QIS for the High School Student: An Exploration of "Spin First" Methodologies

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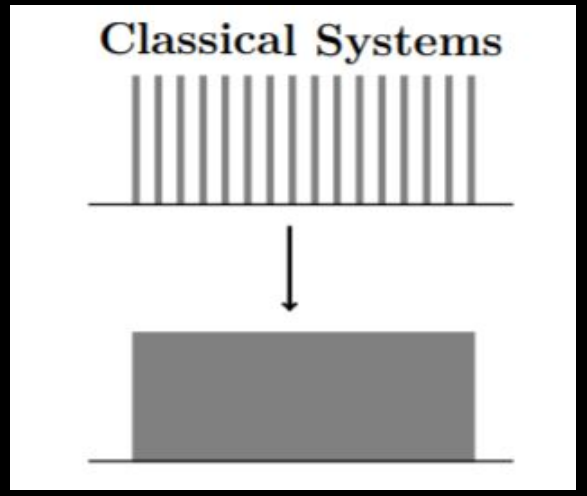
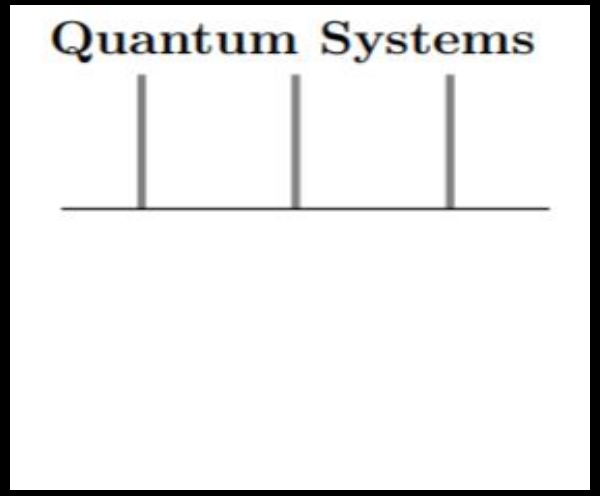
Agenda

- → Introduction
- → Why QIS for high schoolers?
- → Pedagogical Approach: “Spin first”
- → Execution so far
- → Reflections and lessons learned





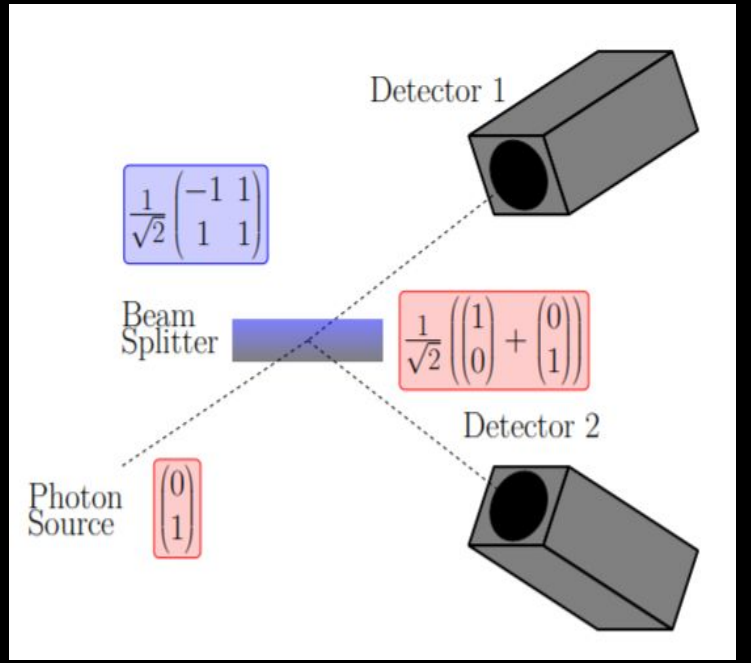
Introduction

Quantum Information Science (QIS) and applied technologies such as quantum computing and quantum communication are emerging technologies deemed critical to the future technical workforce and economy [1] .

These concepts tend to be outside the contents of study in most high school physics classes.

However, recent progress has been made in developing high school accessible curricula.

We will share our recent experience piloting a “spin first” style high school primer into QIS.



[1] National Strategic Overview For Quantum Information Science, Office of the Science and Technical Advisor to the President, September 2018 (https://www.quantum.gov/wp-content/uploads/2020/10/2018_NSTC_National_Strategic_Overview_QIS.pdf)

Logistics

Physics Club	BHS has daily time blocks for students to participate in clubs, eat lunch, & attend study hall.
Weekly	Physics Club meets every Tuesday, 10:32 am – 11:07 am, during the block schedule.
Virtual Session	Dr. Brereton joins-in by means of Google Meet.
Members	Students and faculty participate via Google and/or face-to-face in Schiller's classroom.

Why QIS for High Schoolers:

Engagement with science

→ Quantum technologies are in the news/social media

→ Exposure to the real science behind the “click bait” can be a portal to engagement in science in general

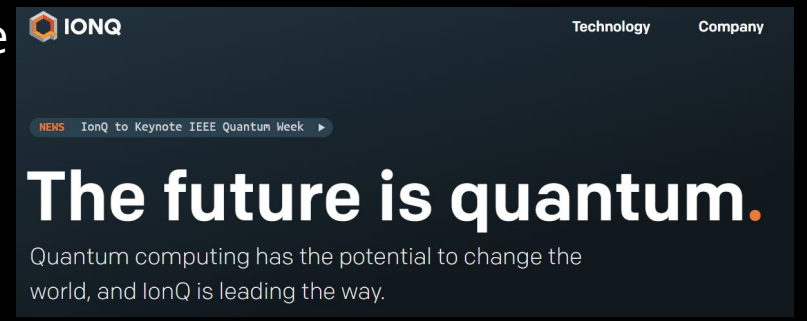
→ Exposure to real people who are working in science is important: representation is critical

Expose to possibilities in an emerging workforce

→ The workforce of the future is highly technical

→ QIS exposes students to a real emerging workforce

→ QIS topics cut across fundamental science, engineering (how to build an actual computer) and software engineering (coding and algorithms are key)



Pedagogical Approach: "Spin first"

Why start with spin?

→ Canonical "qubit" → allows introduction of QIS topics early

→ Parallel shift at the UG level away from "wave function" first

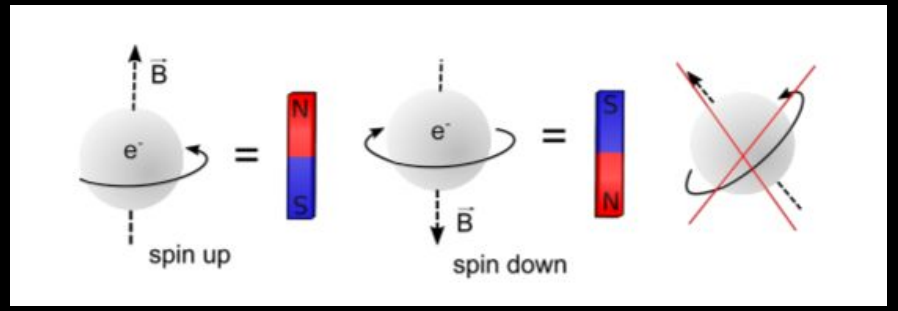
→ Emphasizes superposition and measurement rather than "wave" aspects

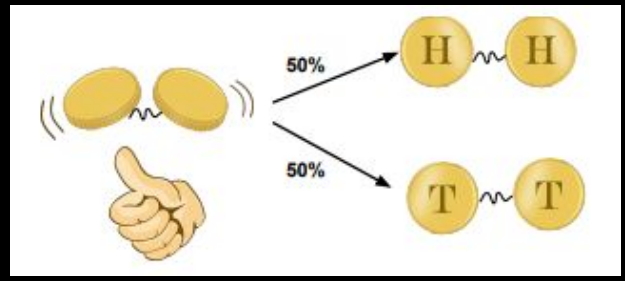
Pedagogical sequence so far

→ "Rules of QM" → emphasize concept of state and statistical nature of measurement

→ Introduce superposition: analogy with single coin, establish concept of "qubit"

→ Introduce concept of entanglement: non-classical aspects of correlations





Pedagogical Tools

Introductory videos

Traditional lecture

Follow on videos + activities

Educate through games

→ **Fundamental science can be fun!**

→ **The basic “rules” of quantum mechanics don’t require advanced mathematics**

→ **Games to illustrate concepts at a level high schoolers can grasp**

Instructor Resources

Introductory videos

- Dr. Talia Gershon, IBM Q
  - "Quantum Computing Explained for kids"
  - https://www.ibm.com/blogs/nordic-msp/quantum-computing-kids-understand/
  - "A Beginners Guide to Quantum Computing"
  - https://youtu.be/JRIPV0dPAd4
- Veritasium: How does a quantum computer work?
  - https://www.youtube.com/watch?v=g_IaVepNDT4

High school curricula

1) Perry, et al, "Quantum Computing as a High School Module", arXiv:1905.00282v2
2) Economu, et al, "Teaching quantum information science to high-school and early undergraduate students", arXiv:2005.07874
3) Dr. Tom Wong, "Qubit Touchdown" https://www.thegamecrafter.com/games/qubit-touchdown

Instructor References

1) Townsend, "A Modern Approach to Quantum Mechanics", 2ed.
2) Lopez-Incera and Dur, "Entangle me! A game to demonstrate the principles of quantum mechanics" AJP, 87, 95 (2019)
3) Qiskit, https://qiskit.org/

Reflections to Date

Reflections from mentor teacher

→ Pleased with student participation

→ 9th - 12th grade students have been involved

→ Will plan virtual field trip tours to reinforce our weekly QIS sessions

→ Photos show student participation

→ Even attended by fellow faculty (via Google Meet)

Reflections to Date

Student Responses

- → *"It's super interesting."*
- → *"I mean it's advanced, but it's not over my head…I'm understanding it."*
- → *"I was kind of shocked by the amount of information there was…quantum physics, oh, ok."*

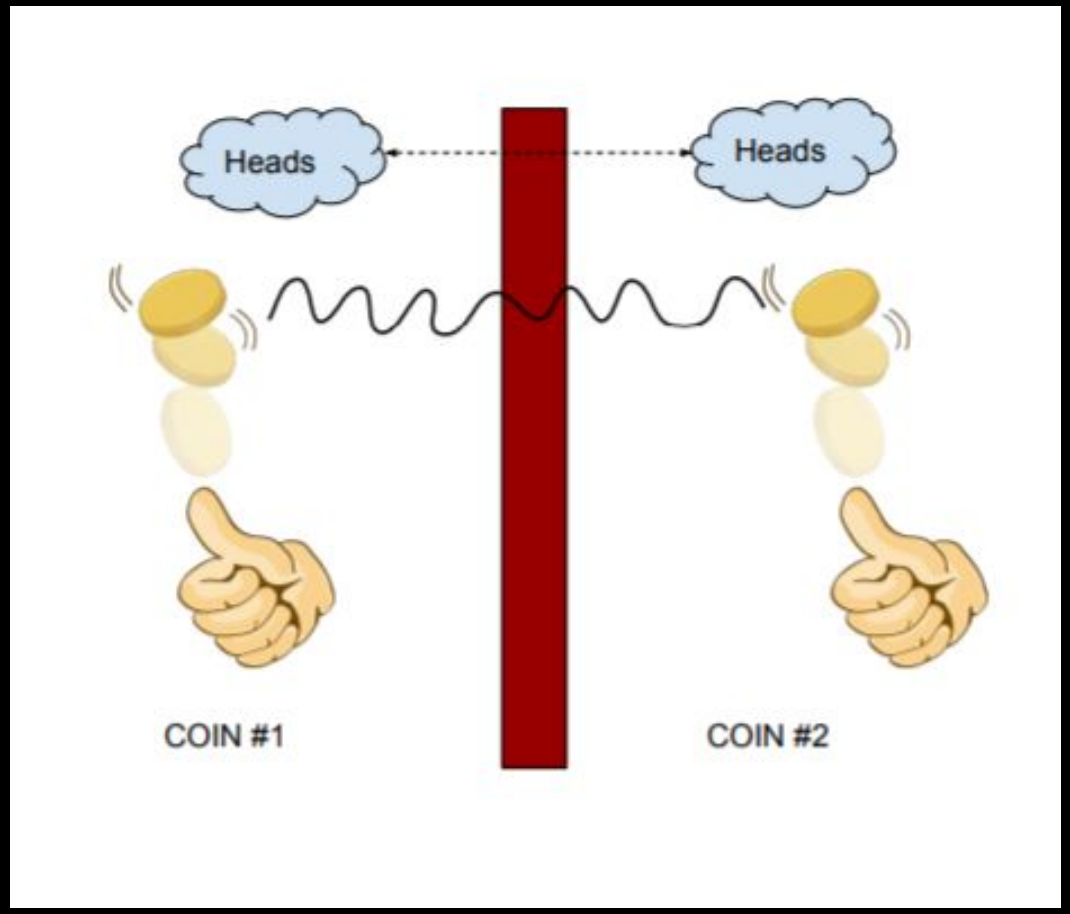
- → *"I got invited, a lot of fun things there."*
- → *"Thanks for inviting me. I hope to study computer science in college."*

Way Forward

Interest level from students has been high

Currently completing the introductory material, more hands-on instruction will be the focus of our next few modules

Eventually, would like to incorporate building quantum circuits on Qiskit (open source portal to IBM Q system)



Thank you

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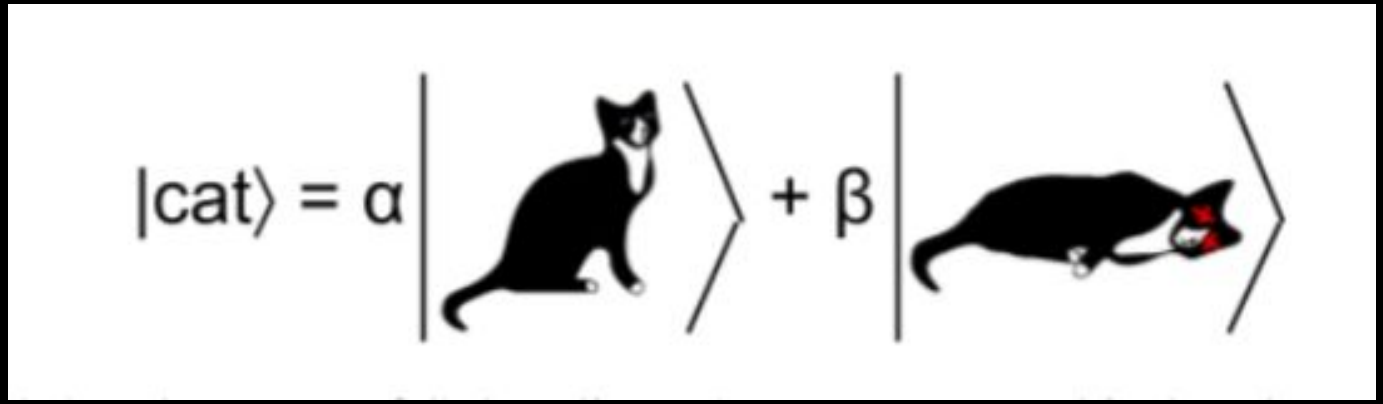

Team

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