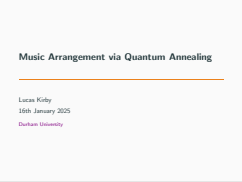
Music Arrangement via Quantum Annealing

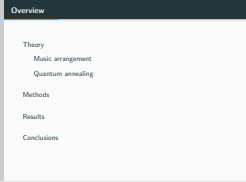
Lucas Kirby

16th January 2025

Durham University



Overview

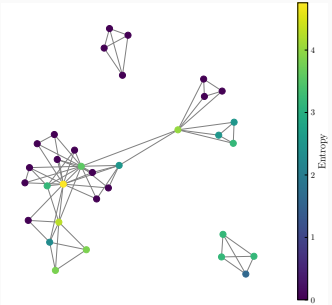


1. Welcome to the talk!
2. As you can see, this slidedeck is a work in progress.

Theory

Theory

Music arrangement

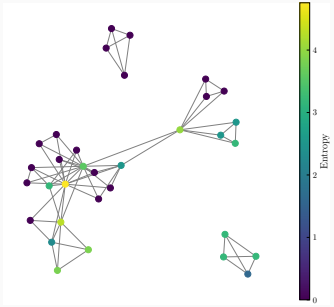


Source: Wikimedia Commons

Music arrangement

Music arrangement

- Adaptation of previously composed pieces for practical or artistic reasons



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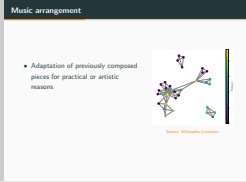
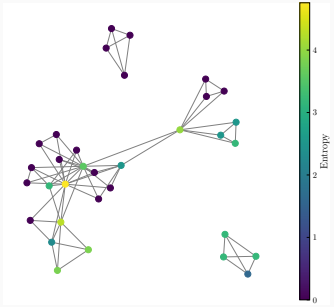


Music arrangement

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



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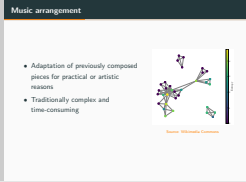
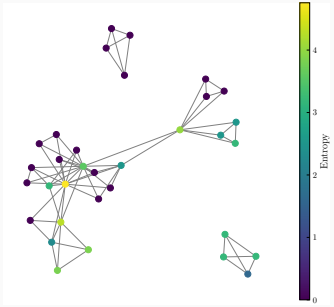


Music arrangement

- Adaptation of previously composed pieces for practical or artistic reasons
- Traditionally complex and time-consuming
- This study focuses on **reduction**



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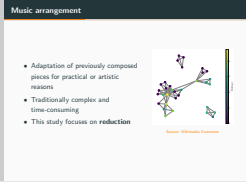

Quantum annealing

Quantum annealing

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- *Materials* — heating and cooling a material to alter its physical properties

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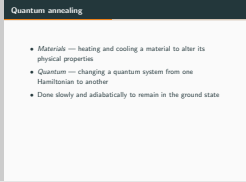
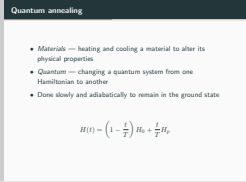
- Done slowly and adiabatically to remain in the ground state



Quantum annealing

- *Materials* — heating and cooling a material to alter its physical properties
- *Quantum* — changing a quantum system from one Hamiltonian to another
- Done slowly and adiabatically to remain in the ground state

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



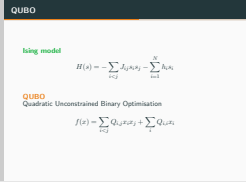
QUBO

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

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



How to combine them?

Methods

Methods

Results

Results

Blocks

$$\oiint_A E \cdot dA = \frac{Q}{\varepsilon_0}$$

Blocks
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Blocks

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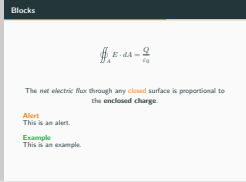
The *net electric flux* through any closed surface is proportional to the **enclosed charge**.

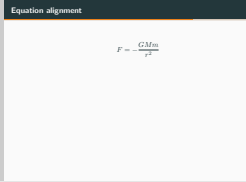
Alert
This is an alert.

Example
This is an example.



Equation alignment

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



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g \cdot 4\pi r^2 &= -4\pi GM
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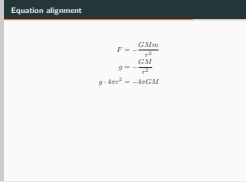

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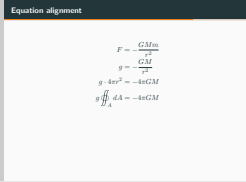

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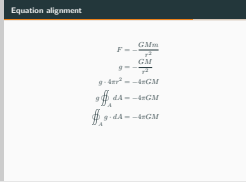

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The gravitational flux through any closed surface is proportional to the enclosed mass.

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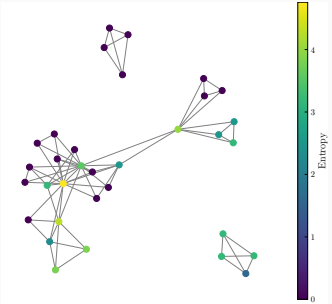
Apperance sync



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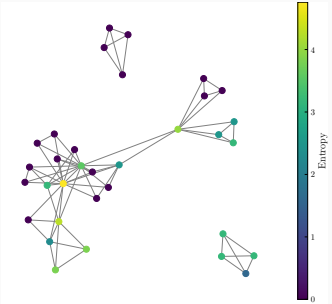
Apperance sync

Apperance sync

- Volume rate of flow equal to divergence



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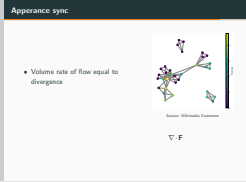
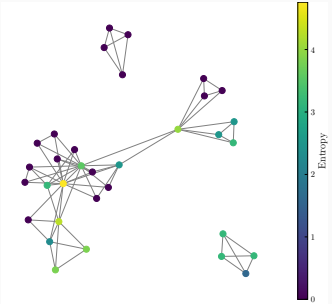
$$\nabla \cdot \mathbf{F}$$



Apperance sync

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



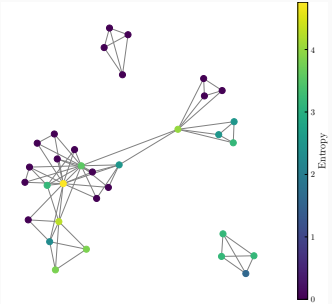
Source: Wikimedia Commons

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

Apperance sync
• Volume rate of flow equal to divergence
• Summed over entire volume
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



Source: Wikimedia Commons

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

Apperance sync
• Volume rate of flow equal to divergence
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Source: Wikimedia Commons
$\iiint_V \nabla \cdot \mathbf{F}\, dV = \oiint_A \mathbf{F} \cdot d\mathbf{A}$

Conclusions

Equation gather

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

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