedural Generation with Partitioned Quantum Cellular Automata

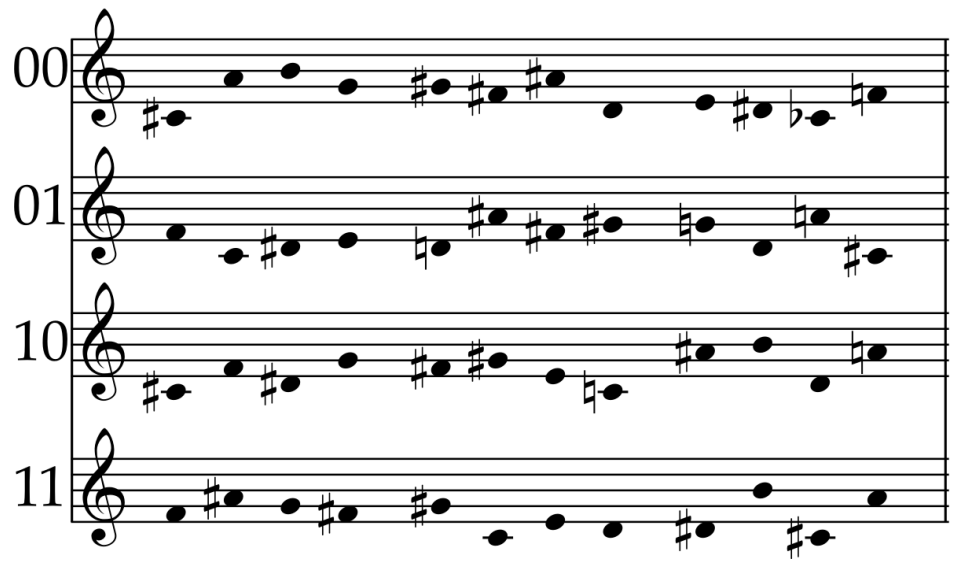
8 x 12 cells = 96 qubits



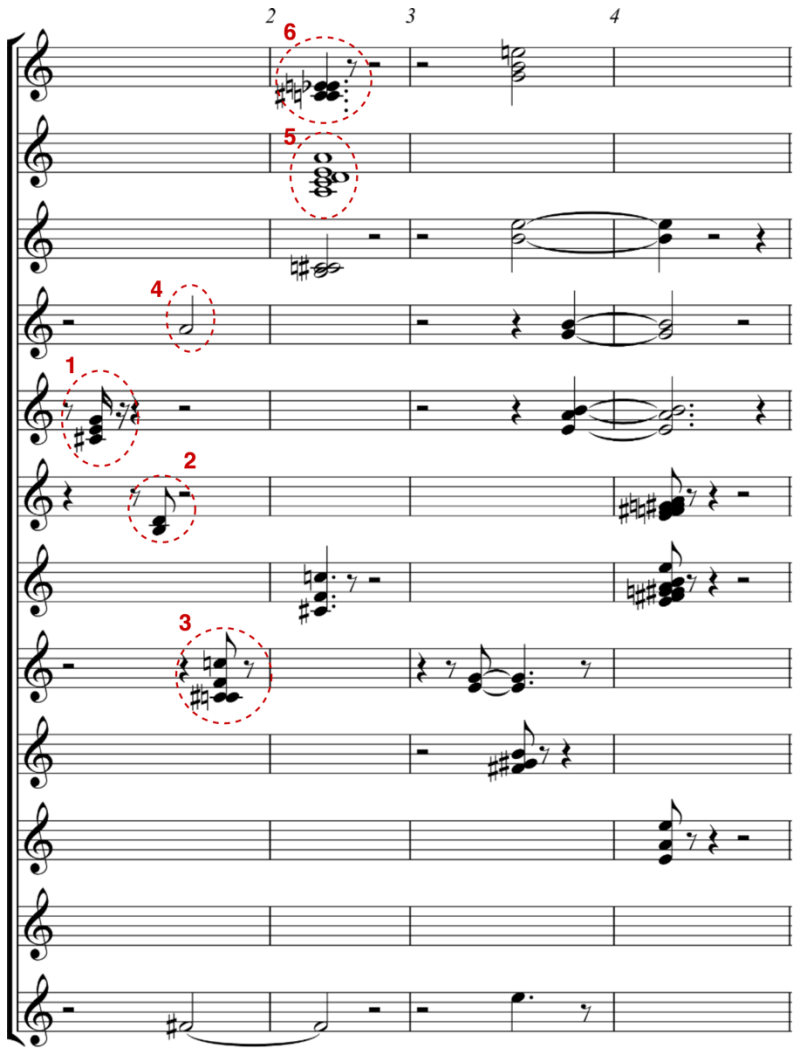
Ran for 50 cycles, 80,000 shots per cycle on IBM hardware.



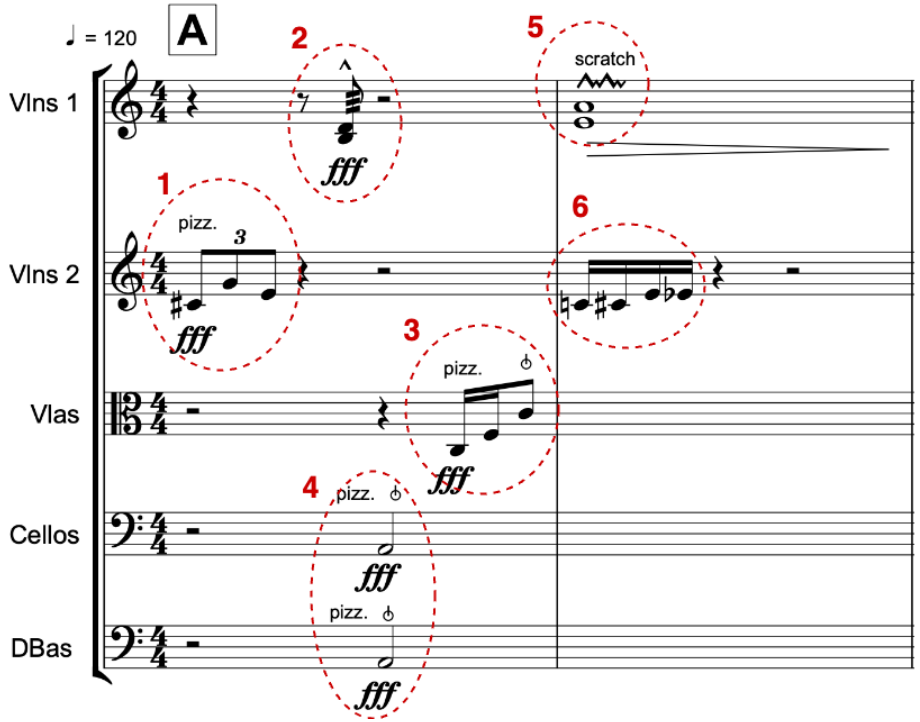
References: 12-tone series and transformation rows



Raw outputs ...



... composed score



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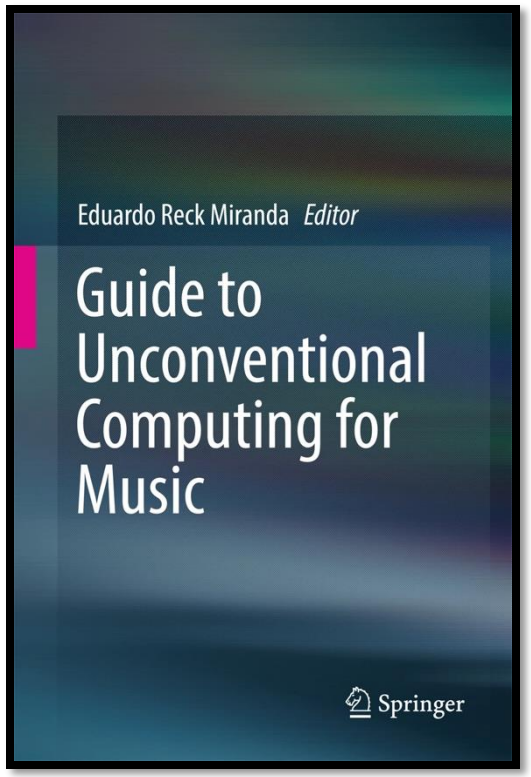

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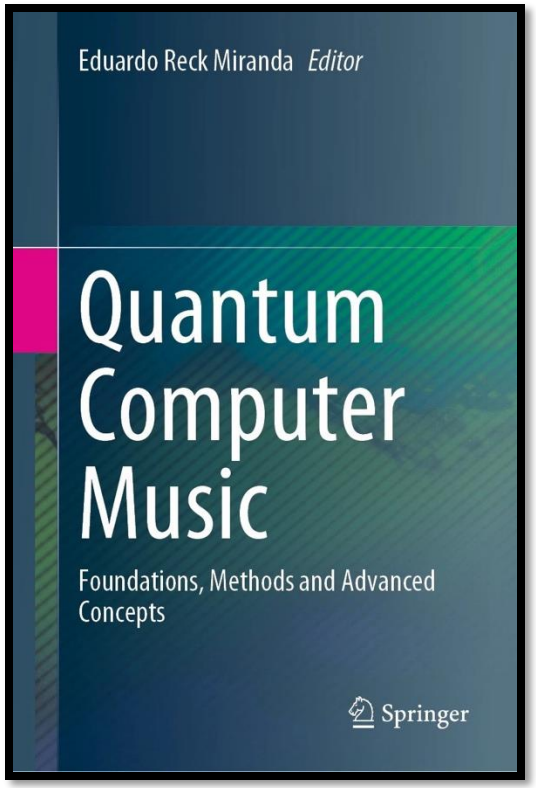

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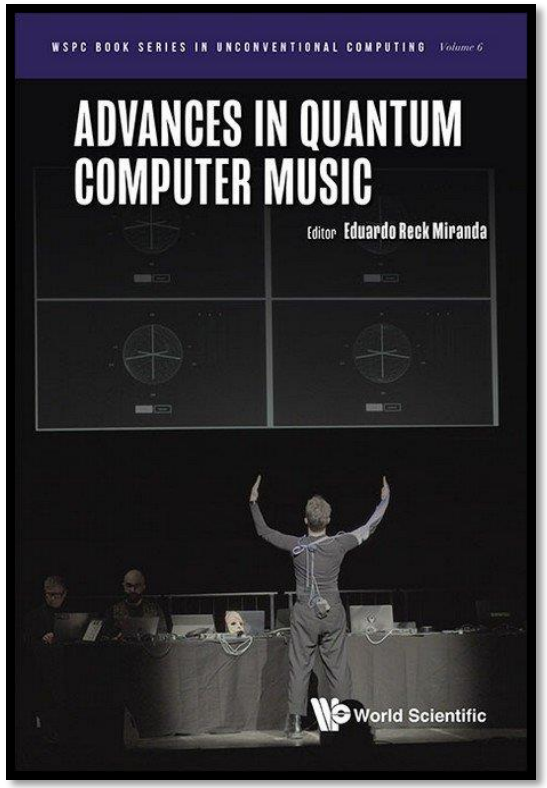

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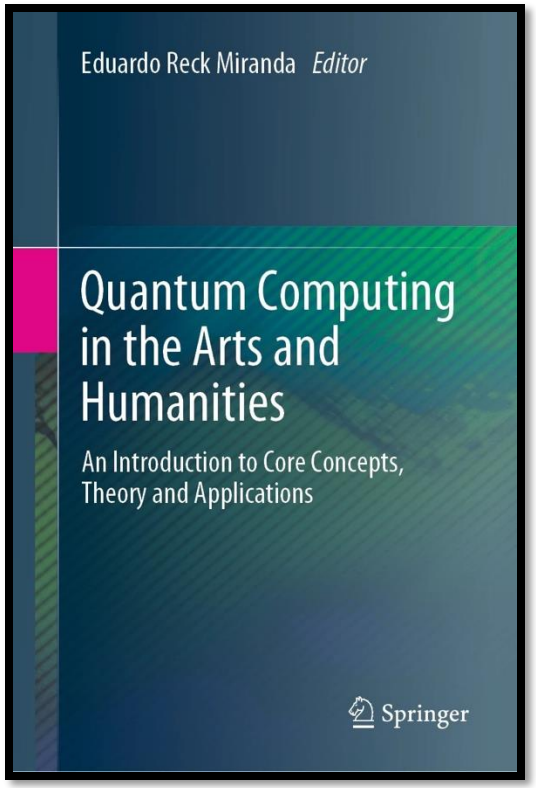

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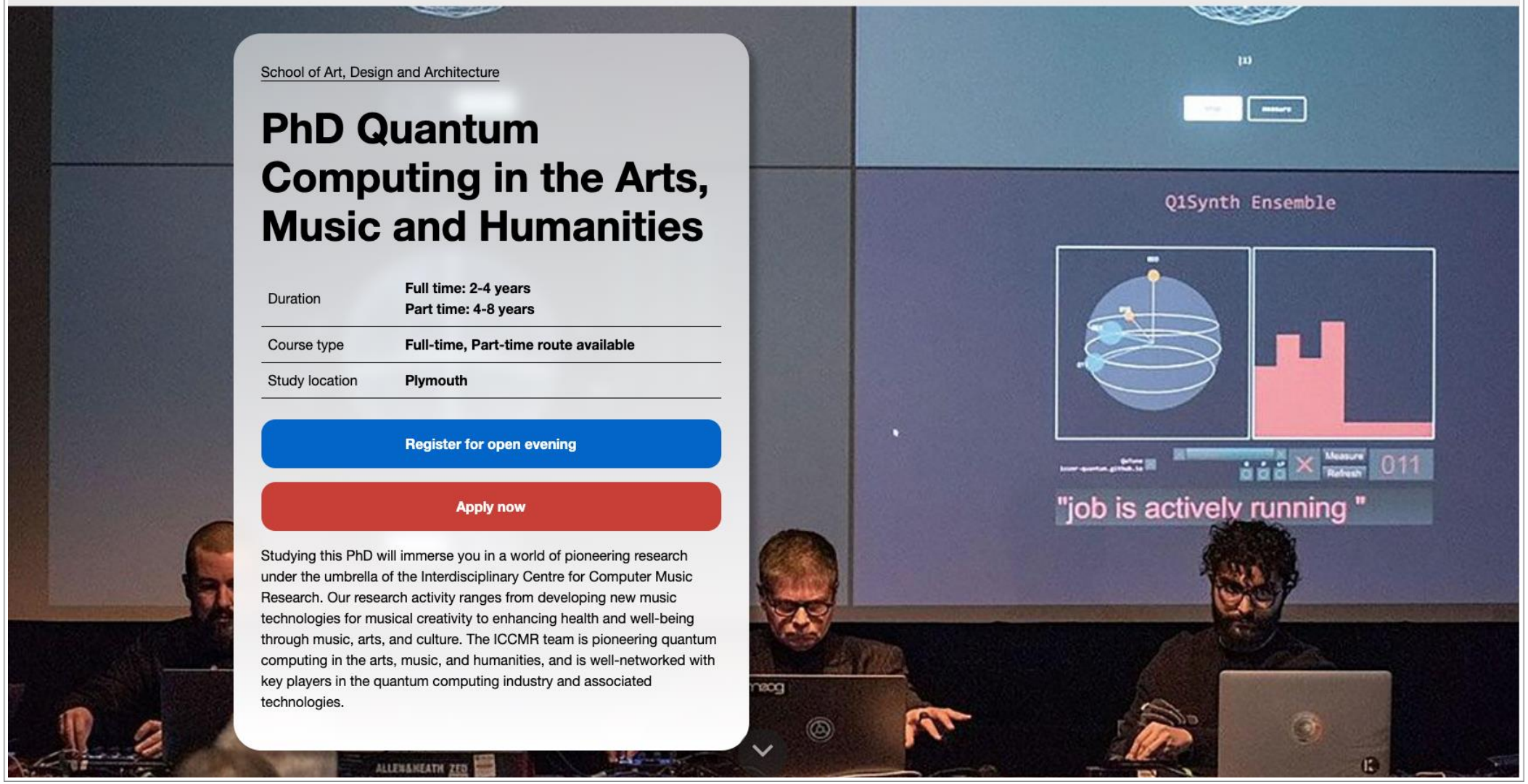

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