Karlsruhe Institute of Technology

(Recent Advances in) Responsible Quantum Technologies

20.06.2024

Zeki C. Seskir

Karlsruhe Institute of Technology (KIT)

Institute for Technology Assessment and Systems Analysis (ITAS)

itas Institute for Technology Assessment and Systems Analysis

Outline

- Introduction: ITAS and QuTec
- Responsible (and Irresponsible) Tech. Development
- Responsible QT Efforts (by others)
- Collingridge Dilemma, Path-dependency, and TEP
- Social acceptance and understanding of QT
- Concluding Remarks

Email: zeki.seskir@kit.edu

LinkedIn: *Zeki Seskir*

Disclaimer: Technology Assessment in English/German

Institute for Technology Assessment and Systems Analysis

Institut für Technikfolgenabschätzung und Systemanalyse (ITAS)

intended and unintended consequences & acceptability of future technological developments

TAB

OFFICE OF TECHNOLOGY ASSESSMENT
AT THE GERMAN BUNDESTAG

QuTec: Quantum Technology Innovations for Society

Project team:
Coenen, Christopher (Project leader); Zeki Seskir (Project coordination), Adrian Schmidt

Start date: 2021

End date: 2025

Research group: Life, Innovation, Health, and Technology

Three main topics:

Landscaping of the QT Ecosystem(s)

Education and Outreach Research in QT

Concept Exploration and Operationalization for ELSA Research on QT

The European Physical Journal

EPJ Quantum Technology

Latest article collections

Quantum Industry

Edited by: Thomas Strohm

Research | Open access | Published: 18 October 2022

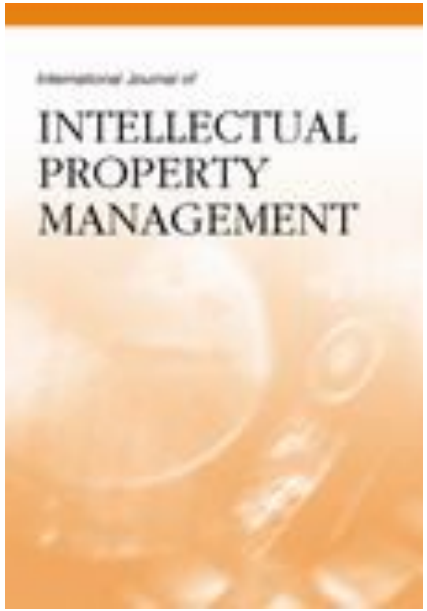
The landscape of the quantum start-up ecosystem

Zeki Can Seskir, Ramis Korkmaz & Arsev Umur Aydinoglu

EPJ Quantum Technology **9**, Article number: 27 (2022) | Cite this article

Abstract

The second quantum revolution has been producing groundbreaking scientific and technological outputs since the early 2000s; however, the scientific literature on the impact of this revolution on the industry, specifically on start-ups, is limited. In this paper, we present a landscaping study with a gathered dataset of 441 companies from 42 countries that we identify as quantum start-ups, meaning that they mainly focus on quantum technologies (QT) as their primary priority business. We answer the following questions: (1) What are the temporal and geographical distributions of the quantum start-ups? (2) How can we categorize them, and how are these categories populated? (3) Are there any patterns that we can derive from empirical data on trends? We found that more than 92% of these companies have been founded within the last 10 years, and more than 50% of them are located in the US, the UK, and Canada. We categorized the QT start-ups into six fields: (i) complementary technologies, (ii) quantum computing (hardware), (iii) quantum computing



Global innovation and competition in quantum technology, viewed through the lens of patents and artificial intelligence

Zeki Can Seskir

Institute for Technology Assessment and Systems Analysis,
Karlsruhe Institute of Technology,
Karlstraße 11, 76133 Karlsruhe, Germany
Email: zeki.seskir@kit.edu

Kelvin W. Willoughby*

Deutsche Bank Chair of Innovation Management and Entrepreneurship,
HHL Leipzig Graduate School of Management,
Jahnallee 59, 04109 Leipzig, Germany
Email: k.willoughby@hhl.de
*Corresponding author

Keywords: *quantum technology; quantum innovation; patent analysis; artificial intelligence; patent landscape; patinformatics; global technological innovation; quantum competition; quantum industry.*
DOI: 10.1504/IJIPM.2021.10044326

1 July 2022

Quantum games and interactive tools for quantum technologies outreach and education

Zeki C. Seskir, Piotr Migdał, Carrie Weidner, Aditya Anupam, Nicky Case, Noah Davis, Chiara Decaroli, İlke Ercan, Caterina Foti, Paweł Gora, Klementyna Jankiewicz, Brian R. La Cour, Jorge Yago Malo, Sabrina Maniscalco, Azad Naeemi, Laurentiu Nita, Nassim Parvin, Fabio Scafirimuto, Jacob F. Sherson, Elif Surer, James R. Wootton, Lia Yeh, Olga Zabello, Marilù Chiofalo

Author Affiliations +

Optical Engineering, Vol. 61, Issue 8, 081809 (July 2022). https://doi.org/10.1117/1.OE.61.8.081809

Abstract

We provide an extensive overview of a wide range of quantum games and interactive tools that have been employed by the quantum community in recent years. We present selected tools as described by their developers, including “Hello Quantum, Hello Qiskit, Particle in a Box, Psi and Delta, QPlayLearn, Virtual Lab by Quantum Flytrap, Quantum Odyssey, ScienceAtHome, and the Virtual Quantum Optics Laboratory.” In addition, we present events for quantum game development: hackathons, game jams, and semester projects. Furthermore, we discuss the Quantum Technologies Education for Everyone (QUTE4E) pilot project, which illustrates an effective integration of these interactive tools with quantum outreach and education activities. Finally, we aim at providing guidelines for incorporating quantum games and interactive tools in pedagogic materials to make quantum technologies more accessible for a wider population.

EUROPEAN JOURNAL OF STEM EDUCATION

European Journal of STEM Education, 2024, 9(1), 03
ISSN: 2468-4368

lectito

Educating to the "Culture" of Quantum Technologies: A Survey Study on Concepts for Public Awareness

Zeki Can Seskir [1]*, Simon Richard Goorney [2,3], Maria Luisa Chiofalo [4]

[1] *Karlsruhe Institute of Technology*, GERMANY
[2] *Aarhus University*, DENMARK
[3] *Niels Bohr Institute, Copenhagen University*, DENMARK
[4] *University of Pisa*, ITALY

***Corresponding Author:** zeki.seskir@kit.edu

Citation: Seskir, Z. C., Goorney, S. R. and Chiofalo, M. L. (2024). Educating to the "Culture" of Quantum Technologies: A Survey Study on Concepts for Public Awareness. *European Journal of STEM Education*, 9(1), 03. https://doi.org/10.20897/ejsteme/14193

Published: February 10, 2024

IOP Publishing

Quantum Sci. Technol. **8** (2023) 024005

Quantum Science and Technology

Karlsruhe Institute of Technology

TU Delft

CrossMark

OPEN ACCESS

RECEIVED
6 August 2022

REVISED
12 January 2023

ACCEPTED FOR PUBLICATION
27 January 2023

PUBLISHED
7 February 2023

PAPER

Democratization of quantum technologies

Zeki C Seskir[1], **Steven Umbrello**[2,*], **Christopher Coenen**[1] **and Pieter E Vermaas**[2]

[1] Karlsruhe Institute of Technology, Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe, Germany
[2] Department of Values, Technology, & Innovation, School of Technology, Policy & Management, Delft University of Technology, Delft, The Netherlands
[*] Author to whom any correspondence should be addressed.

E-mail: S.Umbrello@tudelft.nl

Keywords: democratization, quantum technologies, quantum computing, theories of democracy

IET The Institution of Engineering and Technology

IET Quantum Communication

Vol 4 Issue 1 2023 ISSN: 2632-8925

wileyonlinelibrary.com/iet-qtc
Published by The Institution of Engineering and Technology

OPEN ACCESS

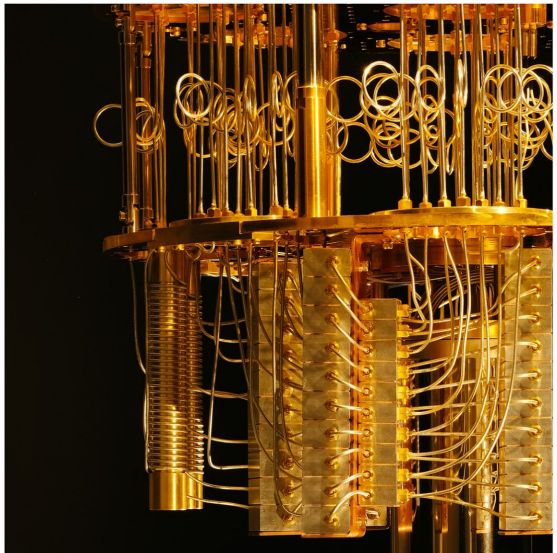
Building a quantum-ready ecosystem

Abhishek Purohit[1,4], Maninder Kaur[1], Zeki Can Seskir[2], Matthew T. Posner[3] and Araceli Venegas-Gomez[1]

[1] *QURECA (Quantum Resources and Careers), Glasgow, Scotland, United Kingdom*
[2] *Institute for Technology Assessment and Systems Analysis, KIT, Karlstraße 11, Karlsruhe, Germany*
[3] *Optonique, Québec, Canada*
[4] *James Watt School of Engineering, Electronics and Nanoscale Engineering Division, University of Glasgow, Glasgow, United Kingdom*

Abstract— The emergence of quantum technologies has led to groundbreaking advancements in computing, sensing, secure communications, and simulation of advanced materials with practical applications in every industry sector. The rapid advancement of the quantum technologies ecosystem has made it imperative to assess the maturity of these technologies and their imminent acceleration towards commercial viability. In this paper, we present the current status of quantum technologies and emphasise the need for a quantum-ready ecosystem. We formulated standard Quantum Technology Readiness Levels (QTRLs) using innovative models and tools to evaluate the readiness of specific quantum technology accurately. We also discuss relevant indicators concerning the key stakeholders, including government, industry, academia or ethics and protocols board in the ecosystem, to deepen our understanding of the readiness of quantum technology and support the development of a robust and effective quantum ecosystem.

Keywords— Quantum Technologies, Quantum Computing, Quantum Communications, Quantum Strategy, Quantum-ready, Readiness indicators, Workforce Development



RESPONSIBLE QUANTUM TECHNOLOGIES

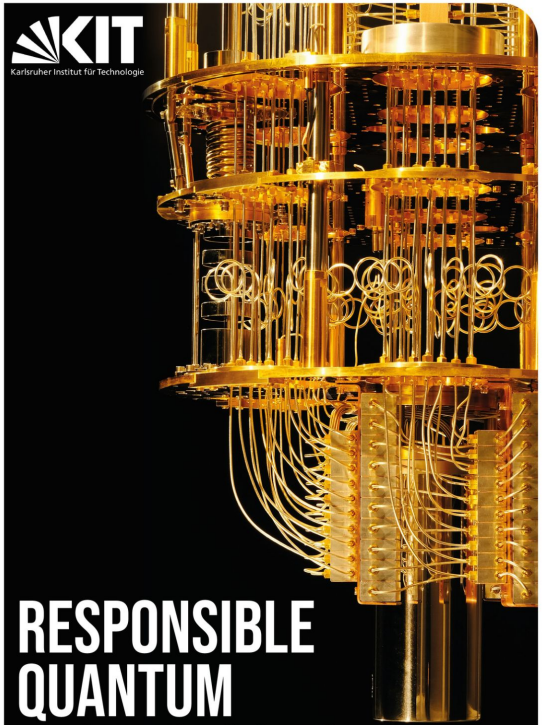
Online Symposium
9th December 2021, 15:00

Karlsruhe Institute of Technology

itas

QUANTUM FLAGSHIP

QUANTUM FOR YOU QUTE4E



KIT Karlsruher Institut für Technologie

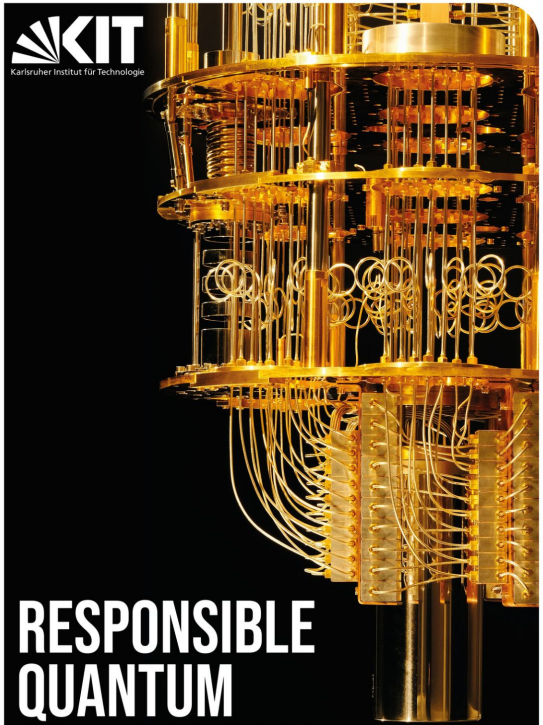
RESPONSIBLE QUANTUM TECHNOLOGIES

Workshop, 6-7 December, Karlsruhe

QUANTUM FLAGSHIP

itas Institute for Technology Assessment and Systems Analysis

KIT – Die Forschungsuniversität in der Helmholtz-Gemeinschaft www.kit.edu



KIT Karlsruher Institut für Technologie

RESPONSIBLE QUANTUM TECHNOLOGIES

Workshop, 27-28 July, Karlsruhe

itas Institute for Technology Assessment and Systems Analysis

KIT – Die Forschungsuniversität in der Helmholtz-Gemeinschaft www.kit.edu

limits/risks
potential
damage

profit
potential
benefit

“Environmentalists”
More worried, than happy
Innovations should only introduced to market, if no potential damage is known

responsible technology development
potential advantages but also possible restrictions and risks are considered (CTA/SA)
“ridge walk”

“Technology enthusiast”
Don’t worry, be happy
Innovations must be pushed, possible damage will be managed


MOVE
FAST AND
BREAK
THINGS


Mr. Mark Zuckerberg
Canon


Cambridge
Analytica
facebook

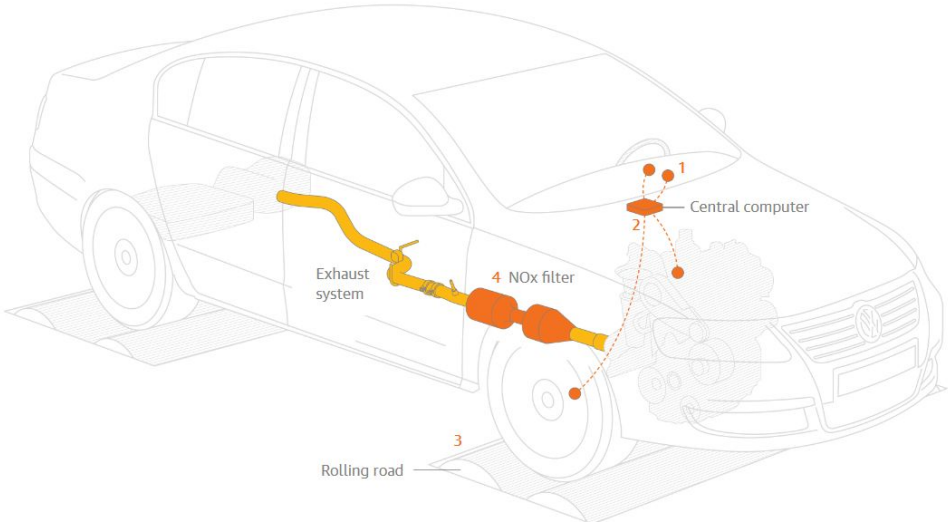
The Boeing 737 MAX's Achilles Heel

January 7, 2020 By Nagesh Belludi

Two thousand nineteen was one of the most turbulent years in Boeing's history. Its 737 MACS (pardon the pun) troubles went from bad to worse to staggering when aviation regulators around the world grounded the aircraft and a steady trickle of disclosures increasingly exposed software problems and corners being cut.

The flaw in this aircraft, its anti-stall mechanism that relied on data from a single sensor, offers a particularly instructive case study of the notion of **single point of failure**.

The accidents and grounding cost Boeing an estimated $20 billion in fines, compensation, and legal fees, with indirect losses of more than $60 billion from 1,200 cancelled orders. The MAX resumed commercial flights in the U.S. in December 2020, and was recertified in Europe and Canada by January 2021.



#Dieselgate

As of 1 June 2020, the scandal had cost VW $33.3 billion in fines, penalties, financial settlements and buyback costs.

Wikipedia
https://en.wikipedia.org › wiki › Volkswagen_emissions...

Volkswagen emissions scandal - Wikipedia

Market Summary > **Meta Platforms Inc**

509.58 USD

+471.35 (1,232.93%) ↑ all time

Follow

Closed: Mar 25, 08:24 EDT • Disclaimer

Pre-market 505.80 −3.78 (0.74%)

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max

Market Summary > **Boeing Co**

188.85 USD

+183.20 (3,242.48%) ↑ all time

Follow

Closed: Mar 25, 08:27 EDT • Disclaimer

Pre-market 194.20 +5.35 (2.83%)

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max

Market Summary > **VOLKSWAGEN GROUP Common Stock**

118.50 EUR

+99.90 (537.10%) ↑ all time

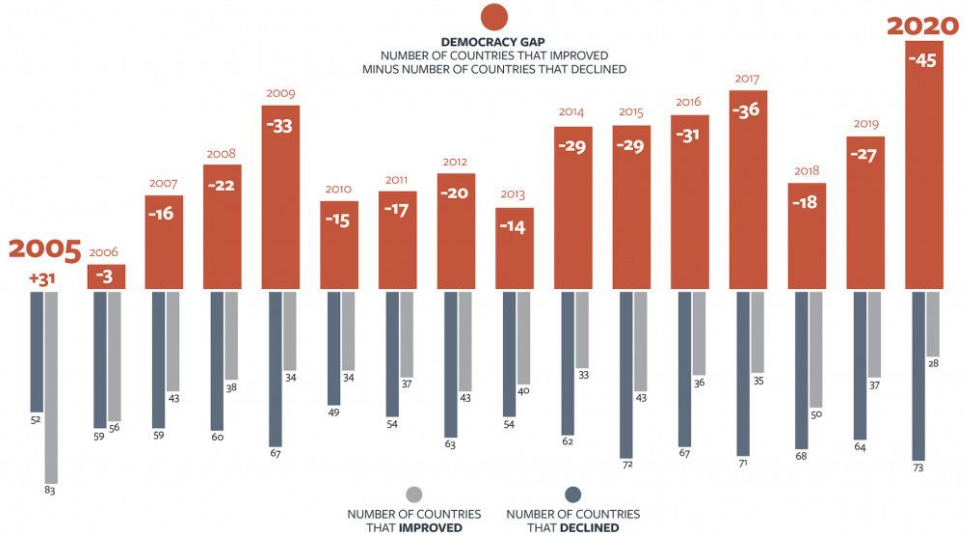
Follow

Mar 25, 13:15 GMT+1 • Disclaimer

1D | 5D | 1M | 6M | YTD | 1Y | 5Y | Max

A Growing Democracy Gap: 15 Years of Decline

Countries with aggregate score declines in *Freedom in the World* have outnumbered those with gains every year for the past 15 years.



Freedom House

For past editions of *Freedom in the World* and more information on the report methodology, visit freedomhouse.org
This infographic is from the *Freedom in the World 2021* report by freedomhouse.org

Is technology good or bad for society?

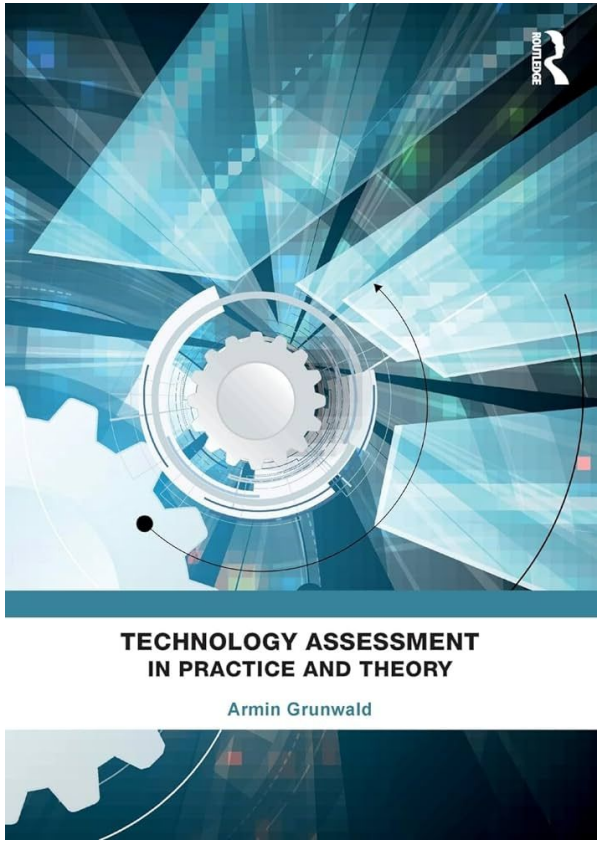
vs.

Consequences of Technology

Between:

- intended and unintended effects
- desired and undesired consequences
- main and side effects
- expected and unexpected effects

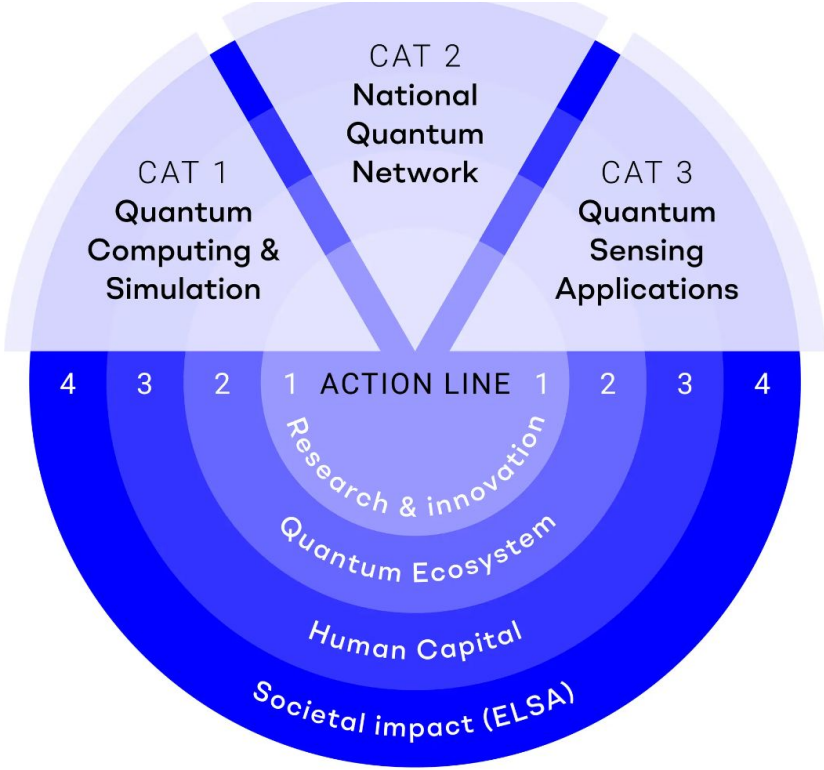
- direct and indirect stakeholders



Exploratory Quantum Technology Assessment

Direct the impact of Quantum Technology

Quantum Delta
the Netherlands



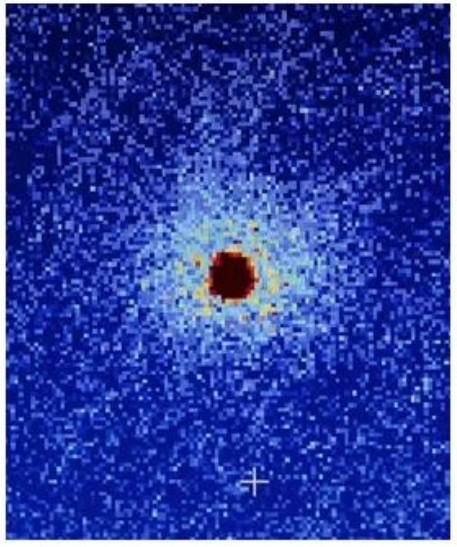

Quantum Delta NL
Centre for Quantum & Society
Home
Hubs
What we do
Welcome to the Centre for Quantum and Society
The world's first knowledge and co-creation centre focusing on applying quantum technologies for the benefit of society.

Innsbruck Quantum Ethics Lab

University of Innsbruck adds ethics think tank to award-winning quantum physics program

Innsbruck is a leading center in the development of new quantum technologies. In order to understand the processes of societal change triggered by these technologies and to be able to develop corresponding ethics frameworks, the University of Innsbruck is founding today the Innsbruck Quantum Ethics Lab (IQEL), in which experts from various disciplines will work together.

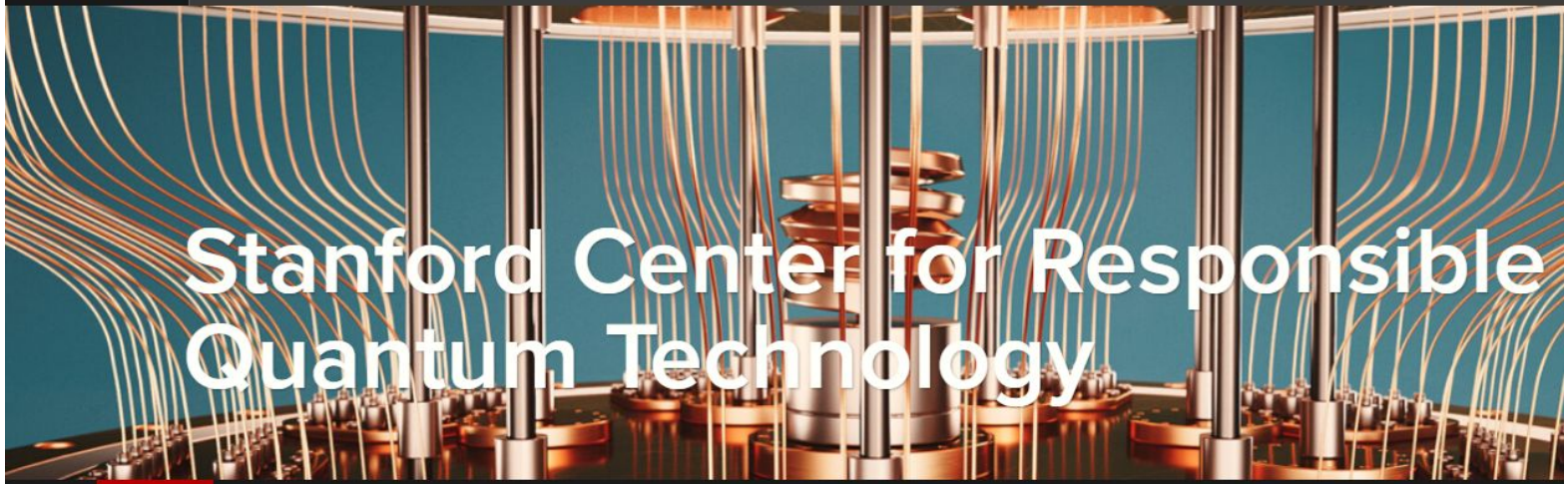
The innovation potential associated with quantum technologies can trigger processes of social change. For this reason, new technical developments must always be scrutinized for their effects on people and society and founded on ethics. At the same time, the freedom to innovate must be preserved.



© Dominik Pfeifer

"The innovation potential associated with quantum technologies can trigger processes of social change. For this reason, new technical developments must always be scrutinized for their effects on people and society and founded on ethics. At the same time, the freedom to innovate must be preserved. "In this area of tension, the Innsbruck Quantum Ethics Lab (aims to create added value for society."

Prof. Dr. Matthias C. Kettemann, IQEL director and head of the Department of Legal Theory and Future of Law



Stanford Center for Responsible Quantum Technology

A new cycle of technology governance has begun. The Stanford Center for Responsible Quantum Technology brings together the quantum community in diverse, multidisciplinary settings to investigate how society should balance maximizing benefits and mitigating risks of an exciting new generation of applied quantum technologies in computation, sensing, simulation, cryptography, communication, materials & devices, and quantum-classical hybrid approaches, taking a pro-innovation stance. Our annual highlight is the Stanford Responsible Quantum Technology Conference. The Center is founded by Mauritz Kop, and is part of the Stanford Program in Law, Science & Technology.

Transatlantic Quantum Forum

The Transatlantic Quantum Forum has been the first of many events organized with the TUM Think Tank. On the 16th and 17th of September 2022, we hosted the Transatlantic Quantum Forum simultaneously at New Haven, Los Angeles, and Munich. The TQF has been a joint initiative of four research centers in the U.S. and Europe: The Center for Quantum Networks at the University of Arizona, the UCLA Institute for Technology, Law & Policy, the Yale Information Society Project, and the Quantum Social Lab at the TUM School of Social Sciences and Technology hosting the European site in collaboration with the TUM Think Tank.

The goal of the Transatlantic Quantum Forum (TQF) has been to explore (potential) policy implications and different future scenarios concerning quantum technologies. During two days, researchers, students, and professionals discussed possible limitations and solutions across the globe within other formats. Below you will find impressions and some blog posts summarising the different workshops in Munich, the coordinated panel discussions, and some images of the event.

Quantum Science and Technology

PAPER • OPEN ACCESS

Ten principles for responsible quantum innovation

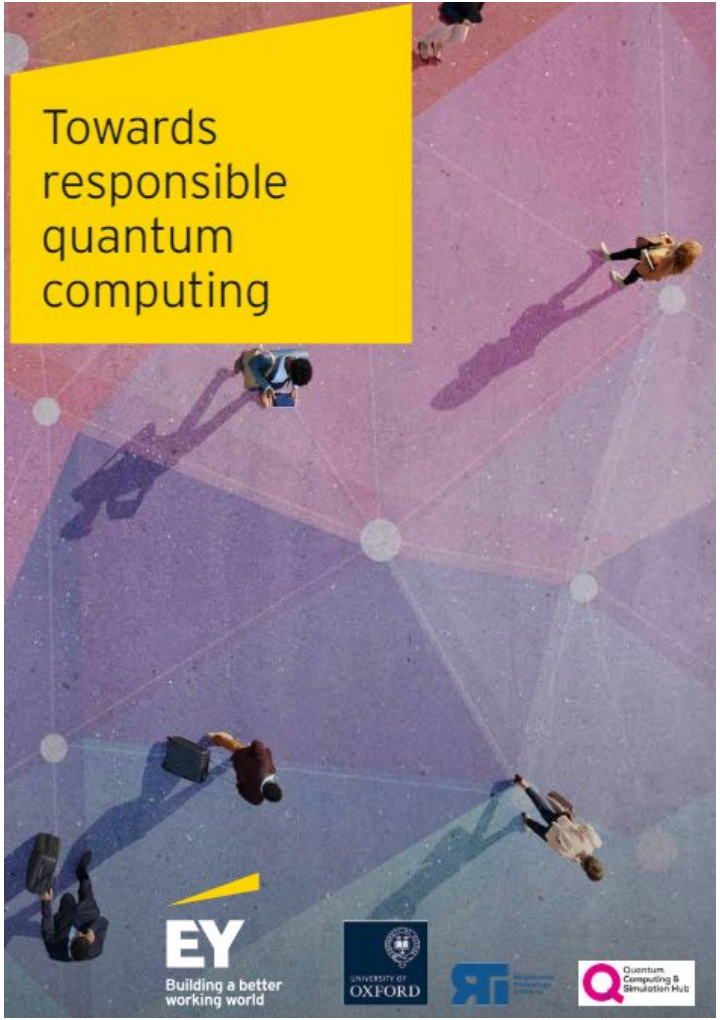
Mauritz Kop[11,1], Mateo Aboy[2,1], Eline De Jong[3,1], Urs Gasser[4,1], Timo Minssen[5], I Glenn Cohen[6], Mark Brongersma[7,1], Teresa Quintel[8], Luciano Floridi[9] and Raymond Laflamme[10]

Published 22 April 2024 • © 2024 The Author(s). Published by IOP Publishing Ltd

Quantum Science and Technology, Volume 9, Number 3

Citation Mauritz Kop *et al* 2024 *Quantum Sci. Technol.* **9** 035013

DOI 10.1088/2058-9565/ad3776



Comment | Published: 09 April 2024

A call for responsible quantum technology

Urs Gasser, Eline De Jong & Mauritz Kop

Nature Physics **20**, 525–527 (2024) | Cite this article

The time has come to consider appropriate guardrails to ensure quantum technology benefits humanity and the planet. With quantum development still in flux, the science community shares a responsibility in defining principles and practices.

CRQIT

Centre for Responsible Quantum Innovation and Technology

Powered by Quantum Algorithms Institute

Leap QuantiK Inc. Canada

PERIMETER INSTITUTE Theoretical Physics

NSERC CRSNG

Chairs for Women in Science and Engineering
Chaires pour les femmes en sciences et en génie

Canadian Innovation Network

WOMEN IN SCIENCE

The era of quantum utility must also be the era of responsible quantum computing

Now that we've entered the era of quantum utility, we are using quantum computers as computational tools to access a computational world we've never had access to before.

Date

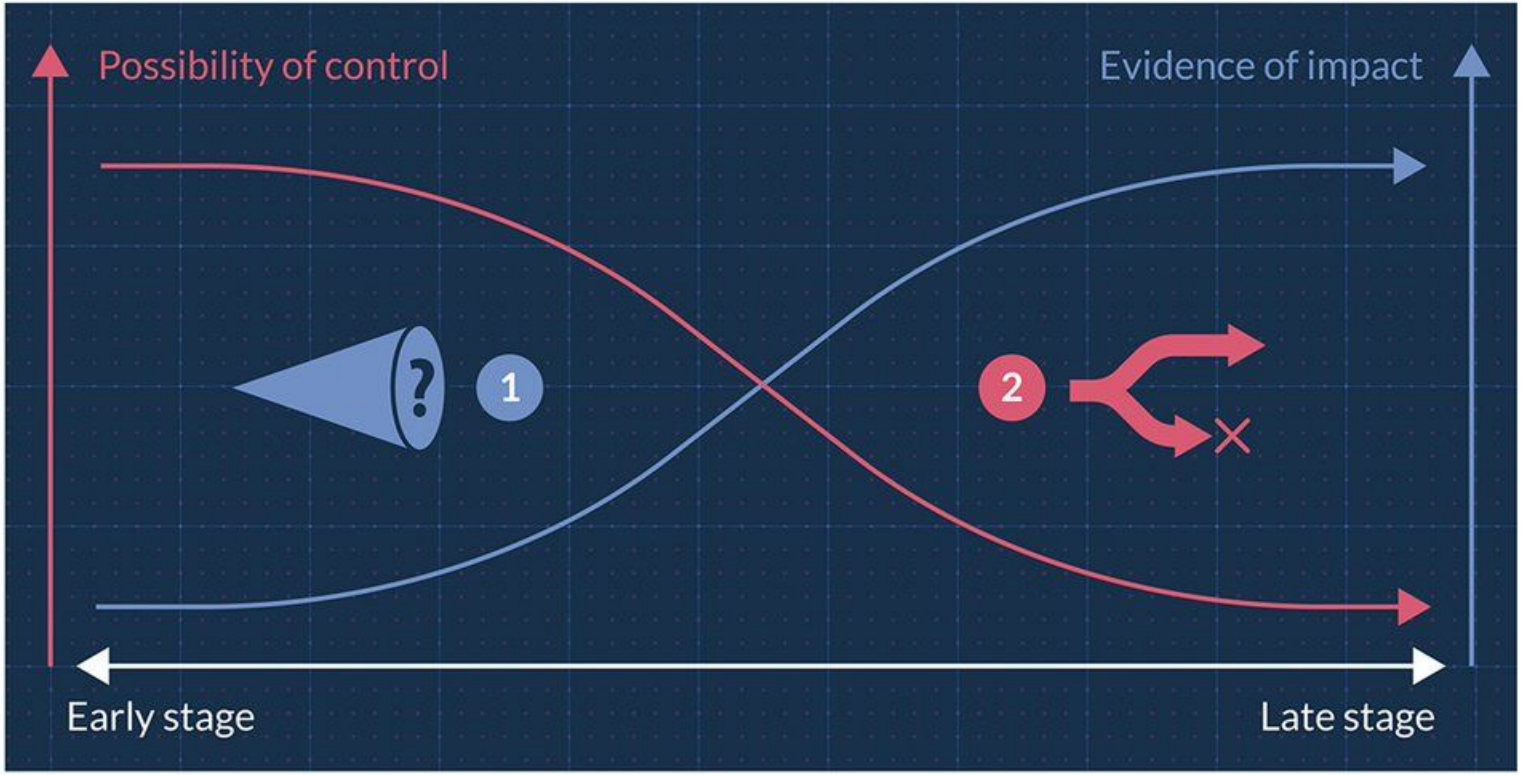
16 Jan 2024

Authors

Mira Wolf-Bauwens

Ryan Mandelbaum

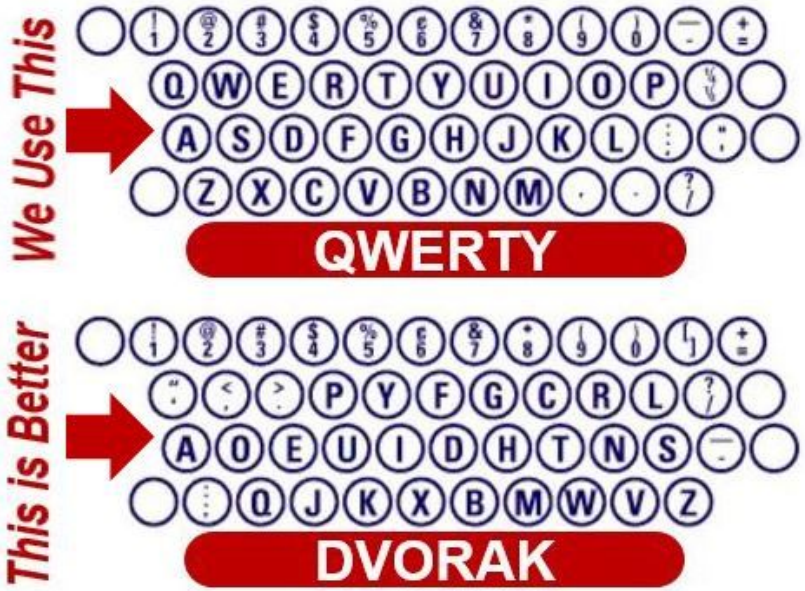
Technology and the Collingridge dilemma



1
- Easy to control
- Hard to know the impact

2
- High evidence of impact
- Hard to control

Path Dependence



Path Dependence

TRACK GAUGE

(Has not changed much in 200 years)

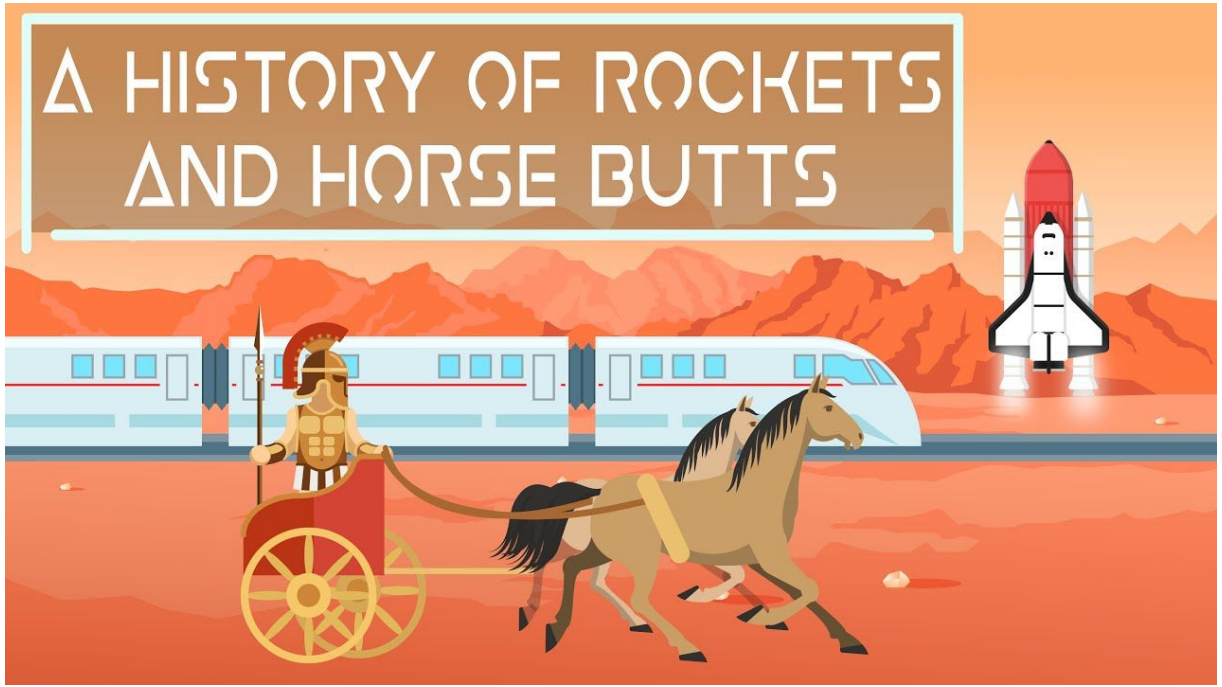
Designed more for horse-drawn wagons than today's trains

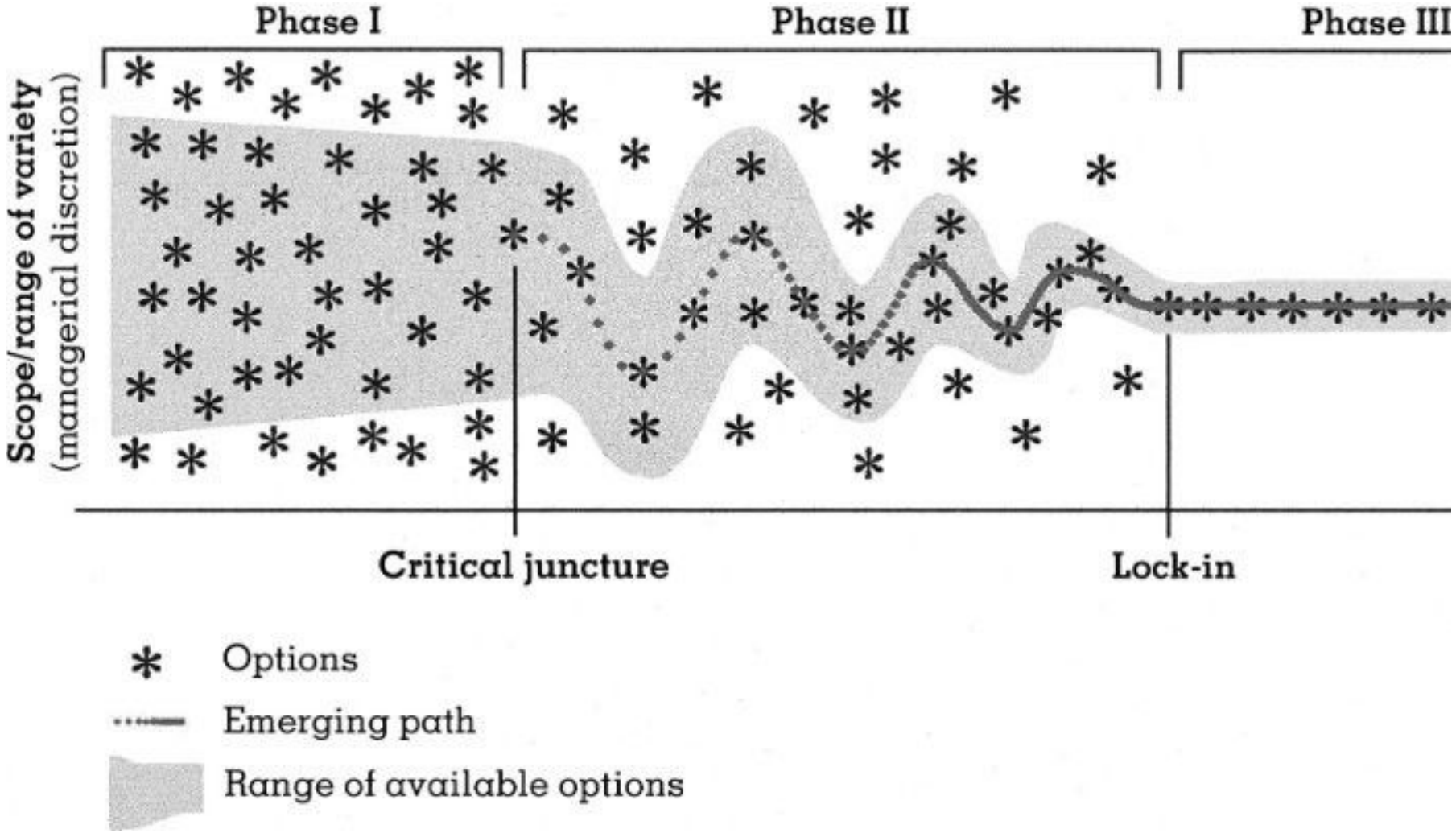
Designed for horse-drawn wagons – ideal in 18th century

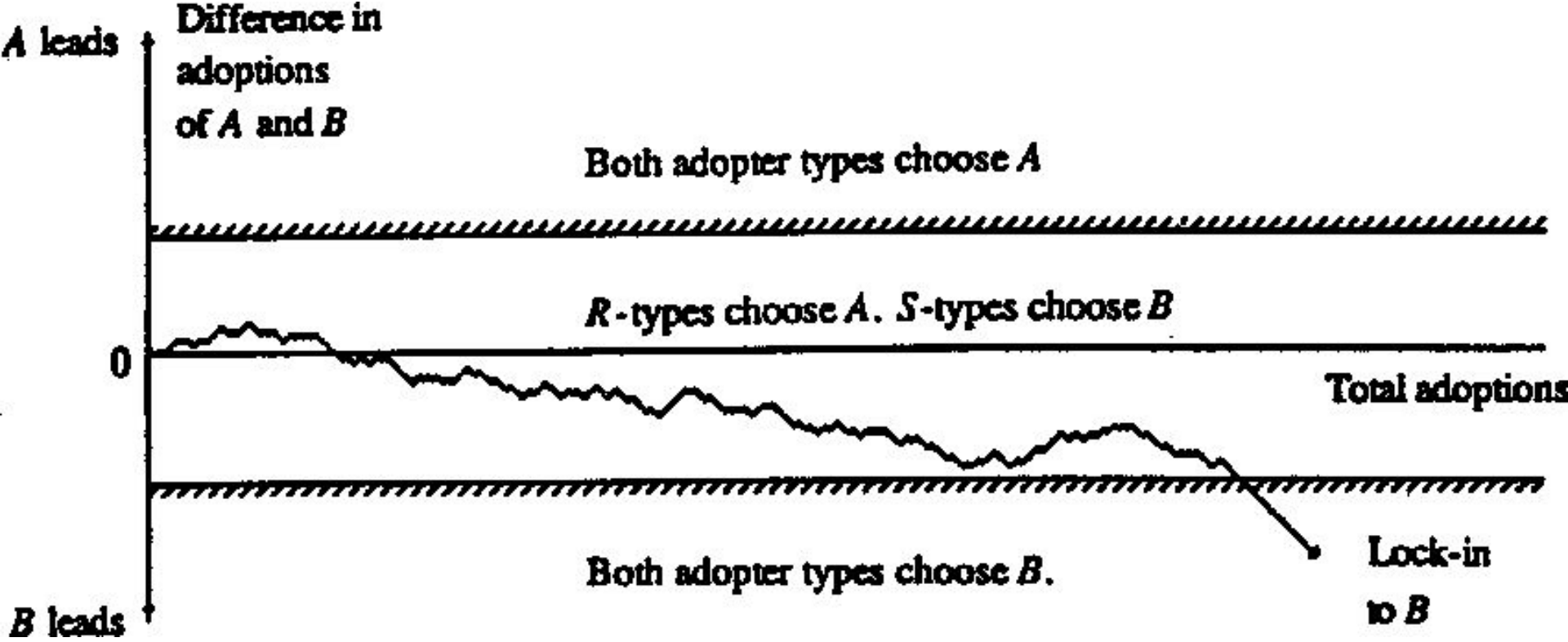
Image credits: Christian Nordqvist

The Space Shuttle and the Horse's Rear End

Space shuttle boosters were sized to fit on rail road cars for delivery from Utah to Florida. Rail roads used in America are vaguely based on Roman cart track widths, which were defined by the width of a horse's butt.



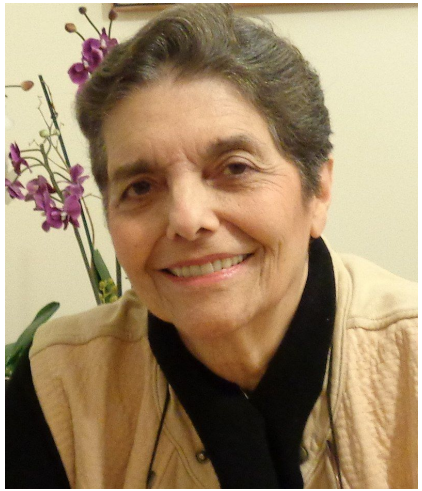

Phase I
Phase II
Phase III
Scope/range of variety
(managerial discretion)
Critical juncture
Lock-in
Options
Emerging path
Range of available options


A leads
Difference in adoptions of A and B
Both adopter types choose A
R-types choose A. S-types choose B
0
Total adoptions
Both adopter types choose B.
Lock-in to B
B leads

Emergence of a new techno-economic paradigm

"*…the space of the **technologically possible** is much greater than that of the **economically profitable** and **socially acceptable**.*" (Perez, 2010)

- Technologically possible
- Economically profitable
- Socially acceptable



Carlota Perez - "*Technological Revolutions and Financial Capital*" (2002)

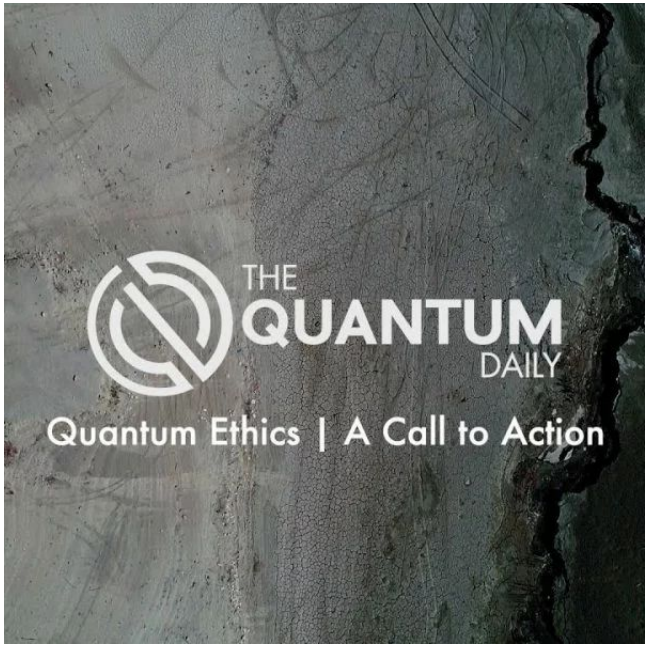
APSNews

September 2022 (Volume 31, Number 8)

Should We Build Quantum Computers at All?

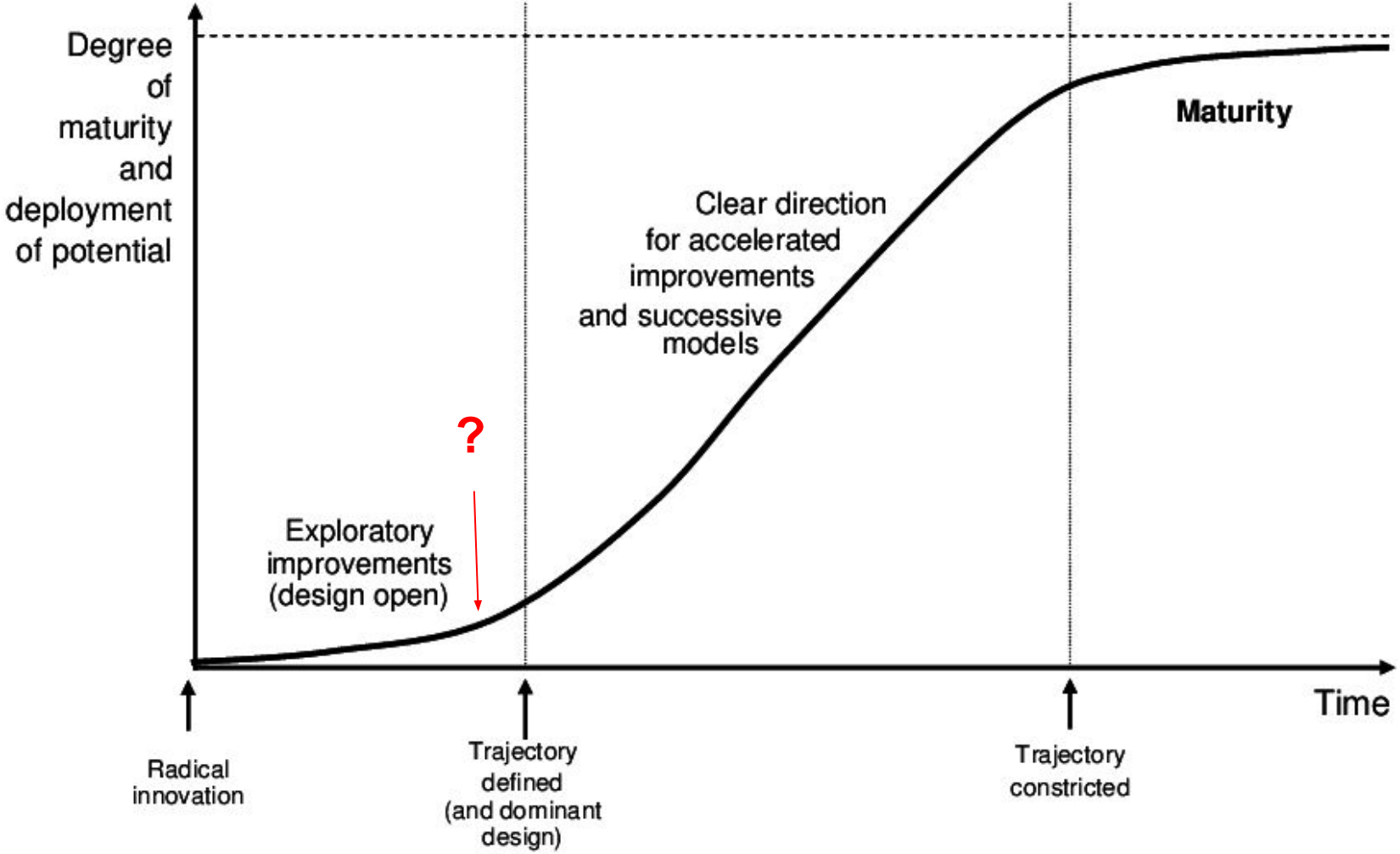
A Q&A with Emma McKay, quantum physicist turned quantum skeptic.

By Sophia Chen | August 8, 2022



Josie Meyer · Feb 8 · 5 min read

Quantum Energy Advantage Will Not Save the Planet


Degree of maturity and deployment of potential
Maturity
Clear direction for accelerated improvements and successive models
?
Exploratory improvements (design open)
Time
Radical innovation
Trajectory defined (and dominant design)
Trajectory constricted

QUANTUM FOR REAL-WORLD IMPACT

$5 MILLION

Prize Purse

XPRIZE Quantum Applications is a 3-year, $5M global competition designed to generate quantum computing (QC) algorithms that can be put into practice to help solve real-world challenges.

THE COMPETITION

XPRIZE Quantum Applications is actively seeking applicants working on quantum algorithms focused on sustainability and social impact. We welcome global innovators from various fields to participate in the competition. The winning submissions will most accelerate the field of quantum algorithms towards quantum advantage for positive real-world applications.

XPRIZE®

The Open Quantum Institute
Spearheading partners

gesda
GESDA Solutions

Solution Idea

Quantum Revolution
& Advanced AI

Open Quantum Institute

Providing global and inclusive access to state-of-the-art quantum technology

Academic

Supporting letters from

CERN

EPFL

ETHZ

Forschungszentrum Jülich

Imperial College London

National Institute for Theoretical and Computational Sciences (NITheCS)

Quantum Delta NL

Raman Research Institute

University of Calgary

University of Copenhagen

University of Geneva

University of KwaZulu-Natal

New York University Abu Dhabi

Bibliotheca Alexandrina

Diplomacy

Permanent Missions from a number of countries have been actively helping to shape the multilateral relevance of the future Open Quantum Institute

Australia
Austria
Brazil
France
Japan
Malta
Mexico
Morocco
Netherlands
Pakistan
Singapore
Switzerland

Intergovernmental Organizations and **NGOs** have been actively helping in defining possible Quantum for SDG use cases

Global Alliance for Improved Nutrition

International Committee of the Red Cross

Periodic Table of Food Initiative

SDG Lab

UN Habitat

UNFCCC

World Food Program

World Health Organization

World Intellectual Property Organization

Impact

Supporting letters from

Alpine Quantum Technologies

AWS

IBM

IQM Quantum Computers

Microsoft

Oxford Quantum Circuits

PASQAL

Strangeworks

Citizens

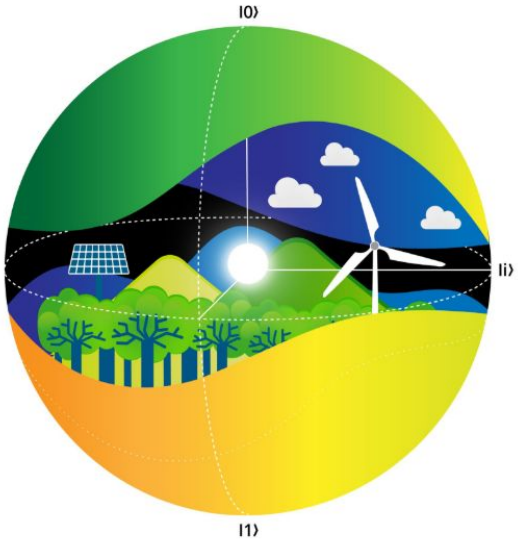
Strategic partners

Fondazione Compagnia di San Paolo

XPRIZE

Deloitte's Quantum Climate Challenge 2024

Flood Prediction



Goal of the challenge

Deloitte's Quantum Climate Challenge 2024 aims to explore the potential of quantum computers in enhancing flood forecasting to improve climate resilience. Climate change has amplified the urgency of disaster prediction in recent years. Rising temperatures and shifting weather patterns have led to more intense floods, wildfires, and other extreme events. As our climate becomes increasingly volatile, accurate forecasting of extreme events can be the difference between life and death.

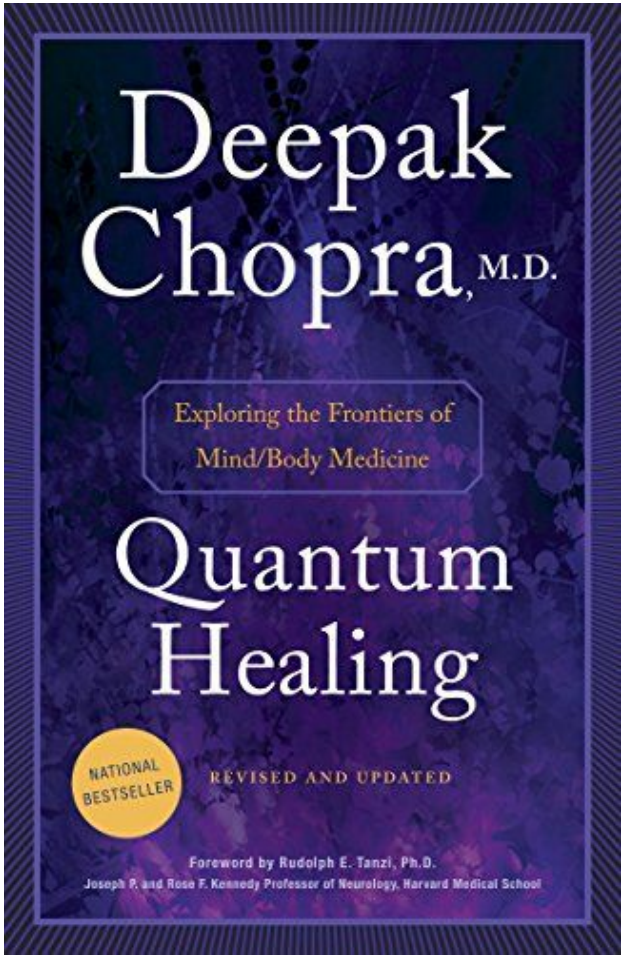
To advance disaster prediction methods, the challenge seeks to explore the application of Quantum Machine Learning (QML) for forecasting floods along the Wupper River in Germany. The challenge aims to develop a new approach in predicting river floods, leveraging nascent quantum computing technologies. By doing so, it endeavors to assess the prerequisites for quantum hardware to significantly enhance disaster prediction on a larger scale and to gauge the potential timeframe for its implementation.

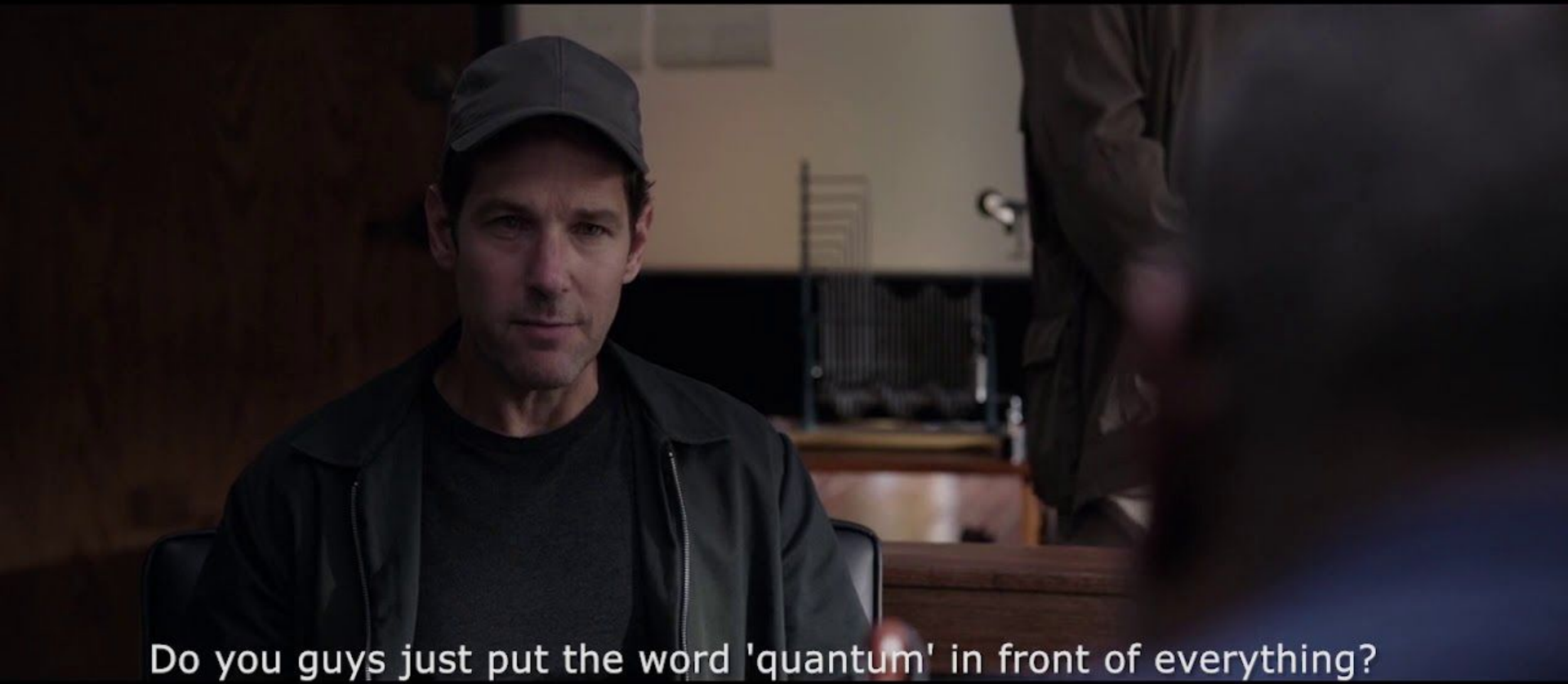
Deloitte.


QUANTUM PILATES
Quantum Pilates


GIGA
#1 BRAND
SAVE WATER.
NO PRE-RINSE NEEDED
finish
POWERBALL
QUANTUM
ALL IN 1
100


Quantum Fresh
FLUORIDE TOOTHPASTE


Deepak Chopra, M.D.
Exploring the Frontiers of Mind/Body Medicine
Quantum Healing
NATIONAL BESTSELLER
REVISED AND UPDATED
Foreword by Rudolph E. Tanzi, Ph.D.
Joseph P. and Rose F. Kennedy Professor of Neurology, Harvard Medical School

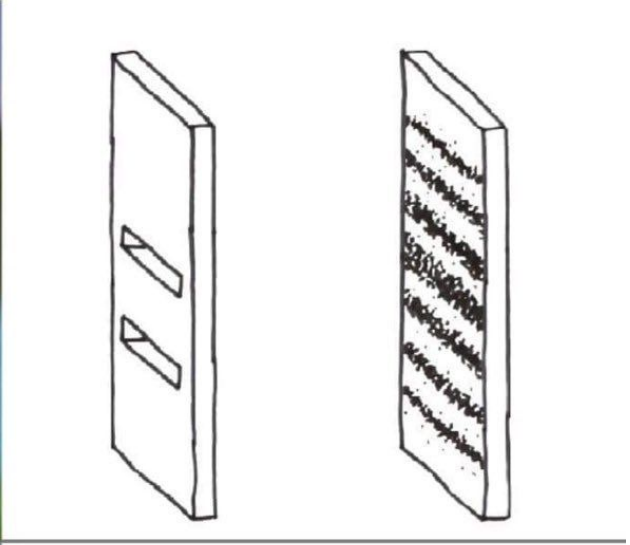

Do you guys just put the word 'quantum' in front of everything?


There are quantum people in the quantum realm!

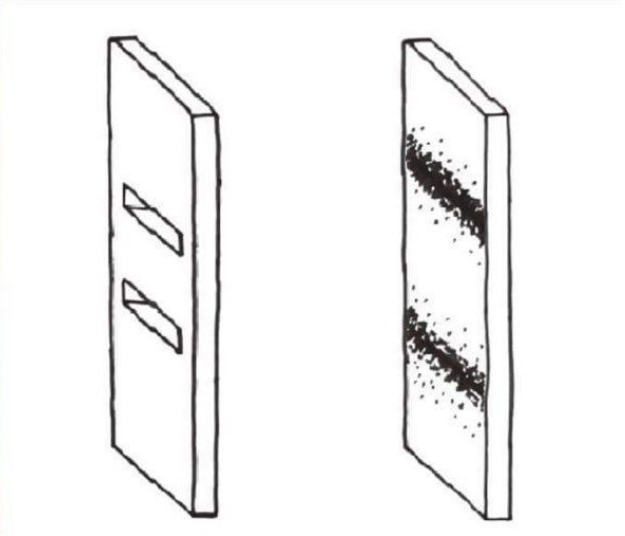

AN FX ORIGINAL SERIES
DEVS
FX

Concluding Remarks

- Technology is not science, QT is a concept beyond scientific research
- There has been an increasing amount of research into “responsible” QT
- Concepts such as the Collingridge dilemma, path dependency, lock-in, and techno-economic paradigms can be utilized for making better QT
- If QT is to bring a new paradigm, we need to consider beyond just the tech.
- “Quantum” is culturally present, but QT is a rather new cultural phenomenon



Thank you for your attention!



Let’s discuss.