

Music Arrangement via Quantum Annealing

Lucas Kirby

16th January 2025

Durham University

2025-01-16

Music Arrangement via Quantum Annealing

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Theory

Music arrangement

Quantum annealing

Methods

Results

Conclusions

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Music Arrangement via Quantum Annealing

└ Overview

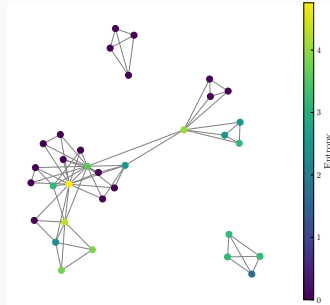
1. Welcome to the talk!
2. As you can see, this slidedeck is a work in progress.

Theory

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Music Arrangement via Quantum Annealing
└ Theory

Theory



Source: Wikimedia Commons

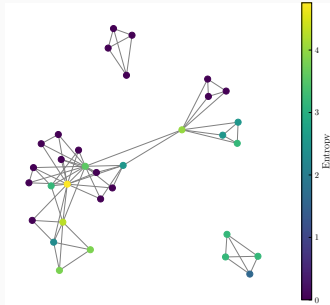
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Music Arrangement via Quantum Annealing

- └ Theory
 - └ Music arrangement
 - └ Music arrangement



- Adaptation of previously composed pieces for practical or artistic reasons



Source: Wikimedia Commons

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Music Arrangement via Quantum Annealing

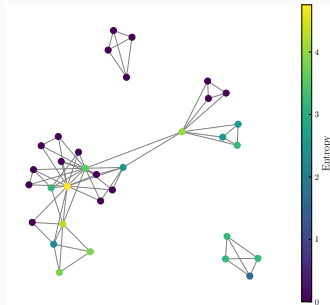
- └ Theory
 - └ Music arrangement
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Music arrangement

- Adaptation of previously composed pieces for practical or artistic reasons



- Adaptation of previously composed pieces for practical or artistic reasons
- Traditionally complex and time-consuming



Source: Wikimedia Commons

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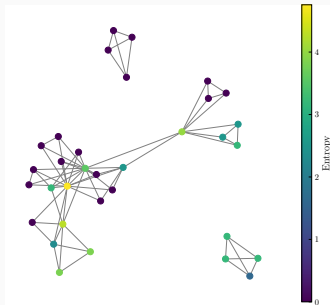
- └ Theory
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Music arrangement

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- This study focuses on **reduction**



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| | |
|---|---|
| | Music Arrangement via Quantum Annealing |
| └ | Theory |
| └ | Quantum annealing |
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- *Materials* — heating and cooling a material to alter its physical properties

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Music Arrangement via Quantum Annealing

- └ Theory
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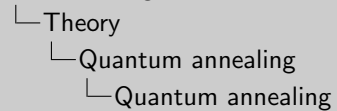
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Quantum annealing

- *Materials* — heating and cooling a material to alter its physical properties
- *Quantum* — changing a quantum system from one Hamiltonian to another

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Music Arrangement via Quantum Annealing



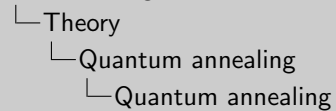
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Quantum annealing

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- Done slowly and adiabatically to remain in the ground state

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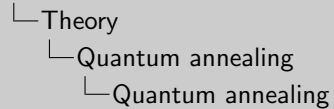
Music Arrangement via Quantum Annealing



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$$H(t) = \left(1 - \frac{t}{T}\right) H_0 + \frac{t}{T} H_p$$



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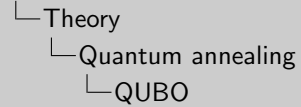
Ising model

$$H(s) = - \sum_{i < j} J_{ij} s_i s_j - \sum_{i=1}^N h_i s_i$$

QUBO

Quadratic Unconstrained Binary Optimisation

$$f(x) = \sum_{i < j} Q_{i,j} x_i x_j + \sum_i Q_{i,i} x_i$$



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How to combine them?

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└ Theory

└ Quantum annealing

How to combine them?

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Methods

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Results



$$\oiint_A E \cdot dA = \frac{Q}{\epsilon_0}$$

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Music Arrangement via Quantum Annealing

└ Results

└ Blocks

$$\oiint_A E \cdot dA = \frac{Q}{\epsilon_0}$$

$$\oiint_A \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$$

The *net electric flux* through any **closed** surface is proportional to the **enclosed charge**.

Alert

This is an alert.

Example

This is an example.

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Music Arrangement via Quantum Annealing

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Equation alignment

$$F = -\frac{GMm}{r^2}$$

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Music Arrangement via Quantum Annealing

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Music Arrangement via Quantum Annealing

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Equation alignment

$$\oiint_A \mathbf{g} \cdot d\mathbf{A} = -4\pi GM$$

The gravitational flux through any closed surface is proportional to the enclosed mass.

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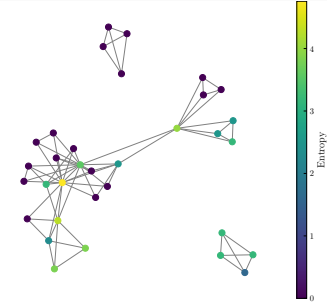
└ Results

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Source: Wikimedia Commons

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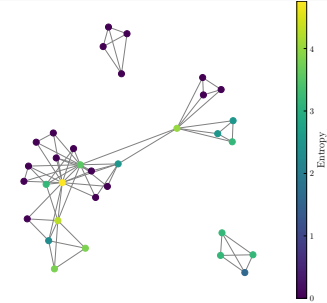
Music Arrangement via Quantum Annealing

- Results
- Apperance sync



Apperance sync

- Volume rate of flow equal to divergence



Source: Wikimedia Commons

$$\nabla \cdot \mathbf{F}$$

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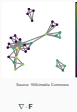
Music Arrangement via Quantum Annealing

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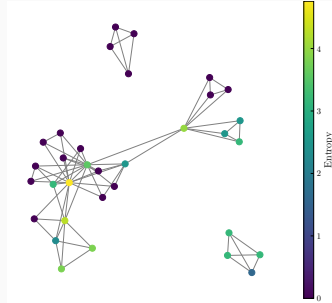


Source: Wikimedia Commons

$$\nabla \cdot \mathbf{F}$$

Apperance sync

- Volume rate of flow equal to divergence
- Summed over entire volume



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$$\iiint_V \nabla \cdot \mathbf{F} dV$$

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Music Arrangement via Quantum Annealing

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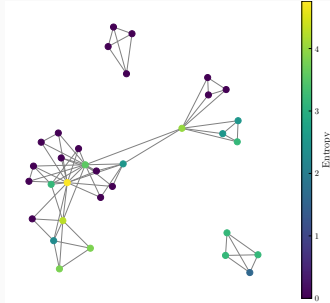


Source: Wikimedia Commons

$$\iiint_V \nabla \cdot \mathbf{F} dV$$

Apperance sync

- Volume rate of flow equal to divergence
- Summed over entire volume
- Equal to net flow across the boundary



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$$\iiint_V \nabla \cdot \mathbf{F} dV = \oiint_A \mathbf{F} \cdot d\mathbf{A}$$

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Source: Wikimedia Commons

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Conclusions



Equation gather

$$\begin{aligned}\nabla \cdot \mathbf{E} &= \frac{\rho}{\varepsilon_0} \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \times \mathbf{B} &= \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \mathbf{I}\end{aligned}$$

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└─ Conclusions

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