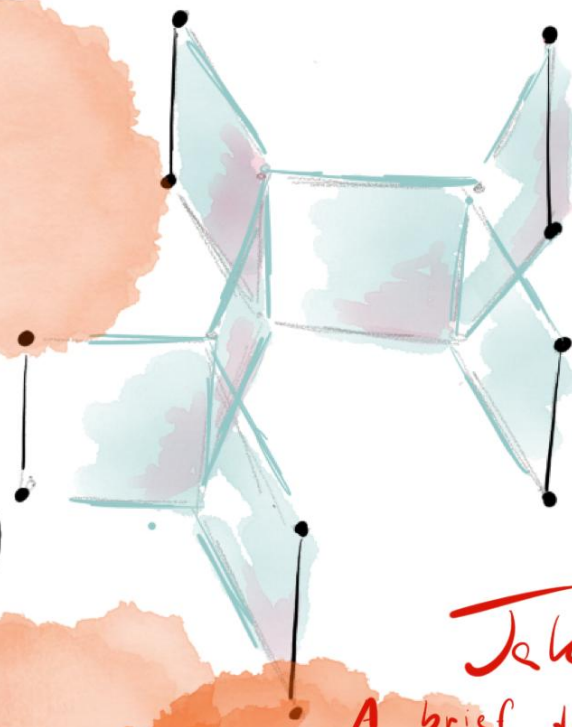
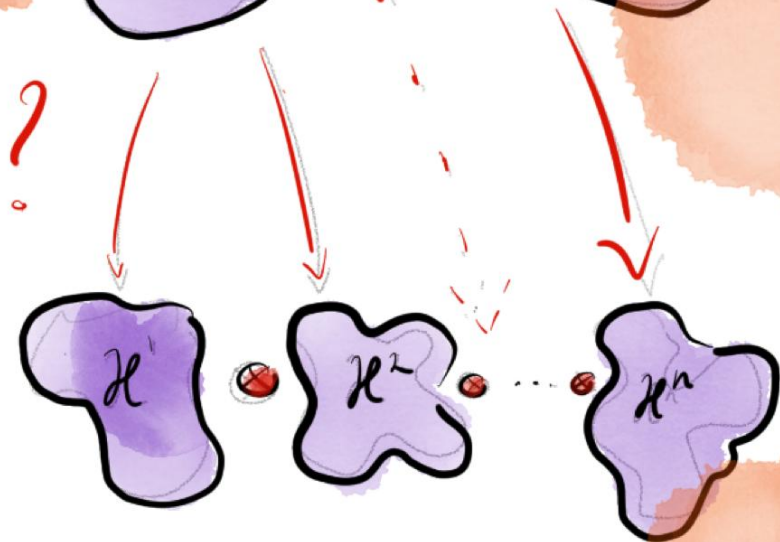
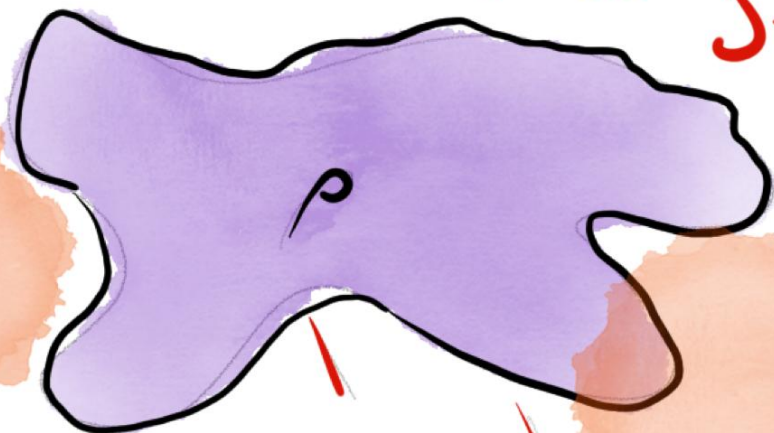


What do entangled states
and Steiner Trees have
in common?



Jake Xuerch

A brief talk for the Math
Mathematical Society

Talk Structure

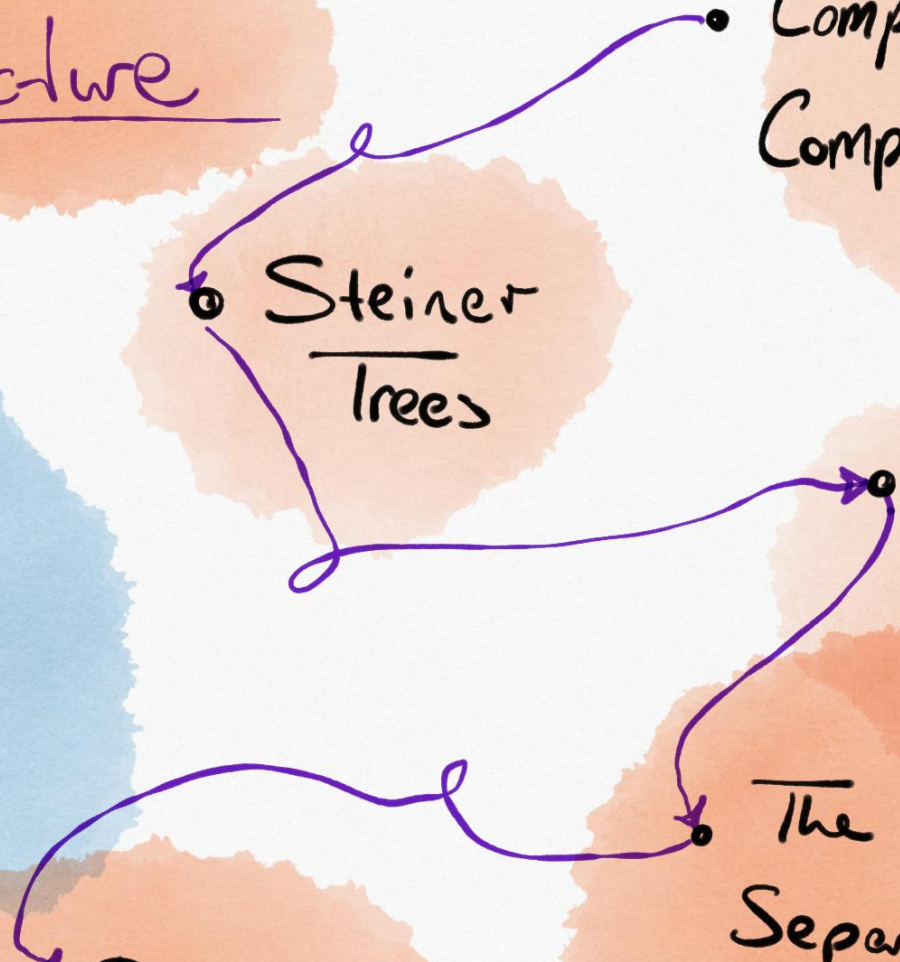
• Computational Complexity

• Steiner Trees

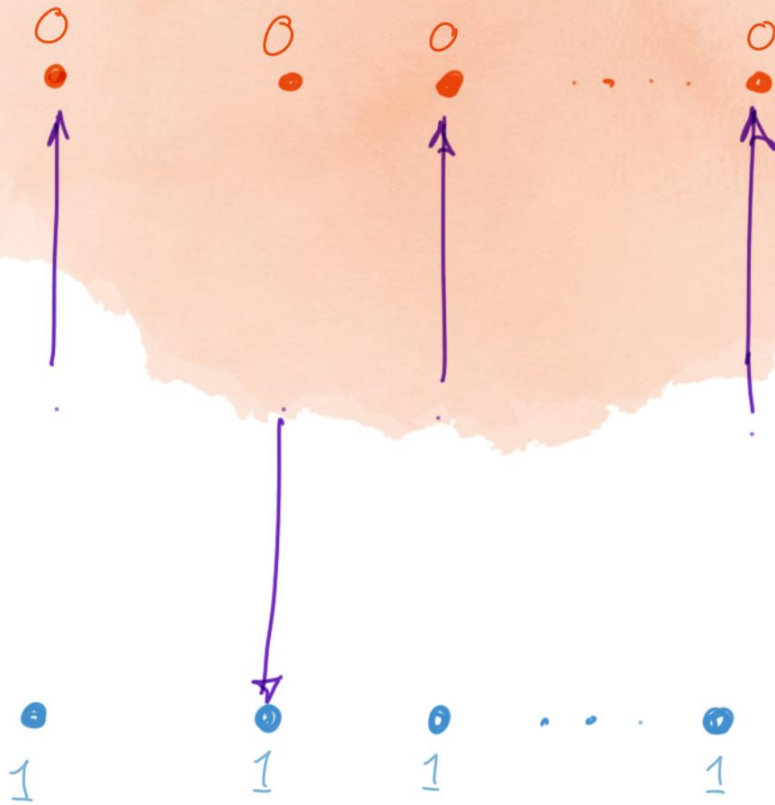
• Soap Bubbles

• The Quantum Separability Problem

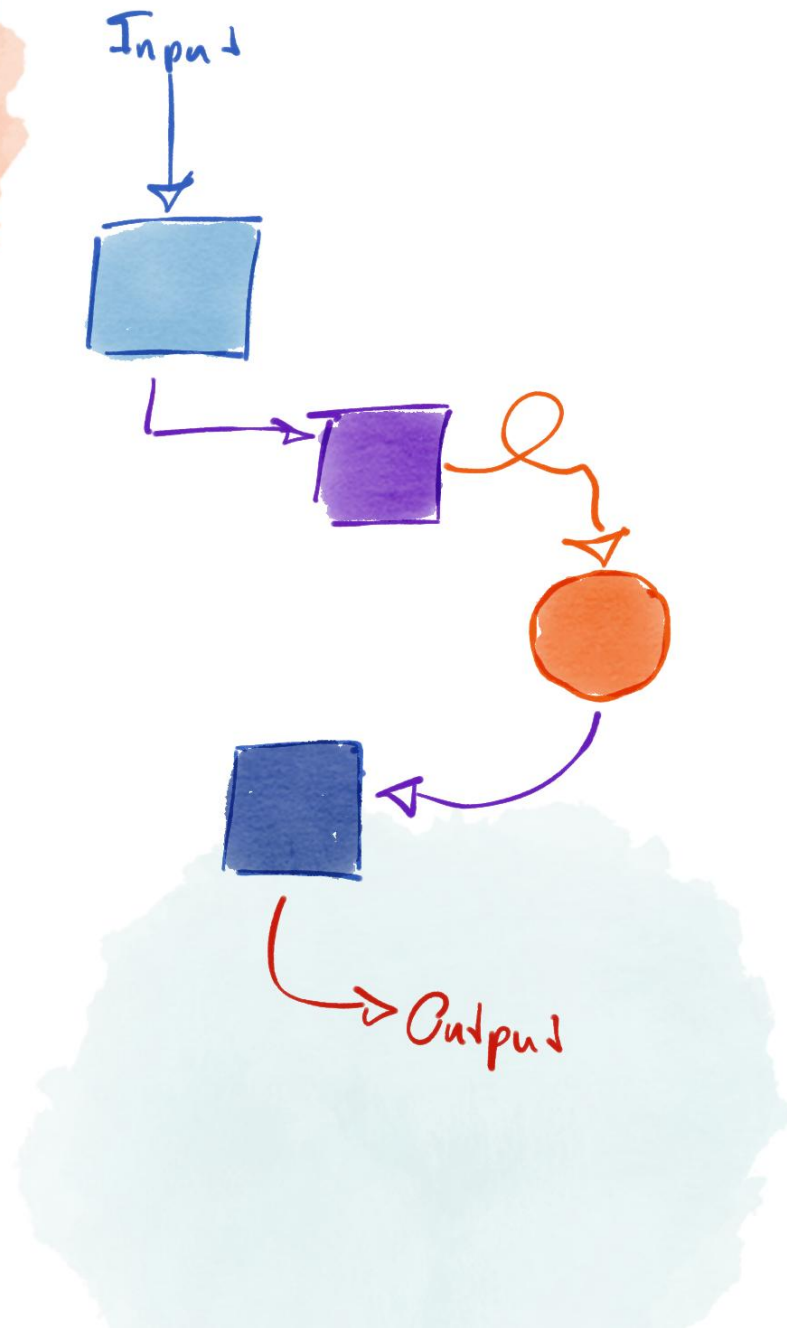
• Does Nature just know better?



What's an Algorithm?



$$f: \{0, 1\}^n \rightarrow \{0, 1\}^n$$



An Example: Unstructured Search



"If I want to find a name in a Yellow pages with no order, what do I do?"

(Query)
Time - Complexity!

$$O(n)$$

vs

$$O(\sqrt{N})$$

An Example: Unstructured Search



"If I want to find a name in a Yellow pages with no order, what do I do?"

(Query)
Time - Complexity!

$$O(n)$$

vs

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Nature's Heuristic to Optimization Problems : Solving the Steiner Tree Problem using a 3D Printer and Soap Films

Author: *Jing Wu (Jack) Lian*

Supervisor: *Toby Walsh, Serge Gaspers*

Research Theme: *Fundamental and Enabling Research*



Background and Motivation

- The Steiner Tree Problem (STP) is to connect cities together using the shortest length of road (Figure 1a)
- NP-Hard problem.
- Applications in circuit layout & network design.
- Can we find solutions with soap bubbles (Figure 1b)?

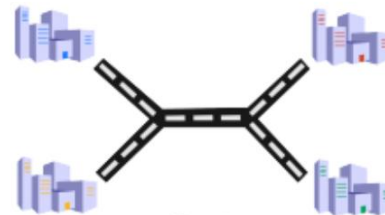


Figure 1a

Aims and Objectives

- To assess the optimality of the bubble's solutions to the Steiner Tree Problem (Figure 1b).
- To compare against traditional computational heuristics (Minimum Spanning Tree, which connects points without road intersections; Steiner Insertion and Incremental Optimization).



Figure 1b

Method

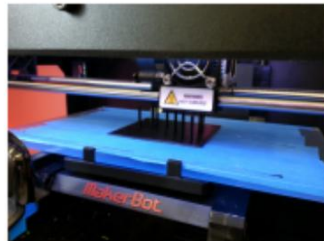


Figure 2a



Figure 2b

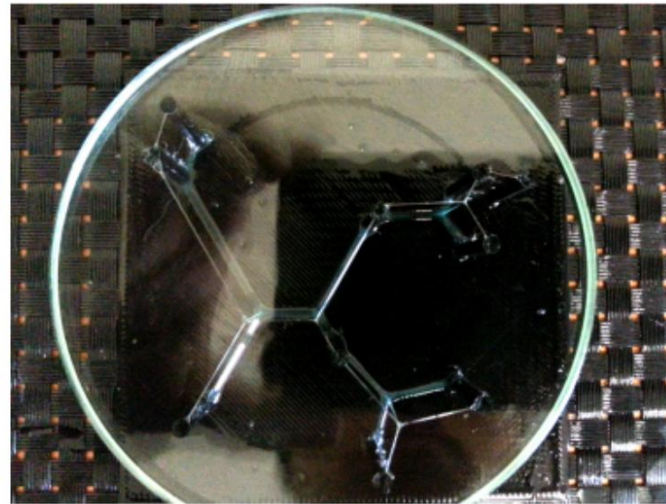


Figure 2c

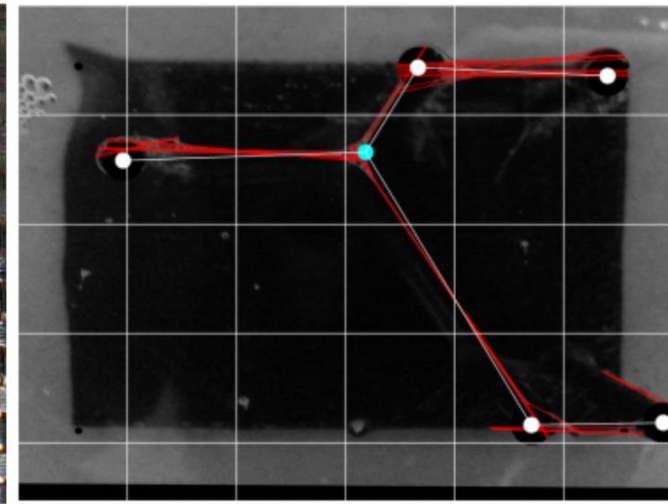


Figure 2d

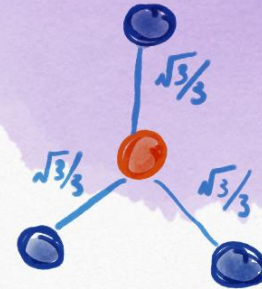
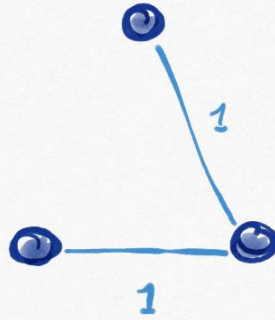
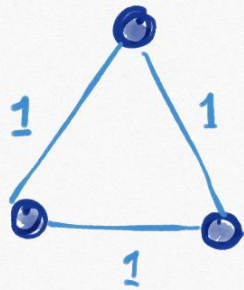
1) We print a 3D model of the graph.

2) We submerge it in a pool of soapy water. When the model is removed, the soap film produce a heuristic solution to the Steiner Tree Problem. We remove it using different angles and select the best solution.

3) We use computer vision to extract the solution and compare it with traditional heuristics.

The Steiner Tree Problem

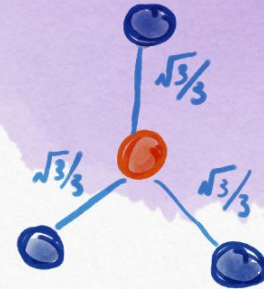
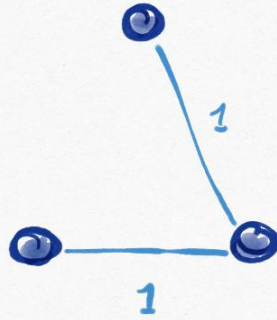
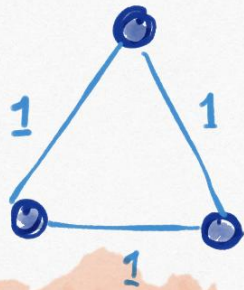
$n=3$



Given a set of points in the plane, find the minimum weight spanning tree connecting those points, such that you're able to add points.

The Steiner Tree Problem

$n=3$

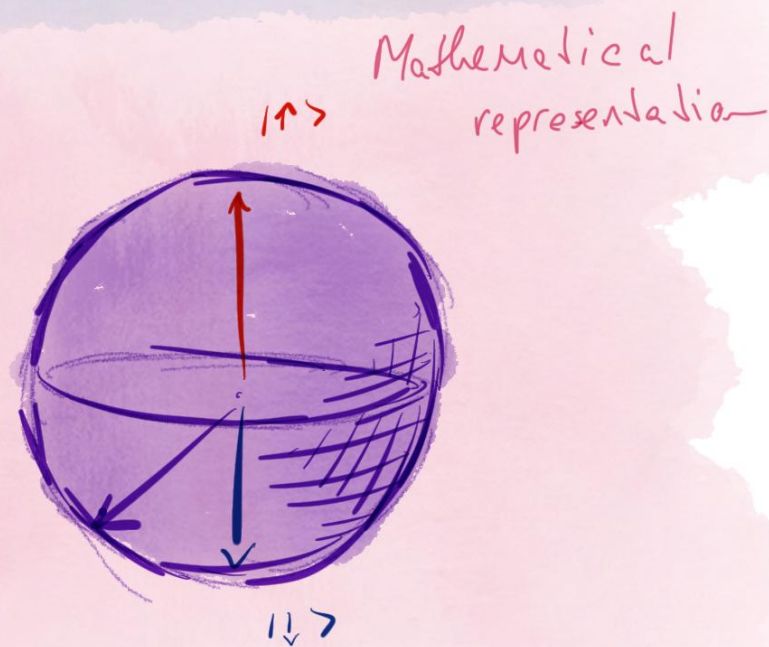
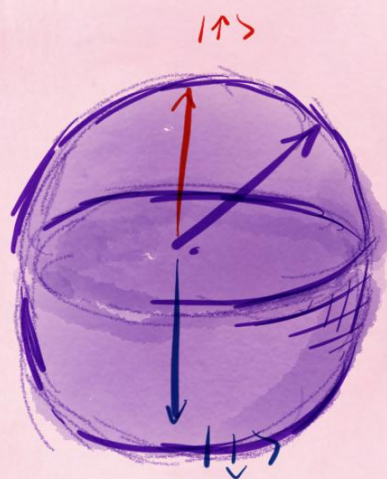
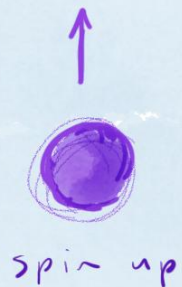


- This problem scales exponentially
 $O(2^{P(n)})$

• NP - Hard

Quantum Entanglement

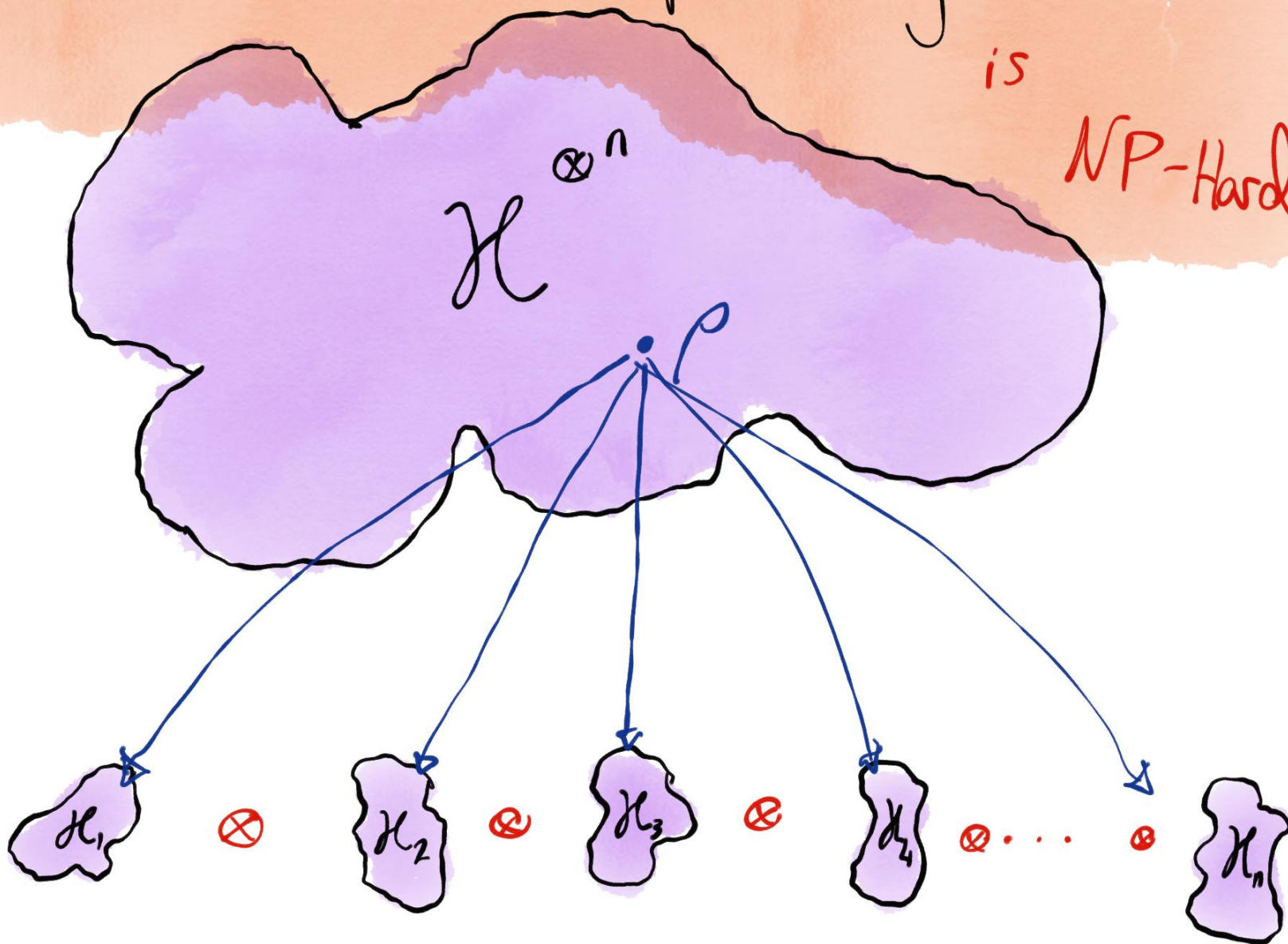
Electromagnetic
Field



The Quantum Separability Problem

is

NP-Hard





Is Nature just
better at this
than we are?