
QUANTINUUM
Quantum & AI
Ilyas Khan, Founder
Quantinuum

- Quantinuum closed a $300m equity fundraise on 16th Jan, with a pre-money valuation of $5Bn.
- Pre-IPO round anchored by JPMorgan Chase with additional participation from Mitsui & Co, Amgen, and HON. Total capital raised since Quantinuum was formed in November 2021 is ~$625m.

Bloomberg

JPMorgan Leads Investment Valuing Computing Firm at $5 Billion

- Mitsui, Amgen also part of Quantinuum's $300 million round
- Honeywell remains majority owner of quantum computer maker

AXIOS PRO

Exclusive: $300M round values Honeywell quantum computing arm at $5B

crunchbase news

CYBERSECURITY • STARTUPS • VENTURE

Quantinuum Raises $300M At $5B Valuation

Chris Metinko January 16, 2024

MITSUI&CO.

Mitsui to invest in Quantinuum, a leading global quantum computing company, and sign a distributorship agreement for marketing in Japan and Asia-Pacific.

Jan. 17, 2024

$300m raise for Quantinuum at $5bn pre-money valuation creates super-unicorn for Cambridge

16 Jan, 2024

Tony Quested

BUSINESSWEEKLY

QUANTINUUM

LARGEST PLAYER

in integrated quantum hardware and software

>$1.3bn

Invested capital

$5.3bn

Valuation

H-SERIES

World class QCCD, ion trap hardware with industry-leading fidelity and scalability

FULL STACK

Origin™ Building a cyber secure future.
InQuanto™ Quantum chemistry software.
TKET™ Open-source Quantum SDK.
LAMBEQ™ Open-source QNLP SDK.

Global teams in largest quantum markets (USA, UK, Europe, Japan)

>350

Scientists and engineers (of which > 200 PhDs)

>400

Global users of H-Series hardware

>1000

Publications including 200+ peer-reviewed in leading journals

>1.9M

Downloads of TKET

A sophisticated list of long-term partners and clients

J.P.Morgan, bp, equinor, Mitsui & Co., Airbus, Amgen, Honeywell, BMW, TotalEnergies, HESS, Roche, abbvie, Nippon Steel, Thales, Fornetix, Panasonic, Ford, Toyota, JSR, DB

Cloud service partner:
MICROSOFT AZURE QUANTUM

SCIENCE LED.
ENTERPRISE DRIVEN.

- **375+** scientists – the largest concentration of quantum expertise in industry
- **15+** quantum hardware performance world-records
- **80+** patents
- **1000+** publications (200+ peer-reviewed in leading journals)
- **100+** proprietary algorithms and methods

Accelerated quantum computing with an integrated approach

Cybersecurity
Quantum Origin: Enterprise-grade quantum-computing-hardened cryptographic solution

Chemistry
Quantum Chemistry: Transforming the discovery of new materials and novel processes

Quantum AI
Artificial Intelligence: Solving commercial and scientific problems that cannot be solved using today's classical computers

Third party platforms
Enables other partners to leverage the power of quantum via open-source access

TKET High-performance quantum software development kit | Open-source, approaching 2m downloads

Nexus Cloud-hosted quantum computing platform

Microsoft aws Google IBM

H-Series Quantum Computers

Powered by **Honeywell**

OQC IQM IONQ

... and many more

Quantinuum Products Partner / Ecosystem Products

The AI Boom So Far….

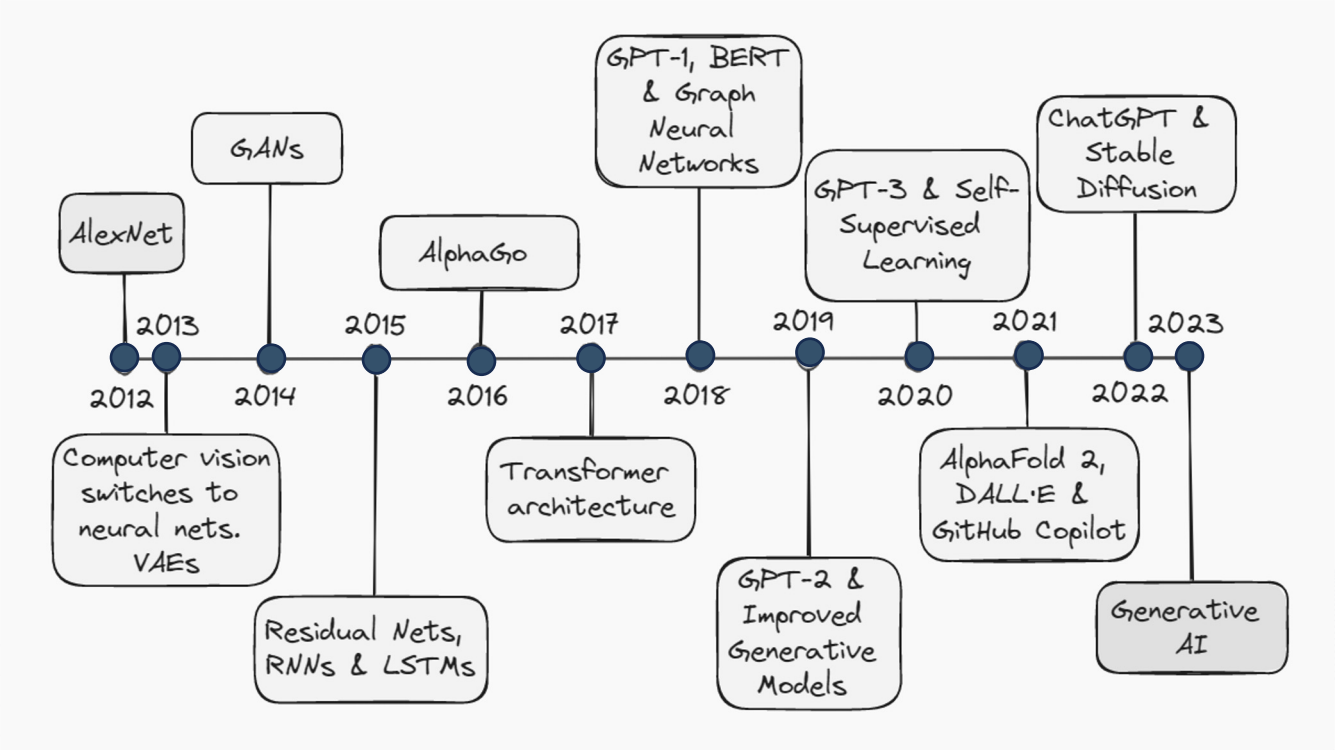


Image by Thomas Dorfer, *Towards Data Science*

The Black Box Problem

"… the dynamic of learning observed in deep neural networks remain much of a **mystery to this day**"

-Yoshua Bengio

Statements that shape opinion

"I think we're moving into a period when, for the first time ever, we may have things more intelligent than us"
-Geoffrey Hinton

Google

OpenAI

"AI will probably most likely lead to the end of the world, but in the meantime, there'll be great companies." *-Sam Altman*

"It may be that today's large neural networks are slightly conscious."
Ilya Sutskever

-

facebook

"Will AI take over the world? No, this is a projection of human nature on machines."
-Yann LeCun

Hype – Conjecture – Rinse and Repeat

Is This the Start of an AI Takeover?

The Atlantic

OpenAI's former top safety researcher says there's a '10 to 20% chance' that the tech will take over with many or most 'humans dead'

FORTUNE

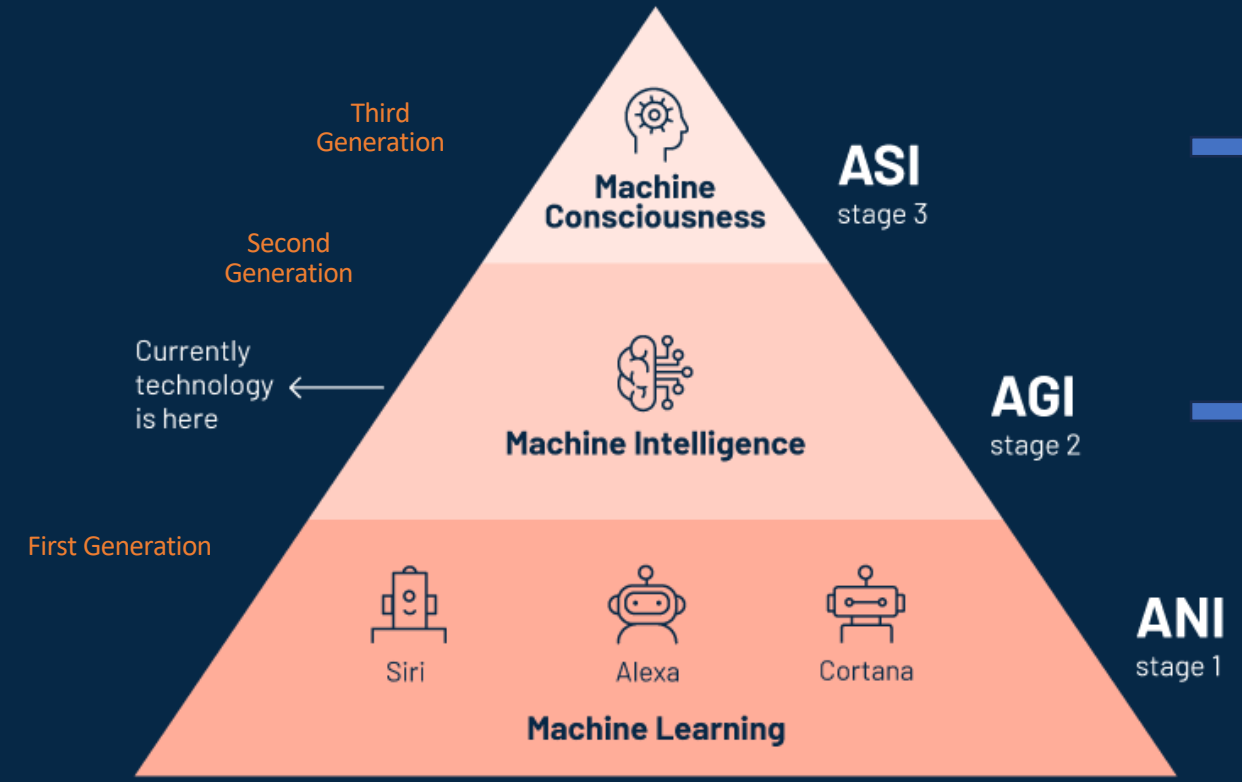
Is the AI apocalypse actually coming? What life could look like if robots take over

The Standard

Will AI Take Over The World? Or Will You Take Charge Of Your World?

Forbes

Stages of Artificial Intelligence



Artificial Super Intelligence

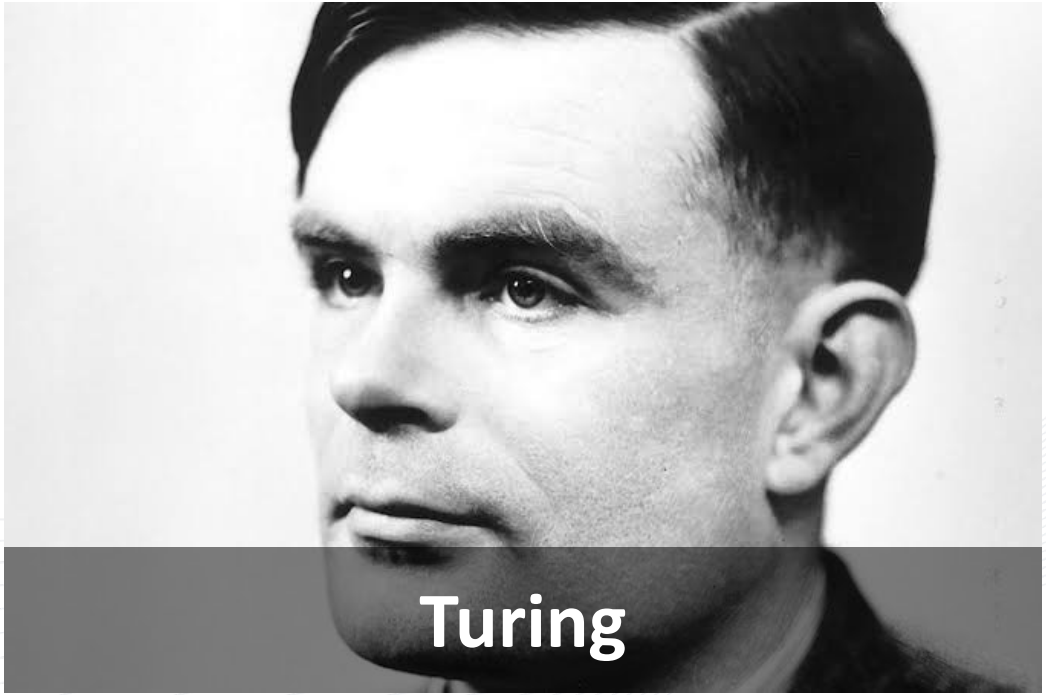
Artificial General Intelligence

Artificial Narrow Intelligence

These issues have been thoroughly reviewed for over 70yrs

"…how many of today's business leaders of AI companies have actually read Turing or Godel;"

- Ed Frenkel



What are the limits of machine intelligence……

WHAT ABOUT QUANTUM AND AI?

- WHAT CHANGES WILL QUANTUM MAKE TO AI? WE ARE STILL IN THE STAGES OF DISCOVERY- THEREFORE ANY JUDGEMENTS ARE PREMATURE
- COMPOSITIONALITY WILL CHANGE THINGS….
- ESPECIALLY WHEN WE BELIEVE LANGUAGE TO BE QUANTUM NATIVE

The future of computing will be hybrid, focusing on the synergy between artificial intelligence and quantum computing (AI <-> QC) to accelerate achieving quantum advantage over current (Classical) state of the art.

Quantum AI

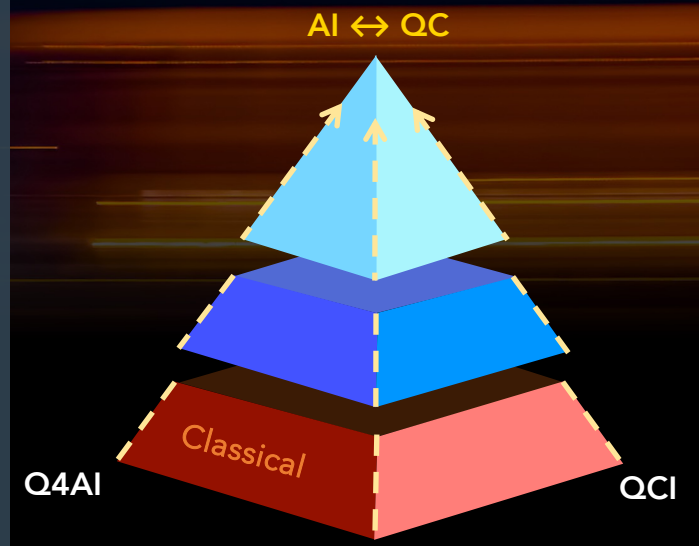
- **Q4AI:** The potential for quantum computers in accelerating AI is an active area of research, both in theory and in practice.
  The advent of Quantum
  Deep Learning – New DL Data for Classical Compute

  Quantum computers will generate data that is unavailable to anyone else in the world

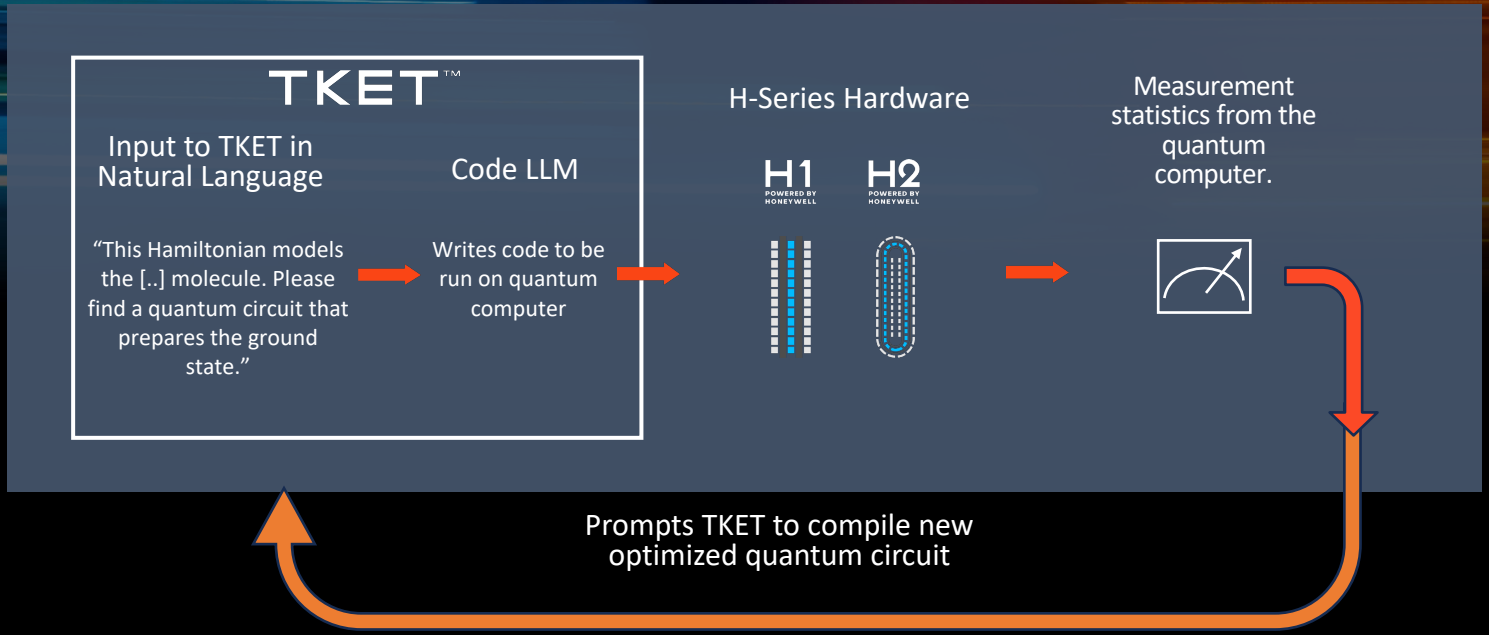
- **AI4Q:** Modern AI methods have the potential to accelerate quantum computing research and application development and to supplement human intuition.

  For example, Autonomous AI Quantum Circuit compilation

- **CI:** Compositional Intelligence provides a high-level model-agnostic framework for Interpretability, enabling the analysis of hybrid quantum-classical AI models.



Autonomous AI with Quantum Oracle



AI4Q: AI for Quantum

DeepMind

Quantum Circuit Optimization with AlphaTensor

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Alexander Novikov[1] Nathan Fitzpatrick[3] Bernardino Romera-Paredes[1]
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Abstract

A key challenge in realizing fault-tolerant quantum computers is circuit optimization. Focusing on the most expensive gates in fault-tolerant quantum computation (namely, the T gates), we address the problem of T-count optimization, i.e., minimizing the number of T gates that are needed to implement a given circuit. To achieve this, we develop AlphaTensor-Quantum, a method based on deep reinforcement learning that exploits the relationship between optimizing T-count and tensor decomposition. Unlike existing methods for T-count optimization, AlphaTensor-Quantum can incorporate domain-specific knowledge about quantum computation and leverage *gadgets*, which significantly reduces the T-count of the optimized circuits. AlphaTensor-Quantum outperforms the existing methods for T-count optimization on a set of arithmetic benchmarks (even when compared without making use of gadgets). Remarkably, it discovers an efficient algorithm akin to Karatsuba's method for multiplication in finite fields. AlphaTensor-Quantum also finds the best human-designed solutions for relevant arithmetic computations used in Shor's algorithm and for quantum chemistry simulation, thus demonstrating it can save hundreds of hours of research by optimizing relevant quantum circuits in a fully automated way.

1 Introduction

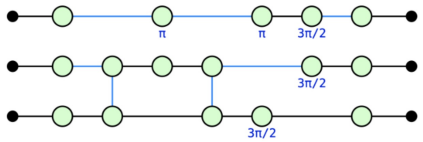
Quantum computation presents a fundamentally new approach to solving computational problems. Since its inception [1, 2], many potential applications in various fields have been proposed, including cryptography [3], drug discovery [4], and materials science and high energy physics [5]. Yet, fault-tolerant quantum computation introduce some expensive components that have a significant impact on the overall runtime and resource cost [6, 7]; thus it is important to minimize the use of these components in order to enable the execution of large computations that address these real-world problems.

*Equal contributors.

In collaboration with **DeepMind**, we reveal a major advancement in quantum computing with Alpha-Tensor Quantum, revolutionizing the optimization of quantum circuits and marking a significant leap forward in computational efficiency

Meta

In collaboration with **META**, we train language models to simplify ZX-diagrams (flexible and expressive representation of quantum circuits), which we represent as **sequences**.



NT0|4P0 NT0|4P0 NT0|4P0 NT1|4P0 NT1|4P0 NT1|4P0 NT1|4P0 NT1|4P0 NT1|4P0 NT1|4P4 NT1|4P0 NT1|4P0
NT1|4P6 NT1|4P4 NT1|4P6 NT1|4P6 NT1|4P0 NT1|4P0 NT1|4P0 NT0|4P0 NT0|4P0 NT0|4P0 NT0|4P0
ET1 ET1 ET1 ET2 ET2 ET1 ET2 ET1 ET1 ET2 ET1 ET2 ET1 ET2 ET1 ET1 ET1 ET2 ET1 ET1 ET1
EP0 EP3 EP1 EP4 EP2 EP5 EP3 EP8 EP4 EP7 EP5 EP6 EP6 EP7 EP6 EP10 EP7 EP9 EP8 EP13 EP9 EP11 EP10
EP11 EP10 EP12 EP11 EP14 EP12 EP18 EP13 EP15 EP14 EP17 EP15 EP16 EP16 EP19 EP17 EP20 EP18 EP21

Breaking the black box of AI with Compositional Intelligence

As AI becomes more regulated, the interpretability of the models used will be under more scrutiny and so there can be real benefits in the future

From Conceptual Spaces to Quantum Concepts: Formalising and Learning Structured Conceptual Models

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6 November 2023

Abstract

In this article we present a new modelling framework for structured concepts using a category-theoretic generalisation of conceptual spaces, and show how the conceptual representations can be learned automatically from data, using two very different instantiations: one classical and one quantum. A contribution of the work is a thorough category-theoretic formalisation of our framework. We claim that the use of category the-

**Using a compositional quantum framework for cognition and AI to demonstrate how concepts like shape, colour, size, and position can be learned by machines –
including quantum computers.**

Quantinuum's World-leading Scientific Research

Constrained quantum optimization for extractive summarization on a trapped-ion quantum computer

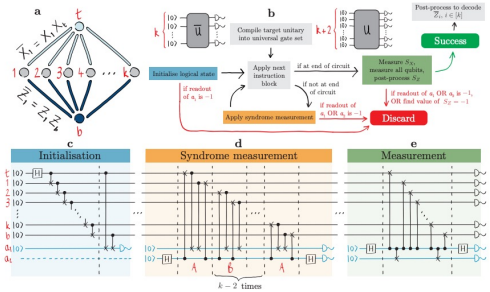
Pradeep Niroula, Ruslan Shaydulin, Romina Yalovetzky, Pierre Minssen, Dylan Herman, Shaohan Hu & Marco Pistoia

nature physics

Article

https://doi.org/10.1038/s41567-023-02282-2

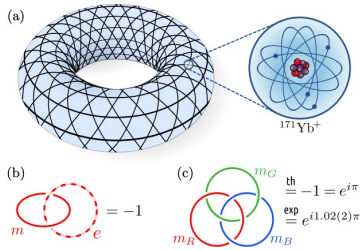
Protecting expressive circuits with a quantum error detection code



NEWS | 09 May 2023

Physicists create long-sought topological quantum states

Exotic particles called nonabelions could fix quantum computers' error problem.



PHYSICAL REVIEW X **13,** 041057 (2023)

Qubit-Reuse Compilation with Mid-Circuit Measurement and Reset

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HARDWARE > QUANTUM | July 13, 2023

Quantinuum builds fault-tolerant logical qubits

The breakthrough opens a new era of fault tolerant quantum computing that could make tasks such as simulating molecules and materials faster.

By Ryan Morrison

QUANTINUUM × Microsoft

Researchers from Quantinuum and Microsoft have built the quantum programming tools for real-time

magic state distillation on a quantum computer

Airbus, Quantinuum, and BMW collaborate on fuel cell research with quantum computers

The three partners report accurately modeling the oxygen reduction reaction on the surface of a platinum-based catalyst.

Aug. 4, 2023

Quantum Physics

[Submitted on 29 Jun 2023 (v1), last revised 8 Sep 2023 (this version, v2)]

Demonstrating Bayesian Quantum Phase Estimation with Quantum Error Detection

Kentaro Yamamoto, Samuel Duffield, Yuta Kikuchi, David Muñoz Ramo

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