Quantum Computing for Computational Engineering

JARA CSD Panel Discussion

ZEIT ONLINE

Forschungszentrum

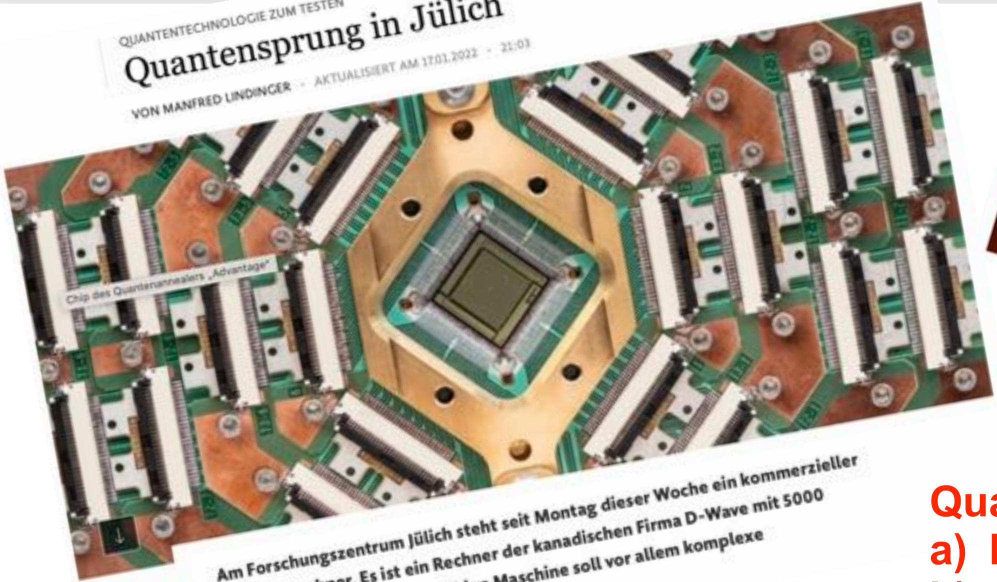
Quantensprung: Start für neuen Computer in Jülich

Aktualisiert am 18. Januar 20…

QUANTENTECHNOLOGIE ZUM TESTEN

Quantensprung in Jülich

VON MANFRED LINDINGER · AKTUALISIERT AM 17.01.2022 · 21:03



Chip des Quantenannealers „Advantage"

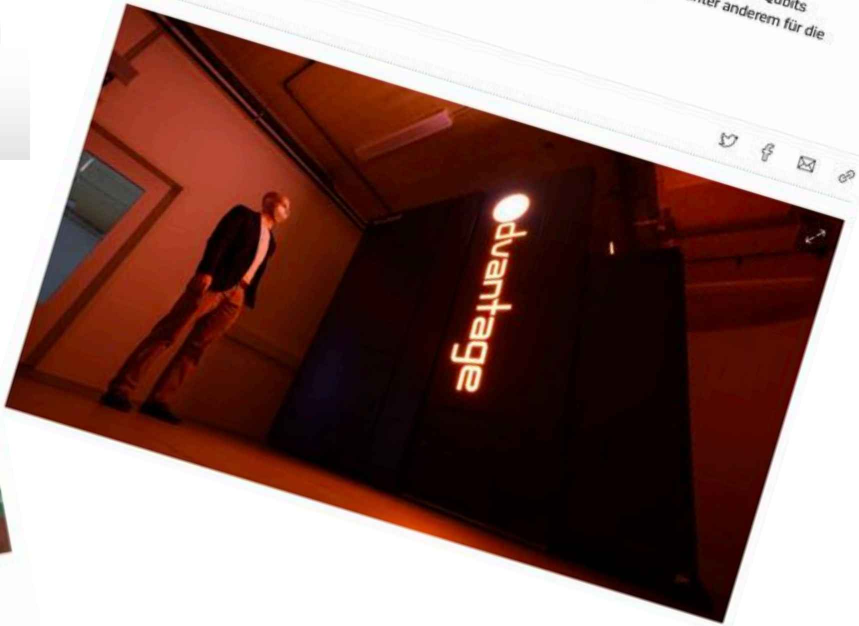
Am Forschungszentrum Jülich steht seit Montag dieser Woche ein kommerzieller Quantenrechner. Es ist ein Rechner der kanadischen Firma D-Wave mit 5000 Quantenbits. Die leistungsfähige Maschine soll vor allem komplexe Optimierungsaufgaben lösen.

Neuer Supercomputer in Betrieb

Quantensprung in Jülich

Am Forschungszentrum Jülich ist der erste Quantencomputer mit mehr als 5000 Qubits außerhalb Nordamerikas in Betrieb. Die komplexe Rechenleistung soll unter anderem für die Klimaforschung genutzt werden.

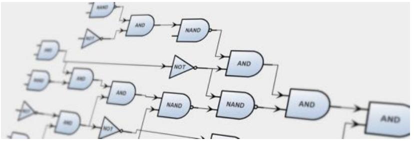
17.01.2022, 17.05 Uhr



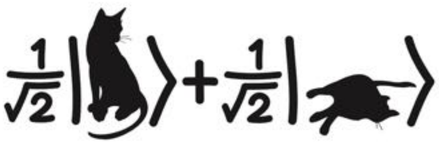
JÜLICH

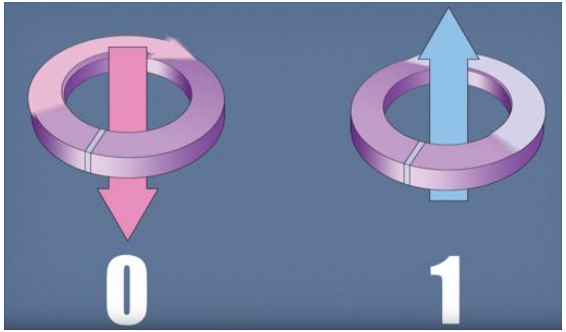
Quantum leap:
a) Revolution of computing?
b) Smallest possible step in nature?

The quantum computing mystery



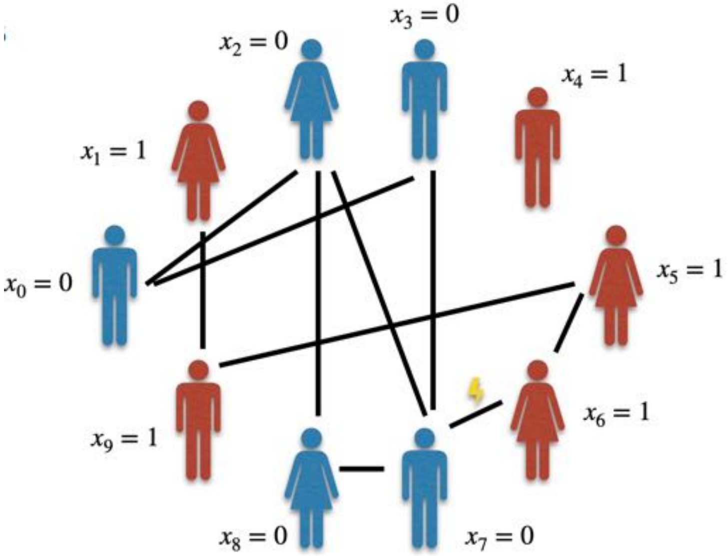
- **Classical computing**: Data stored & processed in **bits**, which are either 0 or 1
- **Quantum computing**: **Qubits** store also superposition states; quantum parallelism treats all states simultaneously





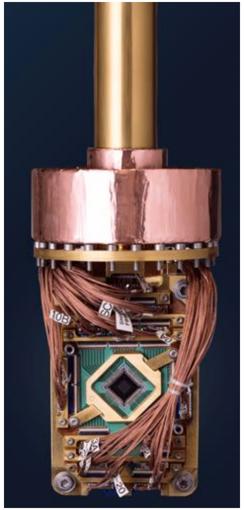
Quantum annealing

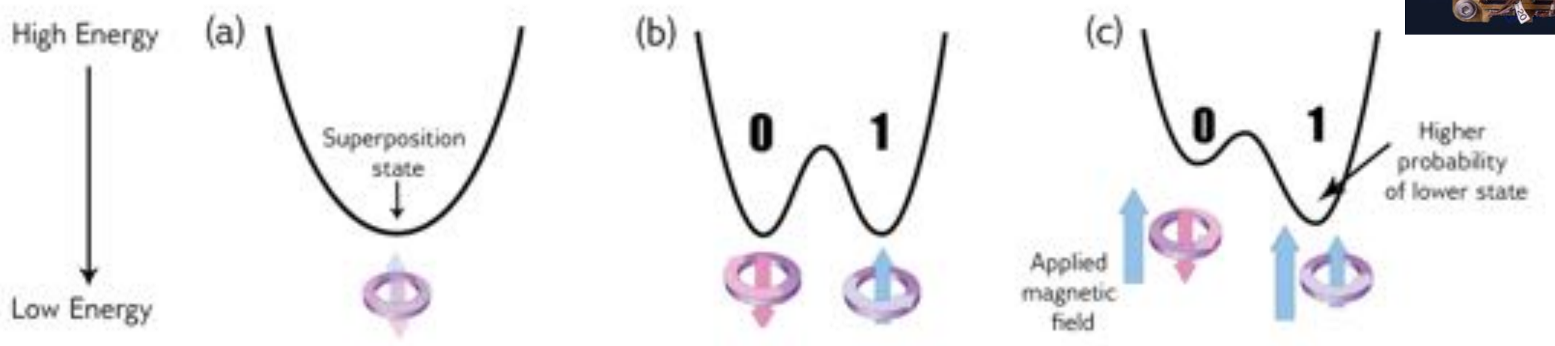
- The D-Wave quantum annealer is not a general purpose quantum computer
- It can solve certain discrete optimisation problems



Quantum annealing

- With **quantum annealers** you initialise the system in a low-energy state and gradually introduce the parameters of a “task” you wish to optimise.
- The Quantum Processing Unit operates at temperatures below 15 mK, and need to be shielded from electromagnetic waves

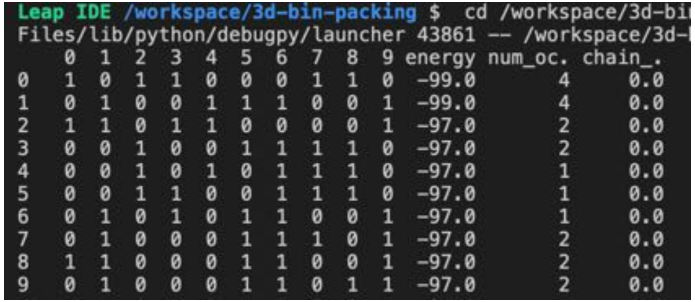




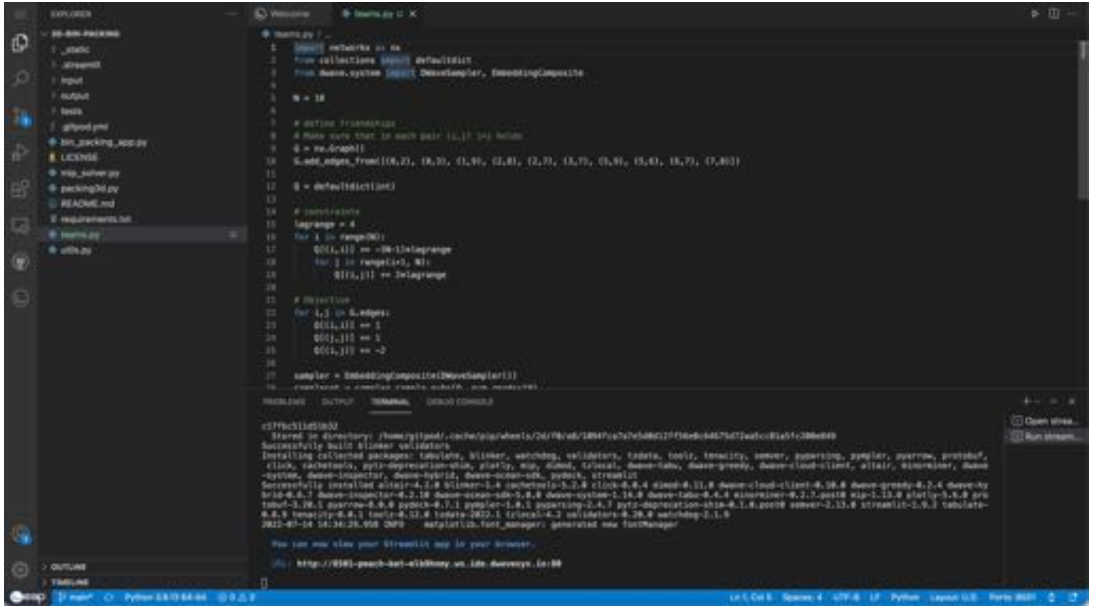
QUBO

- QUBO formulation as **upper triangular NxN matrix *Q***. Minimize

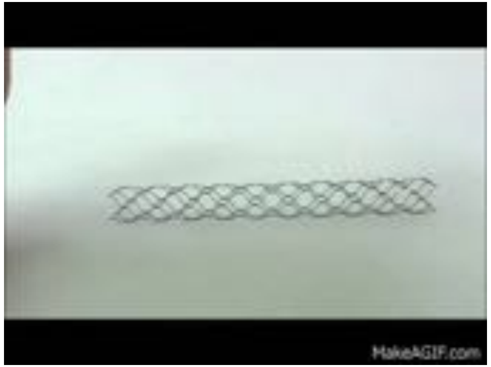
$$E(\{x_i\}) = \sum_i Q_{ii} x_i + \sum_{i<j} Q_{ij} x_i x_j$$

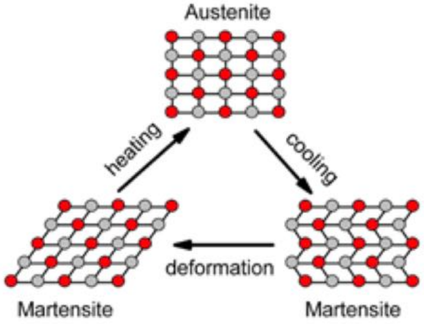


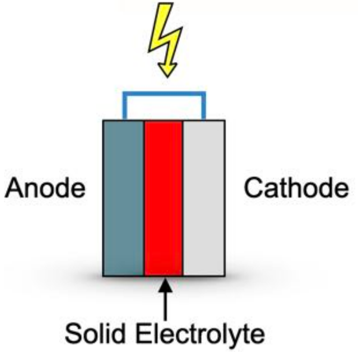
```
Leap IDE /workspace/3d-bin-packing $  cd /workspace/3d-bi
Files/lib/python/debugpy/launcher 43861 -- /workspace/3d-
   0  1  2  3  4  5  6  7  8  9 energy num_oc. chain_.
0  1  0  1  1  0  0  0  1  1  0  -99.0       4    0.0
1  0  1  0  0  1  1  1  0  0  1  -99.0       4    0.0
2  1  1  0  1  1  0  0  0  0  1  -97.0       2    0.0
3  0  0  1  0  0  1  1  1  1  0  -97.0       2    0.0
4  0  0  1  0  1  0  1  1  1  0  -97.0       1    0.0
5  0  0  1  1  0  0  1  1  1  0  -97.0       1    0.0
6  0  1  0  1  0  1  1  0  0  1  -97.0       1    0.0
7  0  1  0  0  0  1  1  1  0  1  -97.0       2    0.0
8  1  1  0  0  0  1  1  0  0  1  -97.0       2    0.0
9  0  1  0  0  0  1  1  0  1  1  -97.0       2    0.0
```



Quantum annealing for materials science







Quantum annealing for microstructures

Step 1: Compute grain-grain interactions (classical)

Step 2: Find optimal variant distribution (quantum)