The future of computing: Quantum

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The future of computing: Quantum

-Our world is quantum mechanical.

-Quantum computers enable novel computations.

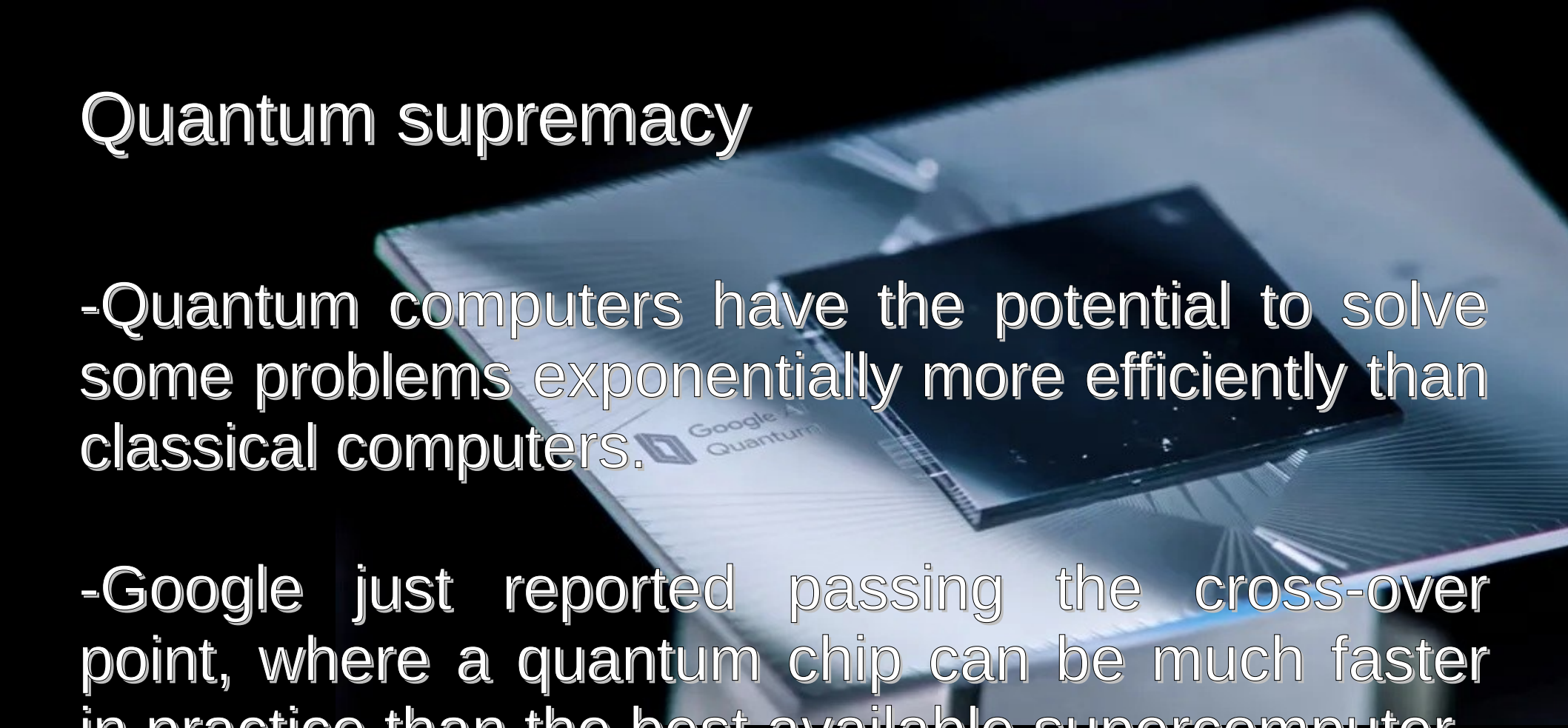
Quantum effects for computing

-Superposition: a qubit can be both 0 and 1 simultaneously (with some amplitudes)

-Interference: computations in superposition can collectively contribute to the final result

-Entanglement: qubits can have stronger than classical correlations

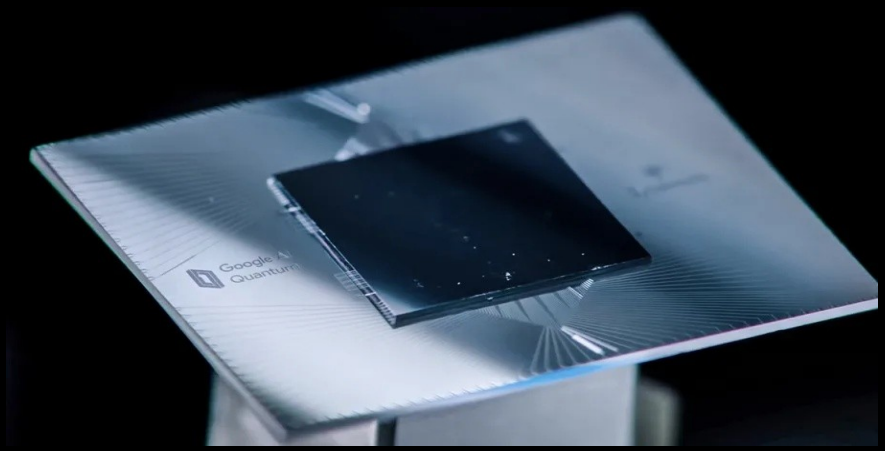
Quantum supremacy



-Quantum computers have the potential to solve some problems exponentially more efficiently than classical computers.

-Google just reported passing the cross-over point, where a quantum chip can be much faster in practice than the best available supercomputer.

Boaz Barak’s analogy (quoted by Scott Aaronson)



vs.

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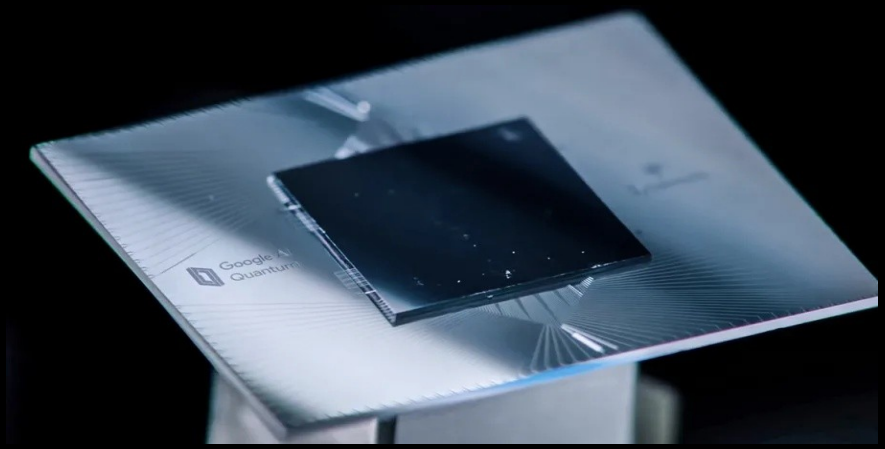


vs.

"Deep Blue vs. Kasparov"

Main techniques for quantum algorithms

-Quantum Fourier transform: Shor's algorithm for factoring, breaking RSA crypto-system, etc.

-Hamiltonian simulation: dynamical simulation of quantum systems for chemistry, material science, etc.

-Grover search: generic quadratic speed-up for unstructured search problems

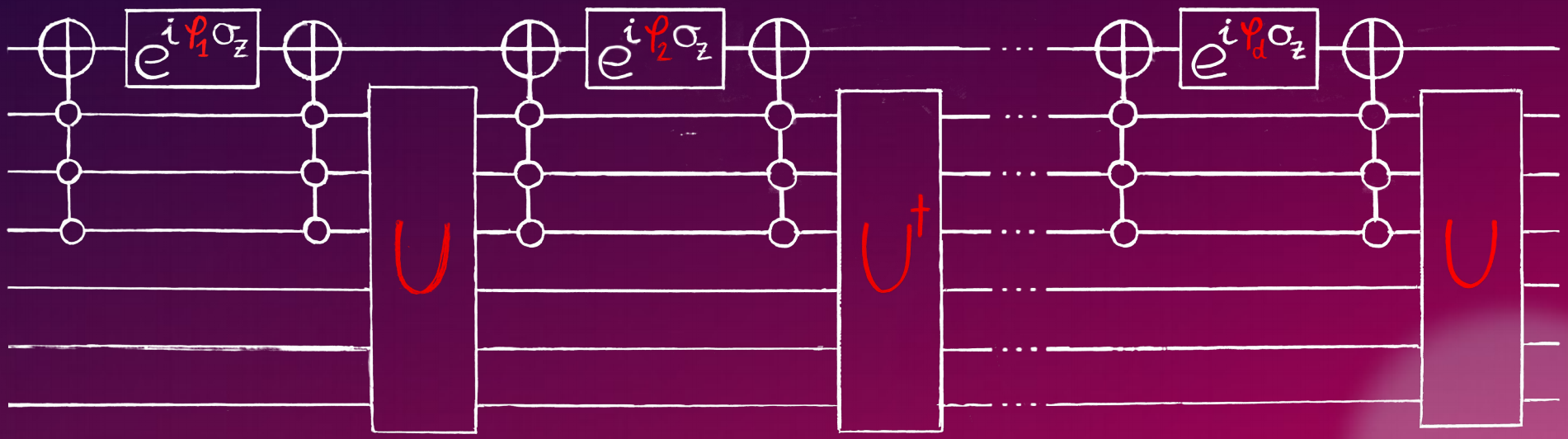
-Large-dimensional regression (HHL algorithm): speeding-up various machine learning applications

Quantum Singular Value transformation

-A common unification / generalization of Hamiltonian simulation, Grover search and regression (HHL).

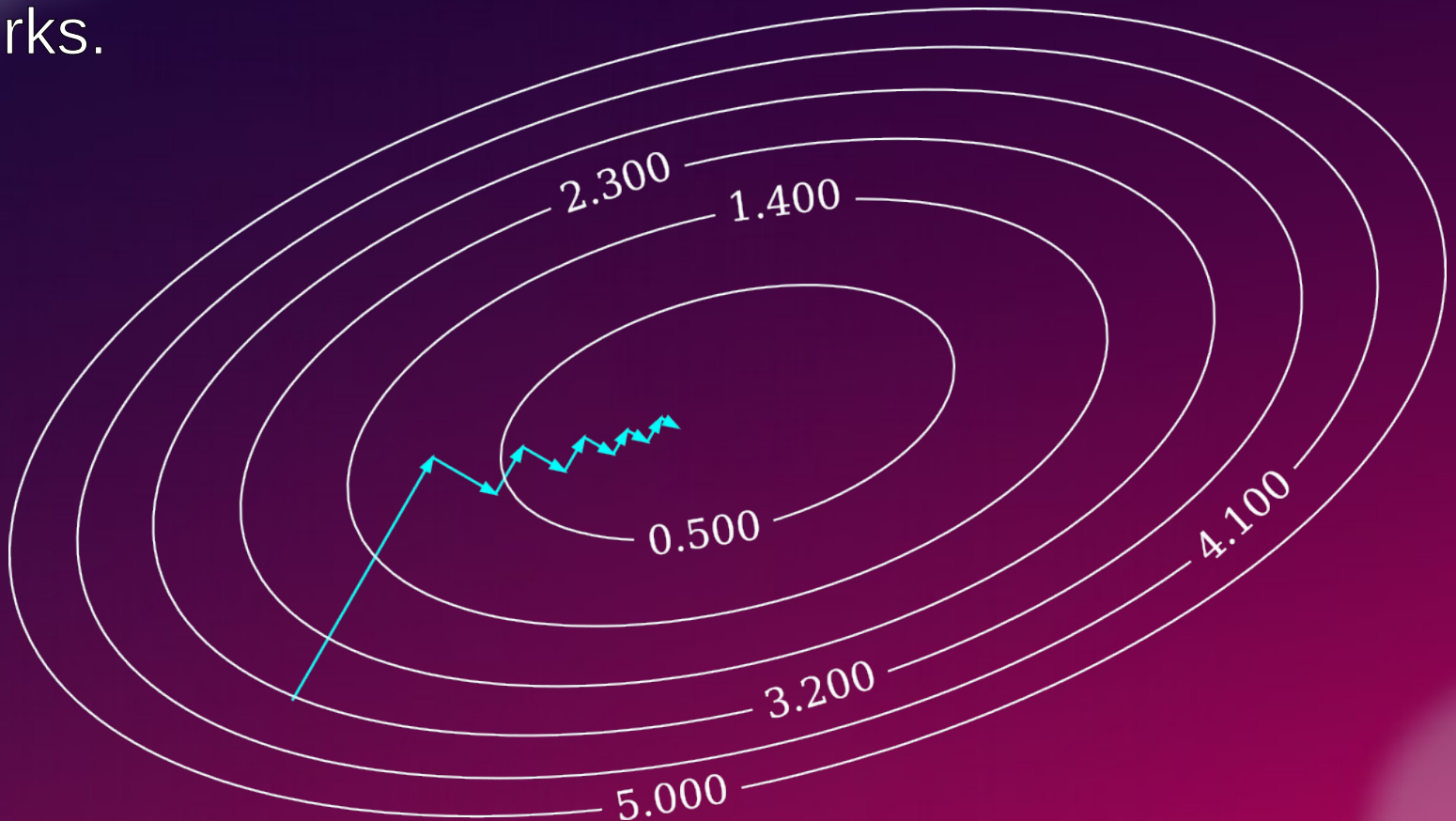
-Block-encodings: exponentially faster matrix operations

-Efficient circuits & near-term applicability



Some applications / other results

-Speeding up gradient computation using quantum computers with applications to variational circuits and quantum neural networks.



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-Efficiently working with the lowest-energy states of some structured Hamiltonians (quantum mechanical systems).

-Using quantum machine learning ideas to speed up classical machine learning tasks.

I would like to thank my wonderful co-authors. Especially, my PhD advisor Ronald de Wolf, for introducing me to these fascinating topics and guiding me throughout my PhD years.

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-Google
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