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Title:	Quantum To-Go
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Intended for:	Outreach program from the American Physical Society that matches a scientist with a teacher interested in bringing THE WORLD OF QUANTUM to their classroom.
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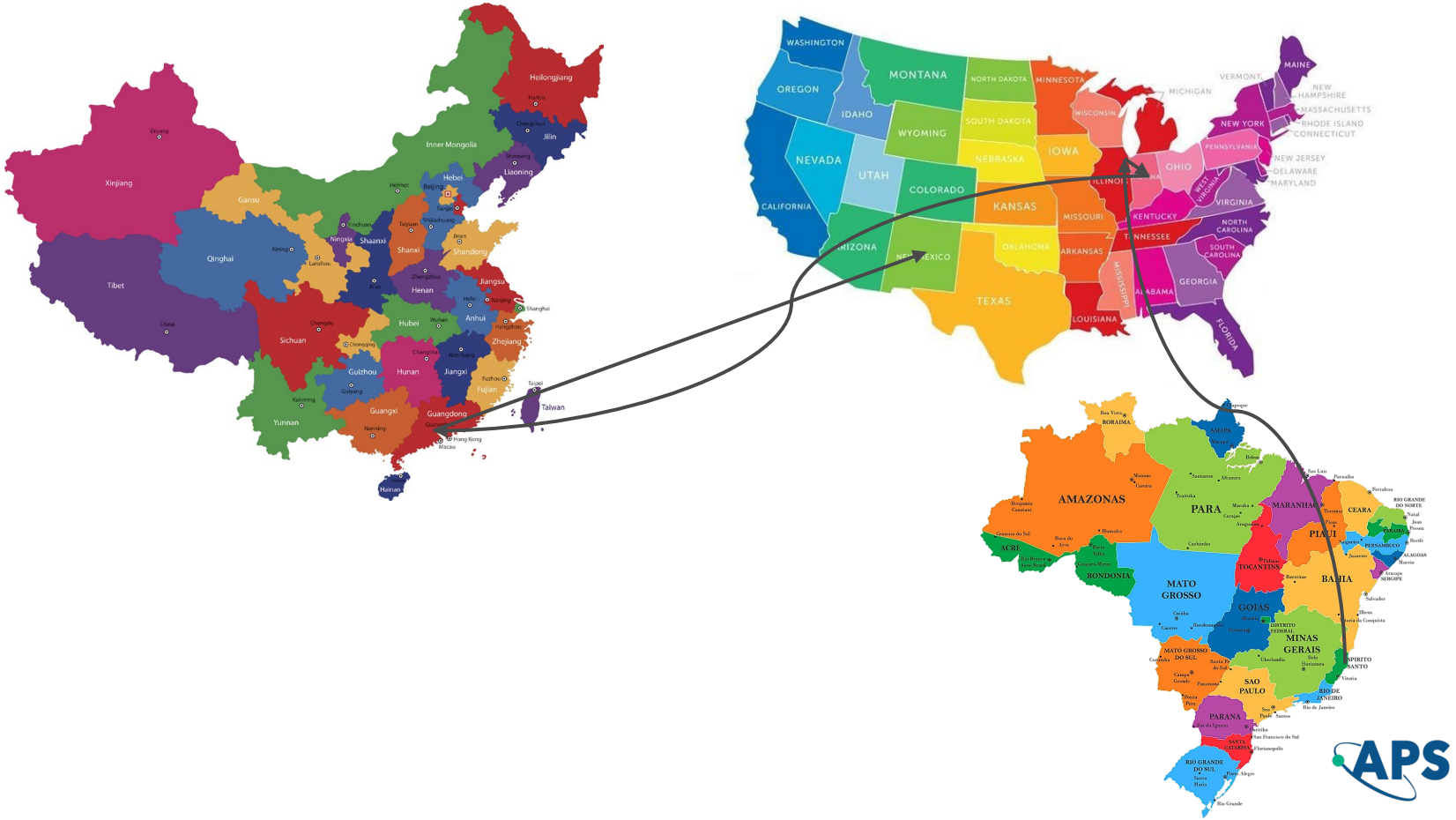
Quantum To-Go

Leonardo de Melo
April 25, 2023

My Quantum Story - The beginning



My Quantum Story - The beginning, continued

My definition of quantum

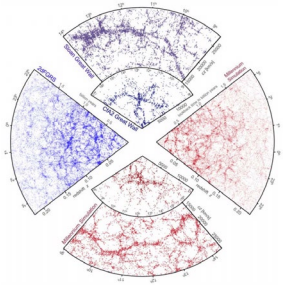
- What is your definition of quantum science and technology
- When you think of quantum science, what comes to mind

Quantum mechanics is the study of matter and its interactions with energy on the scale of atomic and subatomic particles.

Where do we find quantum science?

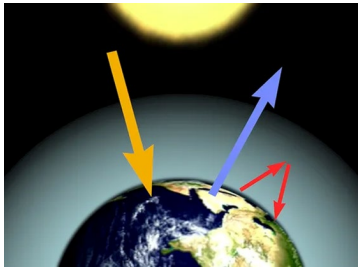
Solar Panels

MRIs and advanced medical



Structure of the Universe

Modern computers and games



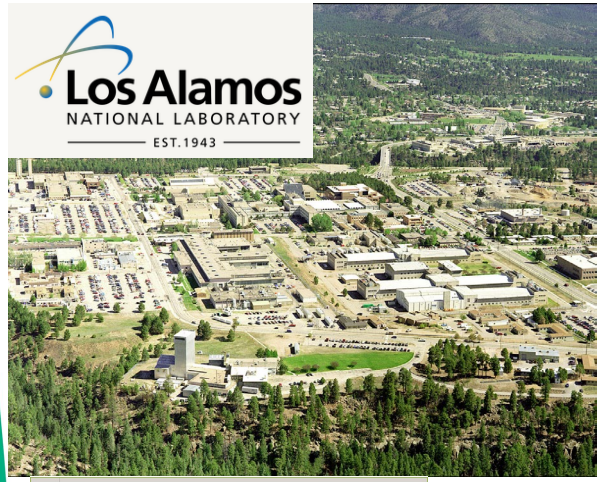
Climate Science

Life-Saving Medicine

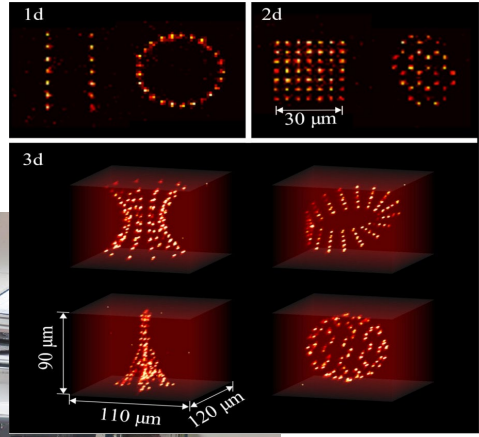
Why the Sun Shines

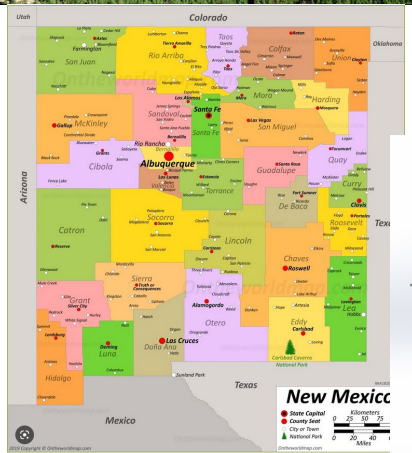
Photosynthesis

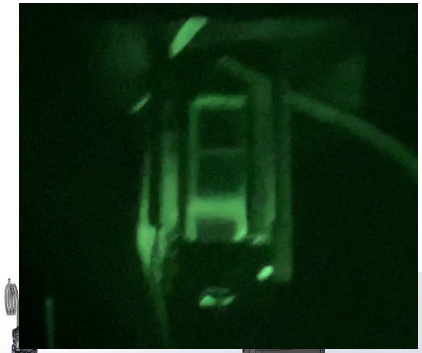
My Quantum Story - The Career

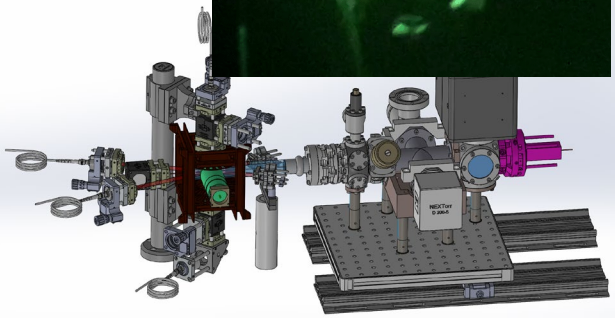


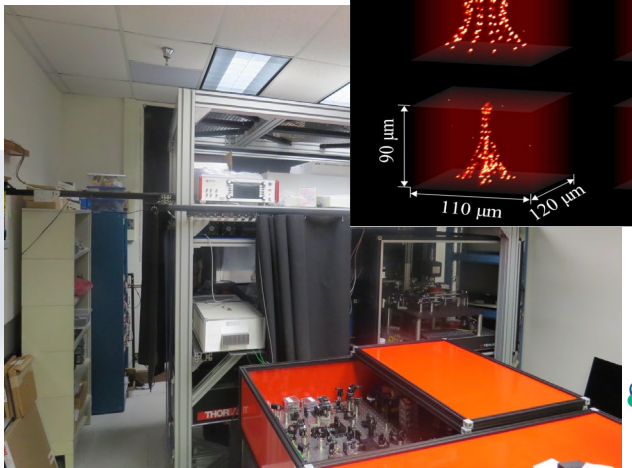
- Staff scientist: I design, build and conduct experiments with ultracold trapped atoms.
- My research is looking at understanding how to use arrays of atoms to make better sensors, quantum gates, and for simulating physical phenomena.











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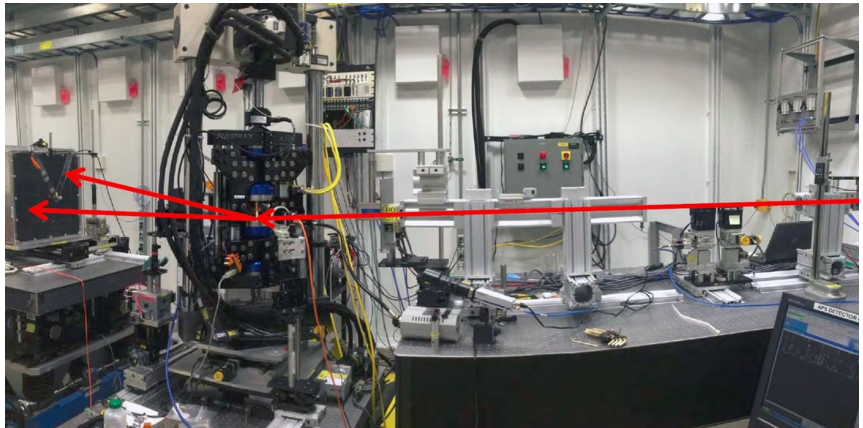
How I got here

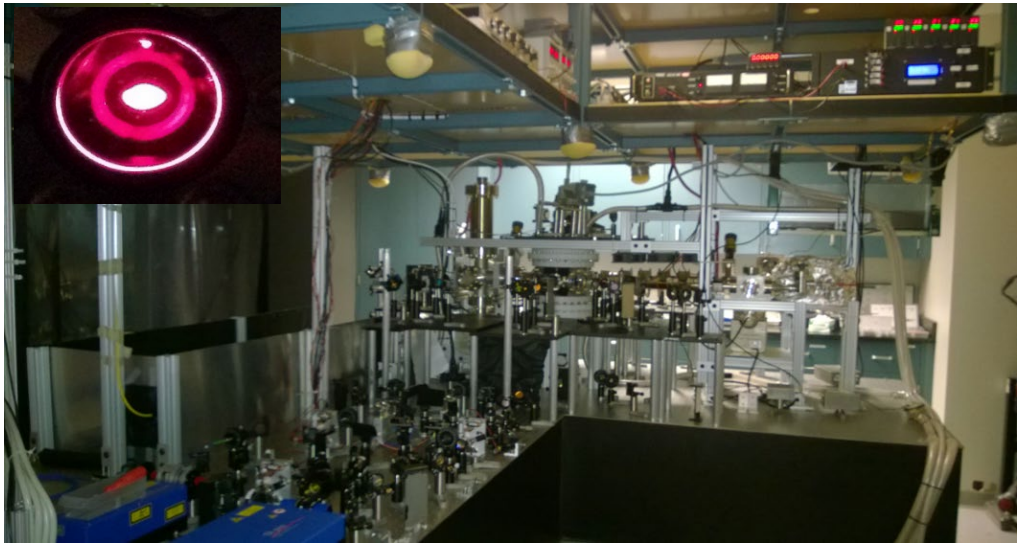
- High school: Took honors physics course. Wish I had taken calculus.
- College:
  1. Attended community college for 2 years and did two summer internships at Argonne National Laboratory setting up a laser lab.
  2. Received my Bachelor's degree in physics from IIT.
  3. Received my Master's degree in physics from IIT. Conducted experiments at the Advanced Photon Source at Argonne, looking at archeological artifacts.

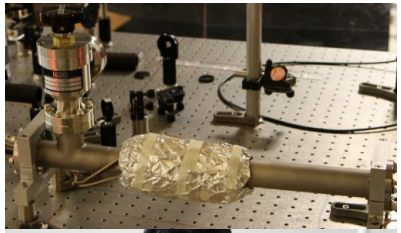


How I got here, grad school

- Indiana University Purdue University at Indianapolis (IUPUI)

- Courses: Classical and Quantum mechanics + many others.
- Research: Ultracold atoms.
- Skills used: Soldering, machining, CAD, electronics, coding, data analysis…





What excites you about Quantum in your professional and personal life?

- Initially though quantum research was purely fundamental.
- In grad school learned that there were real applications.
- The field is now growing so quickly.

Max Planck

The Nobel Prize in Physics 1918

Prize motivation: “in recognition of the services he rendered to the advancement of Physics by his discovery of energy quanta”

The Nobel Prize in Physics 1997

The Nobel Prize in Physics 1997 was awarded jointly to Steven Chu, Claude Cohen-Tannoudji and William D. Phillips "for development of methods to cool and trap atoms with laser light"

The Nobel Prize in Physics 2001

The Nobel Prize in Physics 2001 was awarded jointly to Eric A. Cornell, Wolfgang Ketterle and Carl E. Wieman "for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates"

The Nobel Prize in Physics 2012

The Nobel Prize in Physics 2012 was awarded jointly to Serge Haroche and David J. Wineland "for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems"

The Nobel Prize in Physics 2022

The Nobel Prize in Physics 2022 was awarded jointly to Alain Aspect, John F. Clauser and Anton Zeilinger "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science"

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Support for quantum science

- The US government is putting a lot of money and resources into quantum science and technology
- The CHIPS and Science Act in 2022 to sponsor research and development in these fields
- Companies are investing over $50 billion in quantum science and technology

Prominent companies with known quantum science efforts*

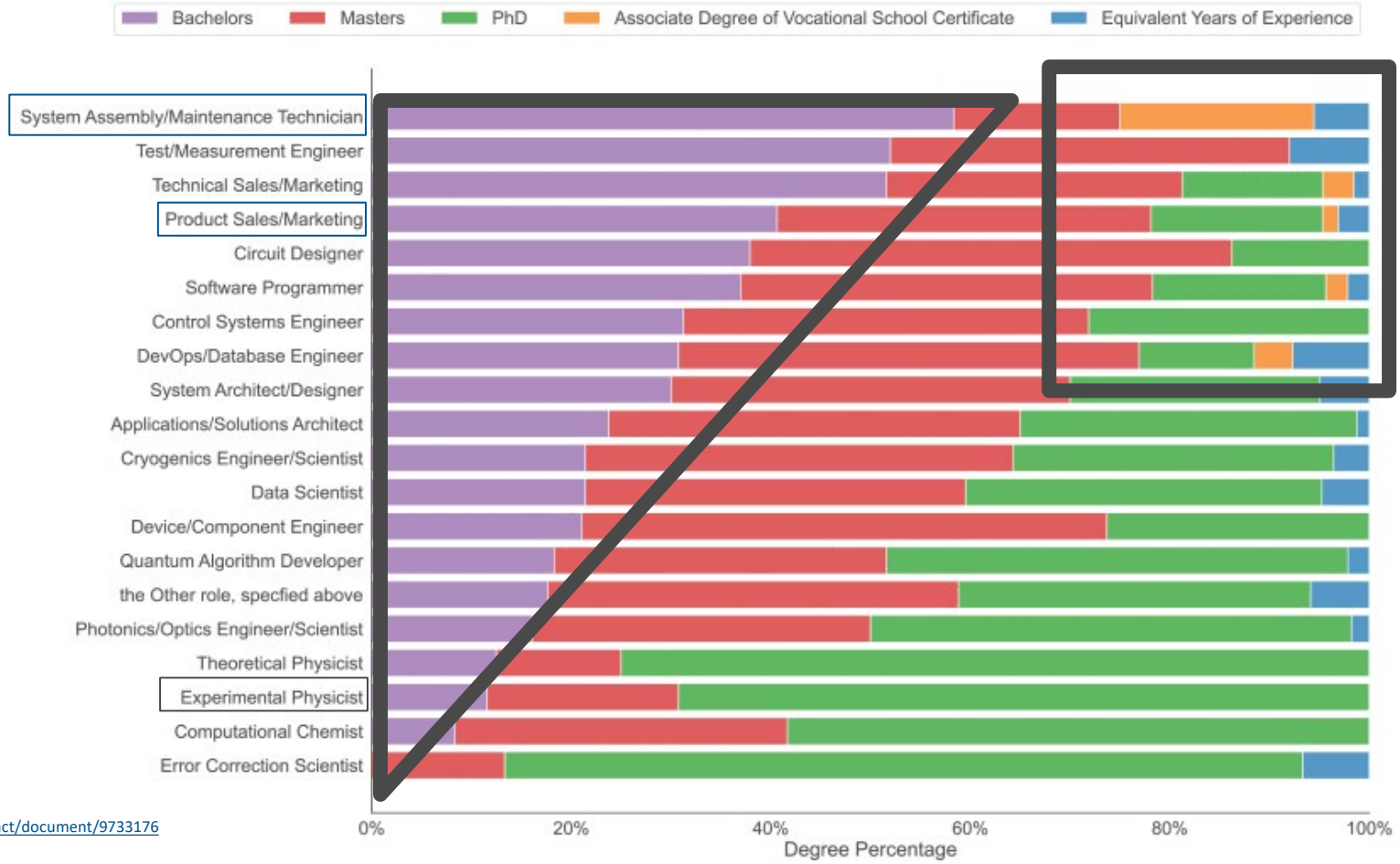
Amazon	Microsoft
AT&T	Mitsubishi
Boeing	Nokia Bell Labs
Google	Northrop Grumman
IBM	Quantum Computing Inc.
Intel	Quantum eMotion
Hitachi	Raytheon
Honeywell/Quantinuum	Toshiba
Lockheed Martin	Start Ups: ionq, infleqtion, qubitekk, zapata, atom computing…

https://quantumcomputingreport.com/public-companies/ https://research.aimultiple.com/quantum-computing-stocks/

Needed Degree for Careers within Quantum

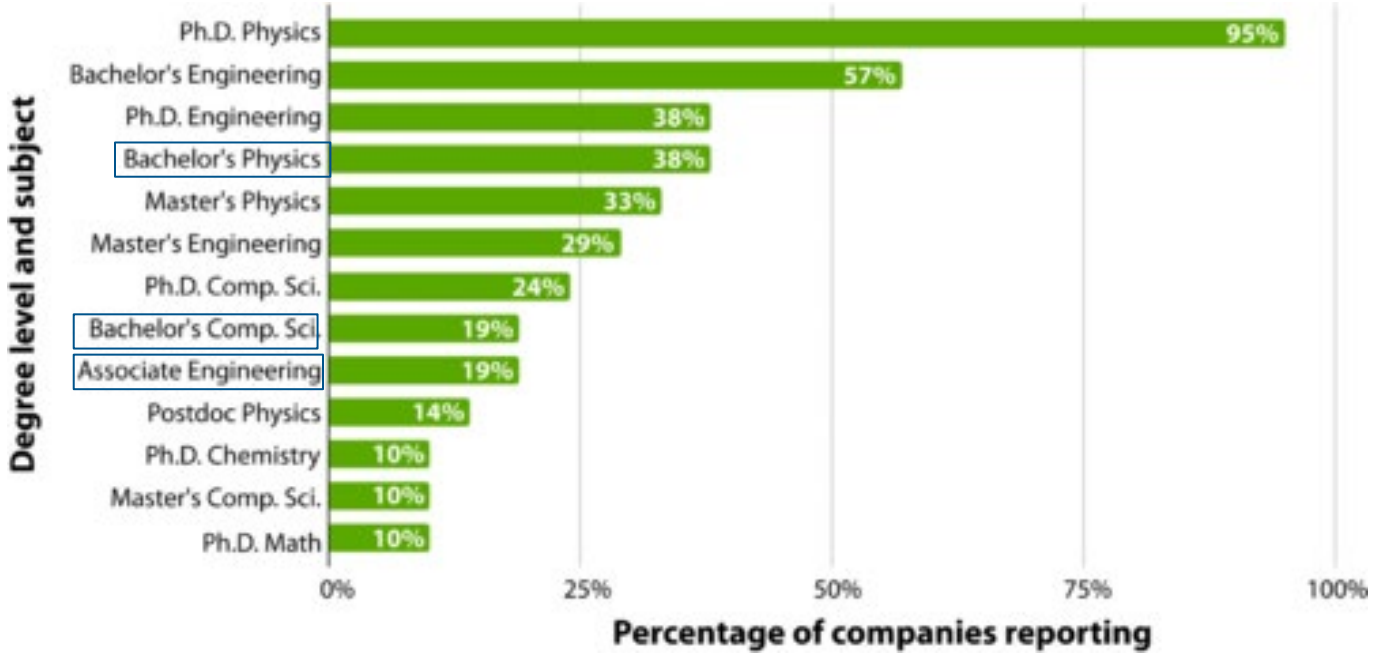
You don't need an advanced degree for many quantum careers! Associates or bachelors degrees are sufficient

There are many types of jobs, from engineer and physicist to sales and marketing



https://ieeexplore.ieee.org/abstract/document/9733176

Degrees needed for quantum careers



Top 13 degrees found in the quantum industry. The percentage corresponds to the number of companies sampled that reported at least one employee with the specific degree combination

https://journals.aps.org/prper/abstract/10.1103/PhysRevPhysEducRes.16.020131

Skills needed for quantum careers

The types of skills and knowledge that may be relevant for "real-world quantum information theory."

The grayed region indicates skills that are shared across multiple quantum information theory courses.

Skills	Examples
Coding	"be able to **program based on established quantum algorithms**, be able to debug the quantum processor, be able to collect and analyze data and discuss the results back with me."
Statistics and data analysis	"Some of what we do is refining our processes and calibrations of [the computer] and that involves doing a bunch of experiments and understanding **if you've nullified your hypothesis or proven your hypothesis.**"
	"we have software engineers that contributed to the **statistical analysis** [of experiments]"
Troubleshooting (debugging)	"**totally different from debugging classical code** 'cause classical codes you can step through and quantum codes you can't do that because you'd have to measure and [when you measure] you just throw your information."
Noise sources	"what a gate model machine is, the principles on how it operates, **decoherence and noise mechanisms** and common failure mechanisms for both models of quantum computation."
Modeling	"understanding how to take noisy data, understanding what the underlying physical model of what is dragging that data, knowing how to fit that data and say something statistically meaningful: **whether your model is correct or not; or how to update your model**."
(De)coherence	"the decoherence mechanisms for the technology upon which the sensor operates"
	"it's important to know for a particular application **whether you want a system that has a longer coherence time** or a system that can easily be coupled to some other system. What are the limits of that kind of coupling?"
Error correction	"for **quantum error correction**, and device design, and simulation obviously need lots of physics"
Open system dynamics	"the Schrödinger equation drives the time evolution that we see or, hopefully even more than unitary dynamics, understanding **open system dynamics**"
Qubit hardware	"when you're talking about quantum computing and applications, you don't need to know a great deal about the base hardware except for **how it's going to propagate up in terms of decoherence mechanisms**"
Hamiltonians	"that sort of connection from some abstract **Hamiltonian** to actual physical reality is of course tenuous and needs to be carefully understood what the limitations are."
Quantum circuit design (physical)	"taking a specification of a quantum system in terms of a Hamiltonian and then **turning that into a design that will be fabricated**. And there's a lot of microwave engineering there, but also strong connections to quantizing microwave circuits."

https://journals.aps.org/prper/abstract/10.1103/PhysRevPhysEducRes.16.020131

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Question and Answer session

Student Reflection

What did you learn about yourself from this presentation?

What is one thing you learned about quantum science and technology from this presentation?