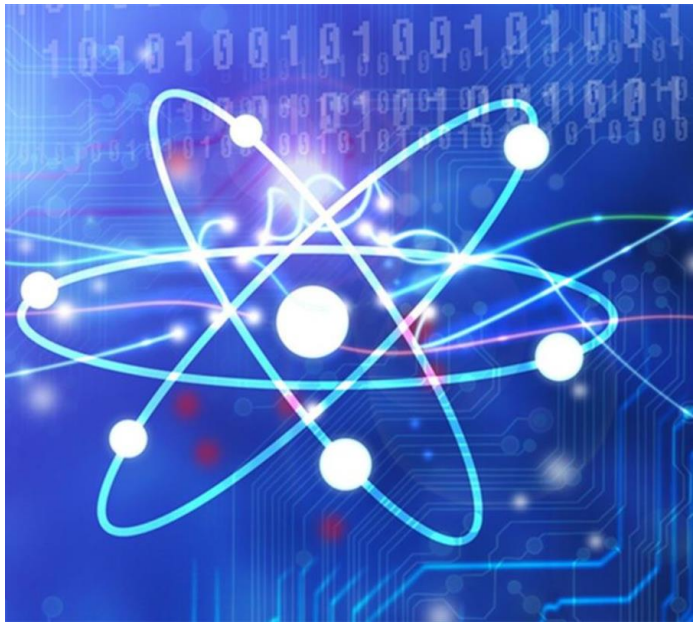
Teaching Quantum to High School Students

Education & Career Pathways



Donn M. Silberman

Founding Director; Optics Institute of Southern California
Optical Society of Southern California, Fellow & President 2007-2008
Founder, UC Irvine Optical Engineering
Fellow & Sr. Member, SPIE
Sr. Member, Emeritus, Optica (formerly OSA)
Advisor, Laser Technology - Pasadena City College
Board Member Vital Link of Orange County
Member, QED-C, Quantum Economic Development Consortium
Contact 949-636-6170 donn@oisc.net

Thank You

The Optics Institute of Southern California: organizing and implementing outreach effort

Author(s): Donn M. Silberman

Paper Abstract

The Optics Institute of Southern California is organizing the local educational outreach effort. Working with local optics businesses, society chapters, science discovery centers, K-12, community college and university educators, and others from the global optics education and training community, the OISC is becoming a one-stop clearing house for a wide range of educational outreach activities.

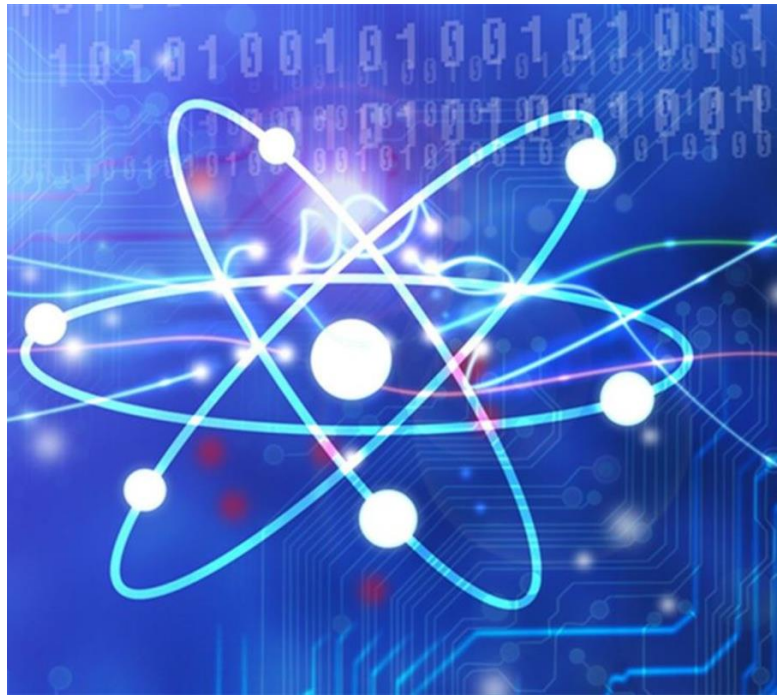
Paper Details

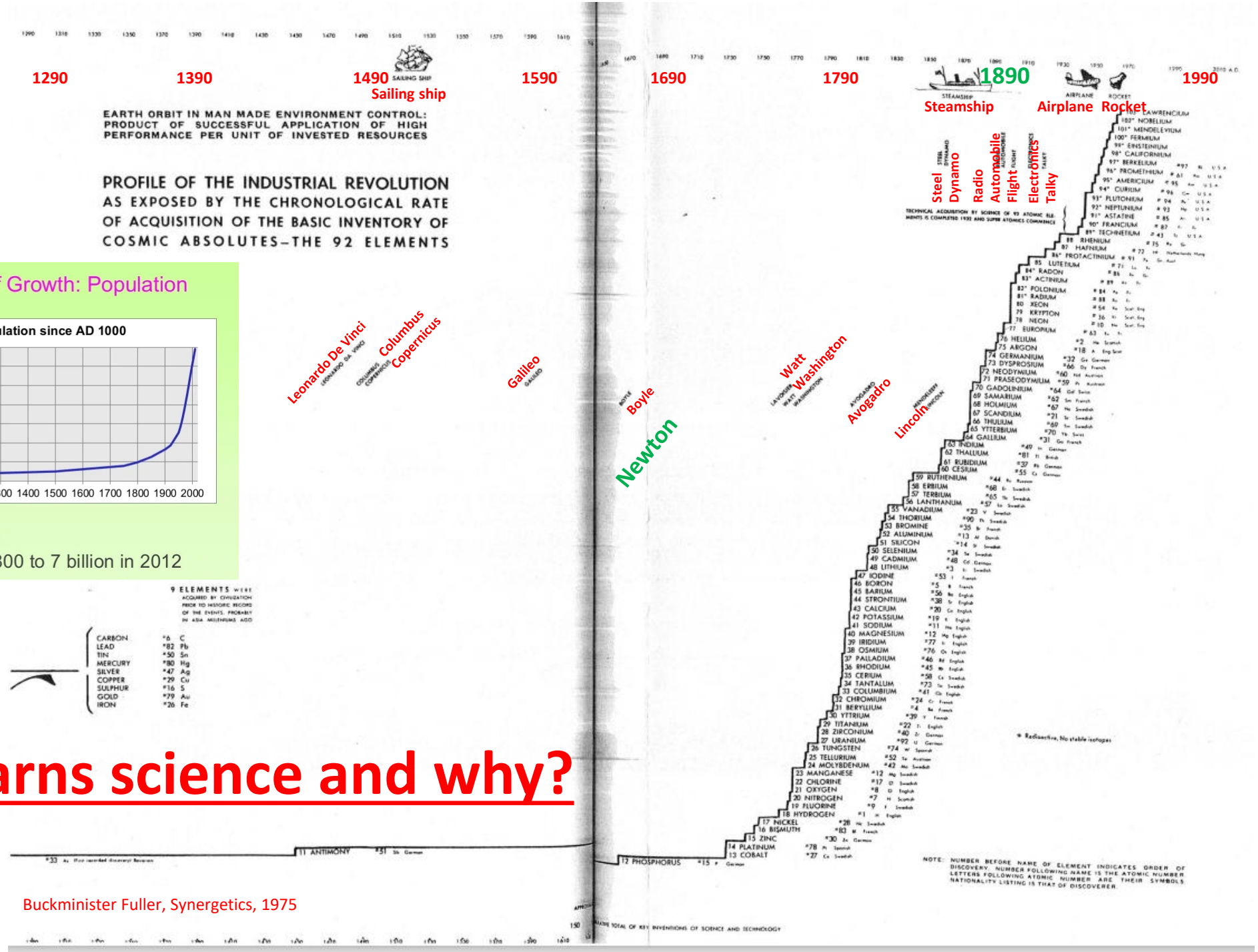
Date Published: 6 October 2003
PDF: 2 pages
Proc. SPIE 9663, Eighth International Topical Meeting on Education and Training in Optics and Photonics, 96631K (6 October 2003); doi: 10.1117/12.2208468
Show Author Affiliations

Published in SPIE Proceedings Vol. 9663:
Eighth International Topical Meeting on Education and Training in Optics and Photonics
Barry L. Shoop; Grover Swartzlander Jr., Editor(s)

Today's Topics

1. Getting Oriented with Quantum Education
2. Motivation for the process described
3. Creating the "Quantum Pipeline" – Paths Forward
4. The Samueli Academy's "Schrodinger's Club"
5. Quantum Cryptography – Univ. of Waterloo
6. Hands-on Lab for Students
   a) Polarization
   b) Atomic Spectroscopy & Laser Diffraction Lab
   c) Qubit x Qubit – with IBM's Qiskit
7. Summary with Q&A





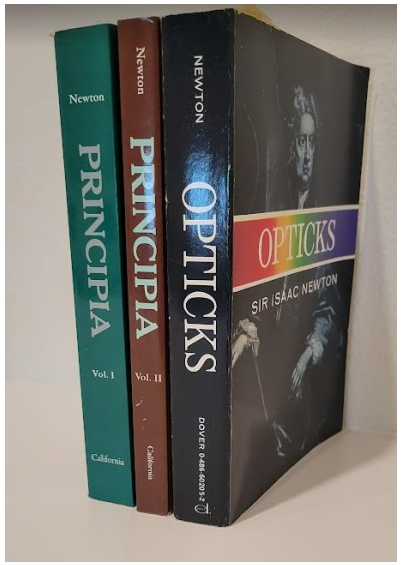
Dimensions of Growth: Population

World Population:
from 1 billion in 1800 to 7 billion in 2012

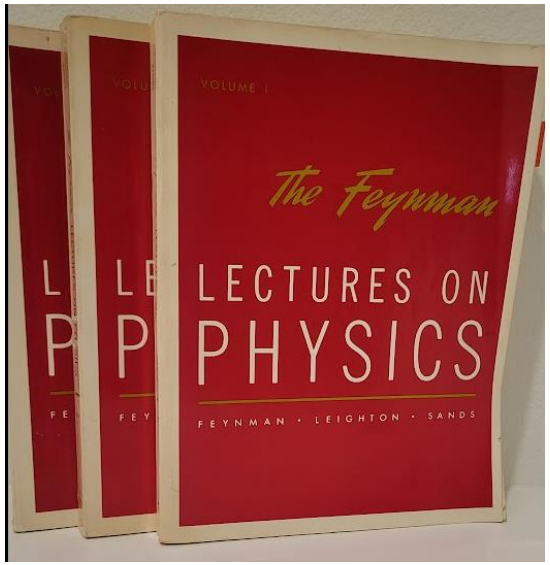
Who learns science and why?

Buckminister Fuller, Synergetics, 1975

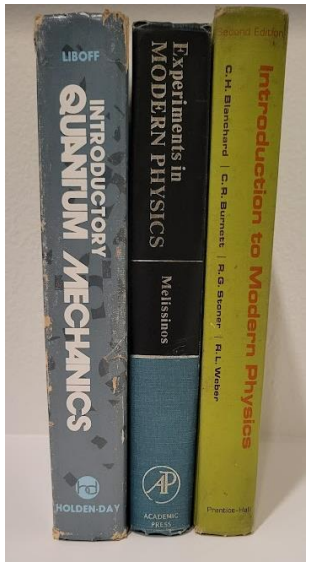
How do we teach physics and to whom?



Newtonian Physics



Feynman Lectures Series



Donn's Quantum Books – 1980s

Seems like students 'self-select' themselves to learn science & technology.

Throughout recorded history, only people with 'time and ability' could learn.

Now many more people have both 'time and ability' to learn science.

But how do we get the message to young people that science is fun and interesting??

Quantum | Pubs &

Quantum for Students

Quantum for Volunteers

Quantum Edu & Work

Quantum Cybersecurity

Donn's Quantum Explorations

EdQuantum - Industry Survey

Home | Quantum | Pubs & Photos | Misc | Contact

Experience Life in the QuantumOptics Age

OpticsAge is a focal point for Donn Silberman's Optics Education Adventures

Weirdness and wonder: Quantum entanglement work wins 2022 Nobel Prize for Physics (spie.org)

OSSC Optical Society of Southern California

FELLOW

Donn's OSSC Bio

OSSC Annual Report 2017-2018

Welcome to EdQuantum Project

HYBRID CURRICULUM IN ADVANCED OPTICS, SPECTROSCOPY, AND QUANTUM TECHNOLOGIES FOR TECHNICIANS

QUBIT X QUBIT

High School Students program starts soon.

Quantum WORLD CONGRESS

Nov. 29 - Dec. 1 , Washington, D.C.

THE UNIVERSITY OF ARIZONA Physics

HONORS COLLEGE 50 years Founded 1962

JWST at the UA

SPIE Fellow

OPTICA SENIOR MEMBER

COLLEGE OF OPTICAL SCIENCES

COLLEGE OF ENGINEERING

PASADENA CITY COLLEGE Laser Technology Program

Optics Outreach Materials donated from the OISC

UCI Division of Continuing Education

Optical Engineering & Optical Instrument Design

UCI Optical Engineering 10 yrs - Photonics Spectra from Sept 2019 Photonics Spectra Magazine

Information Session - August 2019 - YouTube

The Optics Institute Of Southern California

This website is now for archival purposes only to be an educational resource.

Career Assistance Here

SPIE. THE INTERNATIONAL SOCIETY FOR OPTICS AND PHOTONICS

OPTICS & PHOTONICS GLOBAL SALARY REPORT 2022

New Career Assistance page

vital link

OptoBotics℠ Robots need eyes too

This website is now for archival purposes only to be an educational resource.

eLas Americas

This website is now for archival purposes only to be an educational resource. eLas Americas is closed for business. Thank you for your past support.

Starrett

Career Assistance

UC Irvine DCE On-Demand

Wm. Bickel - Collected sayings

New HOME Draft

Experience Life in the (cs Age

OpticsAge is a focal point for Donn Silberm ntures

Weirdness and wonder: Quantum entanglement work cs (spie.org)

Career Assistance

This web page has links to various career assistant and job search websites for the physics, optics, photonics and quantum fields.

More will be added as time goes on. For high school students in Orange County CA, see Vital Link of Orange County

Careers | Optica

Optics and Photonics Jobs

SPIE Career Development | Membership (spie.org)

Education & Careers - IEEE Photonics Society

Physics Today Jobs

Quantum Computing Jobs (quantumcomputingreport.com)

Homepage - Quantum Jobs.net

QED-C | Quantum Jobs | QED-C (quantumconsortium.org)

Hands-On Optics -- Making an Impact with Light

Hands-On Optics

Making an Impact with Light

An educational collaboration of SPIE, OSA, NOAO

Sponsored by The National Science Foundation

A little History 2005

This unique informal science program, funded by the National Science Foundation, pairs optics professionals with science teachers to introduce underserved middle school students to the exciting world of optics. Optics is all about what light is made of and how it behaves. Optics can be found in many everyday situations, from eyeglasses to CD's to hospitals to outer space.

The hands-on, high-interest, standards-connected activities and materials developed by "Hands-On Optics" (HOO) provide six fun and engaging optics activity modules. Educators, parents, science center staff and optics professionals work with HOO activities via informal education programs that range from Saturday morning programs to after-school activities and science center events. HOO serves a dual role: it introduces teachers and students to basic optics concepts. While introducing them to professionals who make a living through optics.

Visit the "Hands-On Optics" Web site: http://www.hands-on-optics.org/

Dr. Murty - The Wizard of Light has been an inspiration for many volunteer optics educators and outreach associates.

FThD2

Optricks Day, Optricks Demos, Optricks Suitcases, Optricks Theme Packets; What are all these Optricks Anyway?

Donn M. Silberman, Optics Institute of Southern California

Abstract
"Optricks" seems to have been coined back in the 1970s by Dr. Murty Mantravadi in Science Today's Series for Young Readers. Recently, it has been applied to outreach tools and activities in his honor.

SPIE. The international society for optics and photonics

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Hands-On Optics | Practical Optics & Photonics Education Tools

Making an Impact with Light
Hands-On Optics (HOO) was a four-year informal science education program funded by a $1.7 million grant from the National Science Foundation (NSF). The project was collaboration between SPIE, the Optical Society of America (OSA) and the National Optical Astronomy Observatory(NOAO).

The program brought science education enrichment to thousands of underrepresented middle school students in more than ten states, including female and minority students, who typically have not been the beneficiaries of science and engineering resources and investments. HOO provided more than 100 teachers with up to six activity modules, each containing enough materials for up to 30 students to participate in 6-8 hours of hands-on optics-related activities. Sample activities, developed by education specialists at NOAO, include building kaleidoscopes and telescopes, communicating with a beam of light, and a hit-the-target laser beam challenge.

Through these activities, students gain experience and understanding of optics principles, as well as learning the basics of inquiry, critical thinking, and problem solving skills involving optics, and how optics interfaces with other disciplines. While the modules were designed for use in informal after- school or weekend sessions, the number of venues has expanded to large and small science centers, Boys and Girls Clubs, Girl Scouts, summer camps, family workshops, and use in the classroom.

Hands-On Activities

I'm Under a Lot of Stress Here! — **Polarization**
Structural engineers and other scientists are always trying to find ways to make structures lighter and stronger.

Fun With the Sun
The Sun gives off a great deal of energy in the ultraviolet (UV) range of the EM spectrum.

Hit the Target
This is the culminating activity, requiring students to use all the practiced skills from the previous activities.

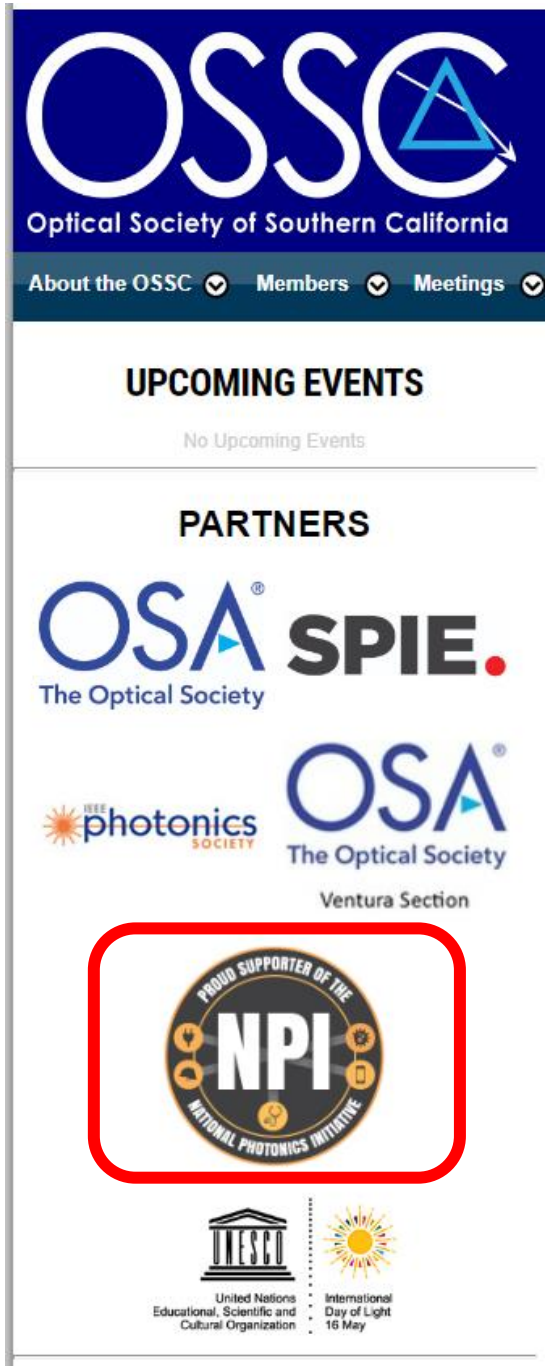
Three Lasers Converging at a Focal Point: A Demonstration — **Lasers & Lenses**
In this activity, students will see how we can use the property of refraction to focus parallel rays of light.

Laser Light: An Activity
This simple activity will help students visualize the difference between laser light and normal light.

Multiple Reflections
We know that when light reflects off a plane mirror, the image appears left/right reversed.

Currently available !!

Polarization and Lasers can help educate students about Quantum.



NATIONAL PHOTONICS INITIATIVE

What Is The NPI?

In 1998, the National Research Council released a report, "Harnessing Light: Optical Science and Engineering for the 21st Century," that presented a comprehensive view of the potential impact of optics and photonics on important industries. In response, several economies – including Germany, China, and the European Union – advanced their already strong optics and photonics sectors. The United States, however, did not develop a cohesive strategy, leaving us at risk of falling sharply behind.

In 2012, the National Research Council released a follow-up report to Harnessing Light - titled "Optics and Photonics: Essential Technologies for our Nation" - that called for an umbrella organization to identify and advance areas of photonics critical to maintaining competitiveness and national security. Heeding the call five organizations – The Optical Society (OSA); SPIE, the international society for optics and photonics; the IEEE Photonics Society (IPS); the Laser Institute of America (LIA); and the American Physical Society (APS) Division of Laser Science – worked together to form a National Photonics Initiative (NPI).

AIM PHOTONICS

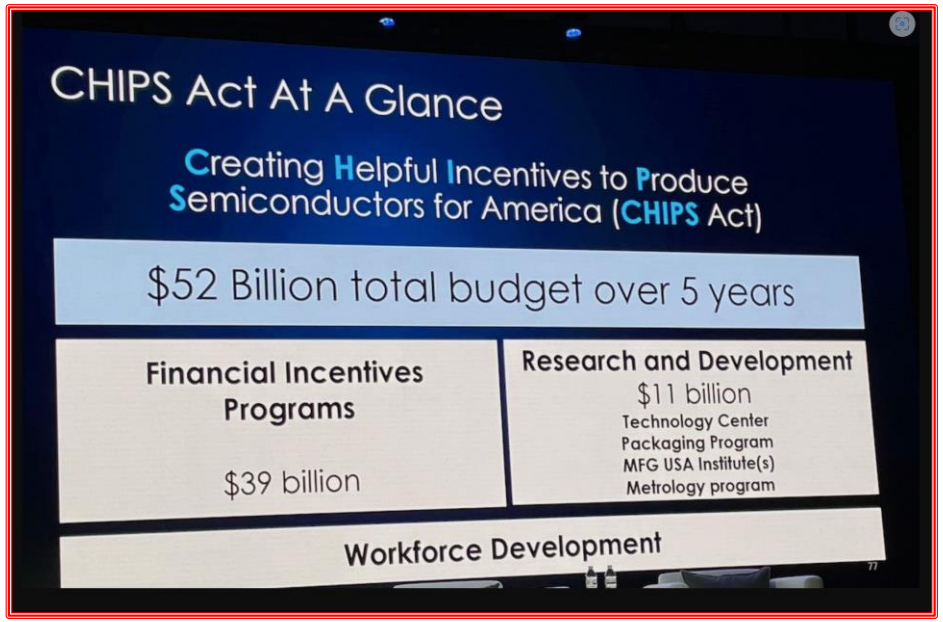
DEPARTMENT OF DEFENSE
MANUFACTURING INNOVATION INSTITUTES

Formation

In 2014, the United States Office of the Secretary of Defense identified interest in developing a Manufacturing Innovation Institute in the field of integrated photonic circuits. This resulted in the Air Force Research Laboratory publishing a funding opportunity announcement (FOA-RQKM-2015-0009) which ultimately lead to the award of the Integrated Photonics Institute for Manufacturing Innovation operating under the name of the "American Institute for Manufacturing Integrated Photonics." The Research Foundation for The State University of New York and The United States of America USAF/AFMC entered into Cooperative Agreement Number FA8650-15-2-5220, dated July 9, 2015 for Phase I of AIM Photonics. On September 29, 2021, a new cooperative agreement was signed and extends federal funding for the institute for another seven years.

The Research Foundation for The State University of New York, acting on behalf of SUNY Polytechnic, serves as the administrator of AIM Photonics. AIM Photonics is an unincorporated research and development center. AIM Photonics operates as a program of SUNY Poly, with the Foundation and SUNY Poly providing administrative support to AIM Photonics, and jointly participating in AIM Photonics as an AIM Photonics member.

And recently we have the new CHIPS Act



AIM Photonics announcement on COVID-19

AIM PHOTONICS

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- TEACHING RESOURCES
- PHOTONICS WORKFORCE ROADMAP

We offer start-ups, designers and developers, and academic researchers access to a supporting infrastructure of services across the entire silicon photonics development cycle: design, simulation, fabrication, packaging, validation, and a path to volume manufacturing.

https://www.aimphotonics.com/education

Motivatic

An official website of the

⟨quantum|g

NATION

THE FEDERAL SOUR

Welcome to *quan*

Quantum Initiative and ong

Quantum Information Scie

Act was signed into law on

OSSC
Optical Society of Southern California

Meeting Announcement

June 12, 2019

Annual Business Meeting

Quantum Computing & The National Quantum Initiative

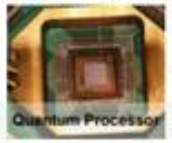
Dr. Sandy Irani, UC Irvine & Dr. Jonathan Habif, USC

Quantum computing is the use of quantum-mechanical phenomena such as superposition and entanglement to perform computation. A quantum computer is used to perform such computation, which can be implemented theoretically or physically.

The National Quantum Initiative (NQI) Act is an Act of Congress passed on December 13, 2018 and signed into law on December 21, 2018. The law gives the United States a plan for advancing quantum technology, particularly quantum computing. OSSC Fellow Donn Silberman will briefly review the NQI and introduce our speakers.

Visit https://www.opticsage.com/donn-s-quantum-explorations to explore these topics prior to the meeting.

About our speakers: **Dr. Sandy Irani** received her PhD from UC Berkeley in 1991 after which she was a University of California President's Postdoctoral Fellow at UCSD. She joined the faculty of UC Irvine in 1992 where she is currently a full professor. Much of her research has focused on algorithm design and analysis with an emphasis on applications to computing systems. In the last few years she has been working in Quantum Computation and Quantum Information Science.



Dr. Jonathan L. Habif is an experimental physicist and research lead at the University of Southern California information Sciences Institute (ISI). His research has focused on photon-starved, classical communication and imaging, quantum-secured optical communications in free-space and fiber, and integrated nano-photonic for both classical and non-classical applications. Prior to joining ISI, Dr. Habif was with BBN technologies where he served as principal investigator for a number of DARPA-sponsored research programs, partnering with university collaborators to demonstrate revolutionary optical technologies impacting traditional communications, sensing and computation systems.

Reception: 6:00; Dinner starts @ 6:30
OSSC Business: 7:00; Presentations: 8:00
Dinner – Cost: $35
$40 after June 7th
OSSC Student Members: $10,
$20 after June 7th

Brea Civic & Cultural Center
1 Civic Center Circle
Brea, CA 92821
(714) 990-7600

On-line Registration: www.ossc.org or
Contact: Alex Small, **OSSC** Arrangements Chair,
arsmall@cpp.edu
(909) 869-5202

REPORTS NEWS NQCO Search...

NT

egic Plan, February 1, 2022

December 6, 2021

nformation Science, October 5, 2021

OSSC EDUCATION & OUTREACH

Optical Society of Southern California

From OSSC Oct 2022 meeting

SPIE. OPTICS + PHOTONICS

Conference 12213

Optics Education and Outreach VII

22 August 2022 | Conv. Ctr. Room 17B

QUBIT X QUBIT

IBM Sponsored High School program

UCI Division of Continuing Education

Optical Engineering & Optical Instrument Design

SAMUELI ACADEMY

SCHRÖDINGER'S CLUB AT SAMUELI ACADEMY

Quantum WORLD CONGRESS

Nov. 29 - Dec. 1, Washington, D.C.

PASADENA CITY COLLEGE

Laser Technology Program

Brown Bag Educational Lunch Series

Introducing optics to undergraduate ECE students and photonics outreach projects

Brown Bag Series

October 5th, 2022

12 – 1 PM

Speaker:

UCSD SPIE Student Chapter

DRS DAYLIGHT SOLUTIONS

Recruiting Workshop

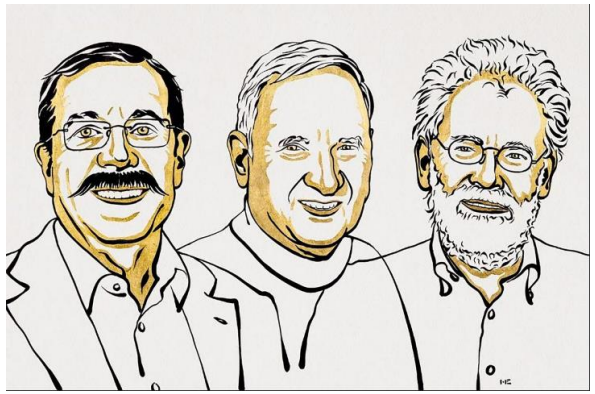
Friday Nov. 18th

vital link

Corona Del Mar High School

Python Programming Class

Tues. Nov. 22 – Intro to Quantum Computing



Weirdness and wonder: Quantum entanglement work wins 2022 Nobel Prize for Physics

Alain Aspect, John Clauser, and Anton

From OSSC Oct 2022 meeting

OSSC Optical Society of Southern California EDUCATION & OUTREACH

SPIE. OPTICS+ PHOTONICS **Optics Education and Outreach VII**
22 August 2022 (recording available)

SPIE. DIGITAL LIBRARY

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3 October 2022

Quantum education and pathways: an open-source modifiable presentation to high school and college students

Donn M. Silberman

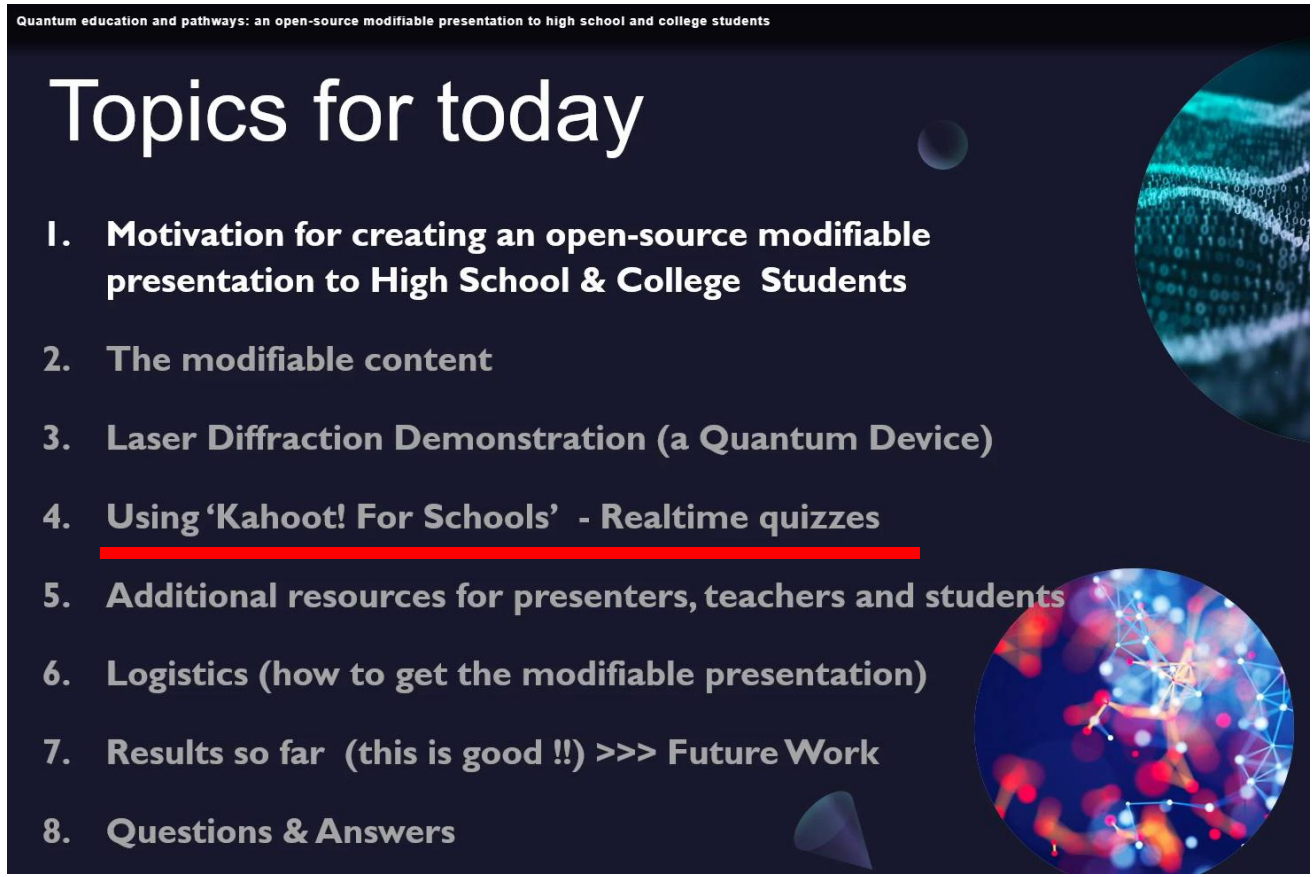
Author Affiliations +

Proceedings Volume 12213, Optics Education and Outreach VII; 1221308 (2022)
https://doi.org/10.1117/12.2641537
Event: SPIE Optical Engineering + Applications, 2022, San Diego, California, United States

ARTICLE | CITED BY

Abstract

This paper describes and provides examples of a presentation, 'Quantum for High School and College Students' created to give to high school and college students to encourage them to consider using quantum science and technologies in their studies and careers. Some thoughts on critical thinking about abstract subjects and mentoring capture the attention of the student audience, which is followed by the main topics. The presentation includes an introduction to quantum science (including a laser diffraction demonstration), quantum computers and cybersecurity, many more quantum science and technology applications, education and career pathways that use quantum science and on-line resources. There is a very brief history of



Quantum for Volunteers | opticsage (donn601.wixsite.com)

Motivation:

12213-19

Upskilling photonics technicians to meet challenges of quantum 2.0 revolution

Author(s): Moamer Hasanovic, Indian River State College (United States); Chrysanthos Panayiotou, LASER-TEC, National Ctr. for Laser-Photonics and Fiber Optics Education (United States); Donn Silberman, Optics Institute of Southern California (United States)

Hide Abstract –

A presentation was given in afternoon during the August SPIE Conference..

Recent advances in quantum research have created a significant mismatch between quantum science and the emerging quantum industry, as there is no sizable trained workforce to support product commercialization. Part of this new workforce will be developed through upskilling of incumbent photonics technicians whose current qualifications present a solid foundation for the new quantum-related competencies. To provide the greatest access to these new skills, the curriculum requirements need to be delivered via flexible distance-learning platforms. In this paper, we describe our efforts to produce an open-access educational curriculum to introduce new quantum-related competencies to an incumbent workforce. A detailed list of the competencies sought by the quantum industry is given followed by the results of a survey through which the proposed competencies were assessed. This project pioneers the introduction of the complex subject of quantum science to advanced technological education. The proposed curriculum is expected to help the US maintain the world lead in quantum technologies. This project is funded by the NSF Advanced Technological Education grant that focuses on the education of technicians for advanced technologies that drive the nation's economy.

Quantum Technician Skills and Competencies for the Emerging Quantum 2.0 Industry (SPIE Optical Engineering)
Authors: Mo Hasanovic, Chrys Panayiotou, Donn Silberman, Paul Stimers, and Celia Merzbacher
Available on-line Apr. 9, 2022 - Open Access at the link above. To be published in hardcopy form August 2022

Motivation:

Quantum Technician Skills and Competencies for the Emerging Quantum 2.0 Industry (SPIE Optical Engineering)

6 Alignment with the NSB Vision 2030 Roadmap

The EdQuantum project will specifically develop STEM talent for America by researching any ongoing quantum educational efforts at a middle and high school level using the support structure and network of our partners such as LASER-TEC. To develop a smart workforce, the EdQuantum will integrate into the curriculum higher-level skills such as critical thinking, problem-solving, creativity, and digital literacy as well as the STEM pedagogy and practices for diversity and inclusion. To help fill the quantum education pipeline for future years, the EdQuantum project will use educational tools and recruiting networks for K-12 so EdQuantum students, teachers, and professional industry volunteers can work with K-12 educators in their local regions to prepare K-12 students for college and university programs that include quantum technologies. To expand our outreach across the country, the EdQuantum team will leverage the assets of the Optics and Photonics College Network (OPCN)—currently consisting of 44 college programs in 29 states (see Fig. 4)—to promote the quantum educational content.

Optics & Photonics Education Pipeline, now will include Quantum

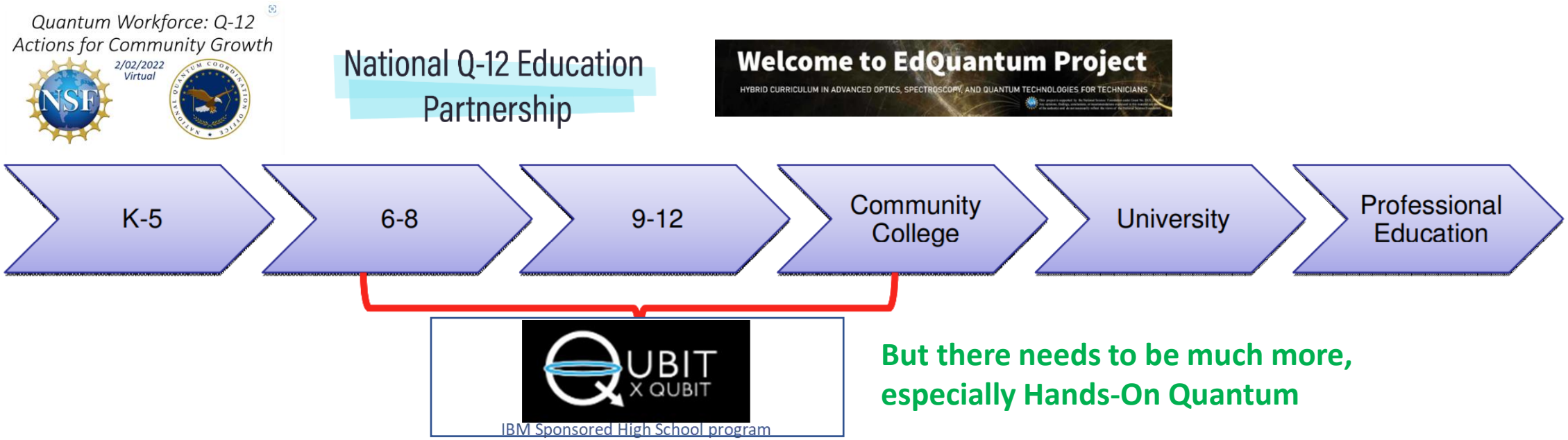
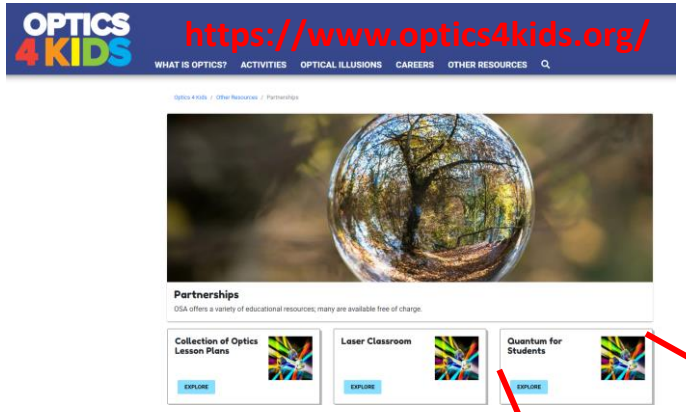


FIG. 1. This Optics education pipeline shows where OptoBotics fits into the progression of optic education outreach.

The Quantum Industry is built on top of the optics, lasers, photonics, semiconductor & general physics fundamentals.

Optics Education and Outreach III, edited by G. Groot Gregory, Proc. of SPIE Vol. 9188,
91880E © 2014 SPIE · CCC code: 0277-786X/14/$18 · doi: 10.1117/12.2061268

The Quantum Education & Outreach – Paths Forward

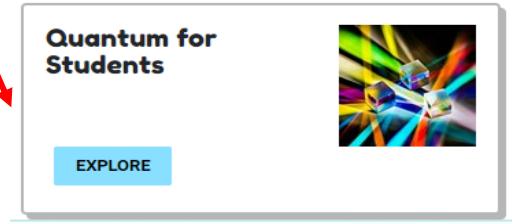


SPIE. The international society for optics and photonics
Student Chapters and Clubs

OPTICA | Formerly OSA
Get Involved
Student Chapters

Working with local Non-profits
Linking K-12 school districts to industry
And local colleges and universities

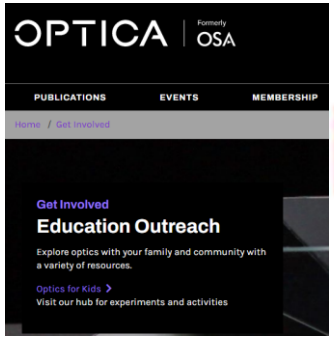
Working with local SPIE, Optica, IEEE Photonics and other College Student Clubs to reach out to local high schools



[Quantum for Students | opticsage (donn601.wixsite.com)]

SAMUELI ACADEMY
SCHRÖDINGER'S CLUB
AT SAMUELI ACADEMY

vital link
Corona Del Mar High School
Python Programming Class
Tues. Nov. 22 – Intro to Quantum Computing



Brown Bag Educational Lunch Series
Introducing optics to undergraduate ECE students and photonics outreach projects

October 5th, 2022
12 – 1 PM

Speaker:
UCSD SPIE Student Chapter

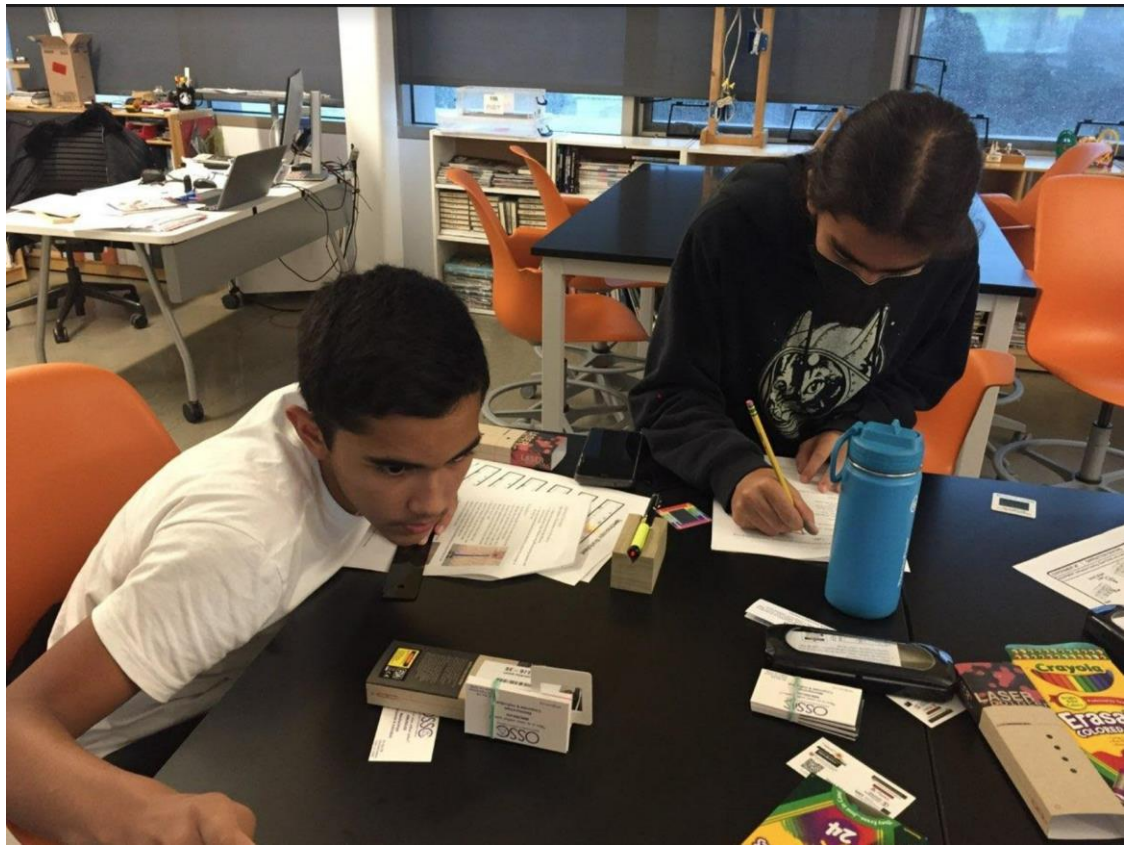
DRS DAYLIGHT SOLUTIONS

High School Quantum Workshop
Friday Nov. 18th

SAMUELI ACADEMY

SCHRÖDINGER'S CLUB AT SAMUELI ACADEMY

Hands-On Laser Diffraction, Polarization & Spectroscopy



SCHRÖDINGER'S CLUB

AT SAMUELI ACADEMY

Introduction to Quantum Cryptography

with a hands-on polarization laser lab

Today's Agenda:

1. Introduction to light as an electromagnetic wave & polarization
2. Introductory polarization lab
3. Quantum Measurements using polarization
4. Introduction to Quantum Cryptography
5. Quantum Cryptography lab with polarization filters and lasers

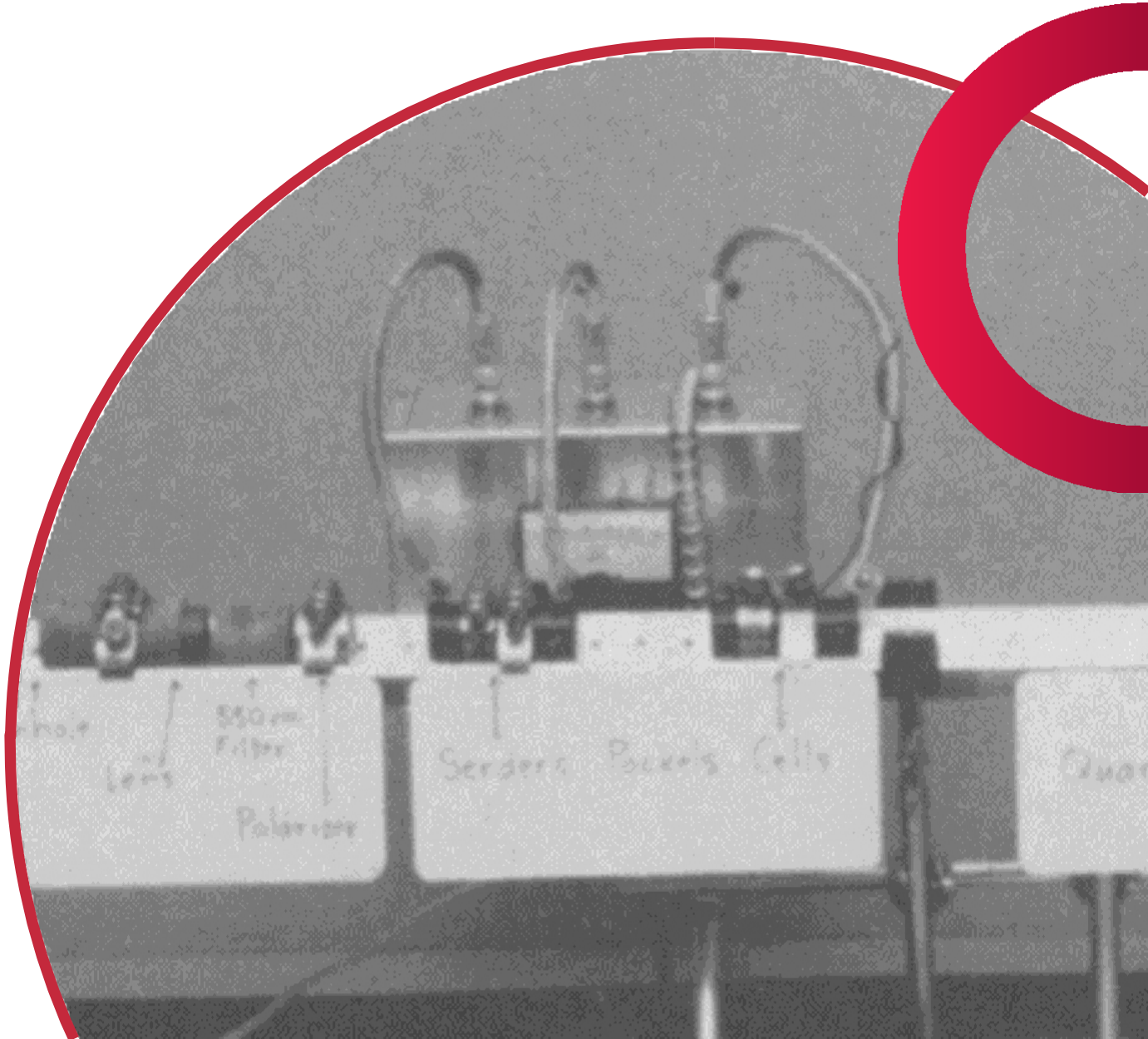
Donn Silberman

Mentor

The Optics Institute
Of Southern California

UNIVERSITY OF WATERLOO | IQC Institute for Quantum Computing

QUANTUM CRYPTOGRAPHY for High School Students

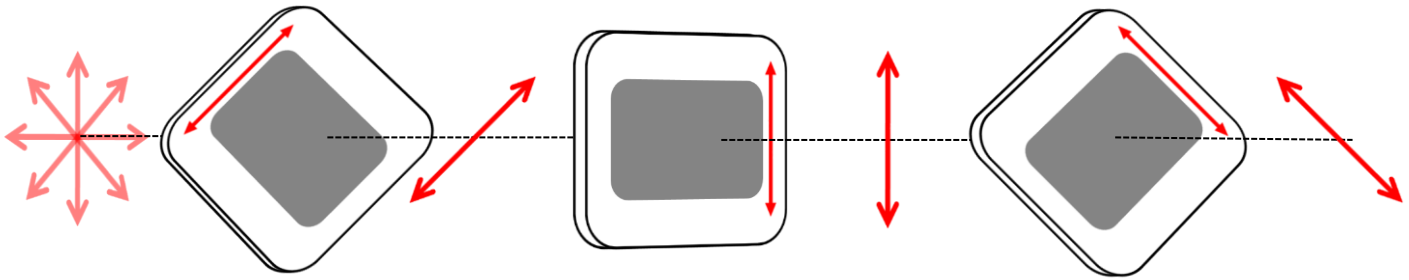


Learning Objectives

- The role of probabilities in quantum mechanics
  - Outcomes are not *necessarily* definite
- The nature of quantum superposition
  - Superposition as a *relative* concept
- Measurement disturbance
  - We can't make two *incompatible* measurements at once
- We can apply these ideas to build technologies
  - Quantum cryptography is based on quantum measurement

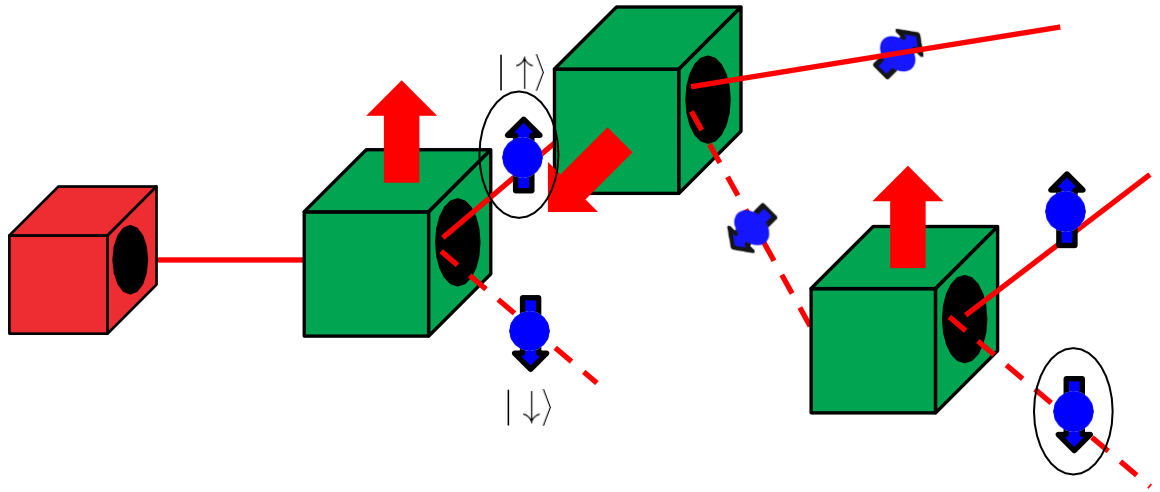
Polarization and Spin

The three-polarizer experiment is mathematically equivalent to the Stern-Gerlach experiment



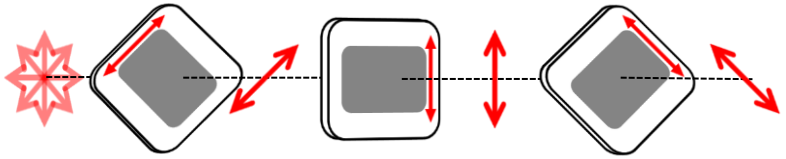
Polarized Photons

Spin-Polarized Electrons

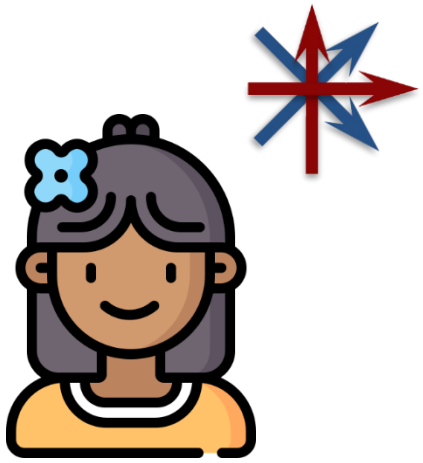


Check out the simulation on QuVis!
www.st-andrews.ac.uk/physics/quvis/
"Measurement Uncertainty" Demo

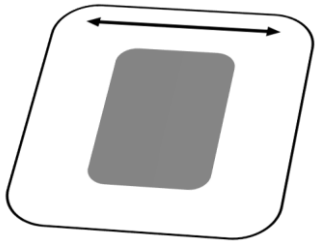
Quantum Key Distribution



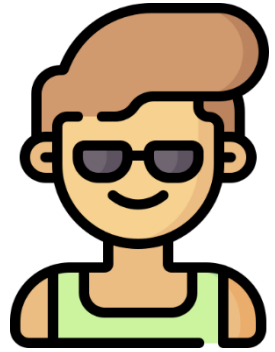
Remember the three polarizers?



Alice



EVE

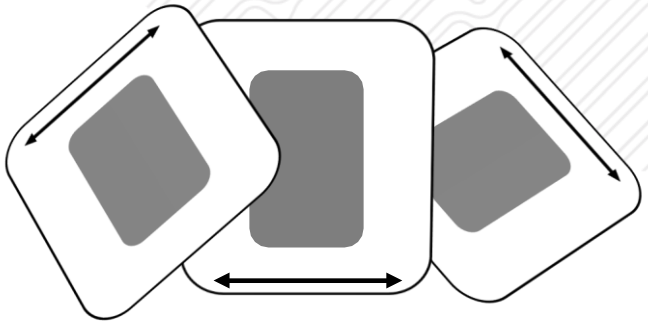


Bob

If the eavesdropper intercepts,
they'll disturb the polarization state

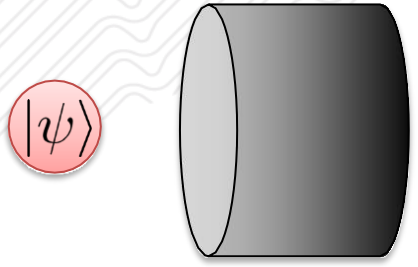
The Heart of Quantum Key Distribution

Measurement Disturbance



When we measure a quantum state, we disturb it

The No-Cloning Theorem



FORBIDDEN

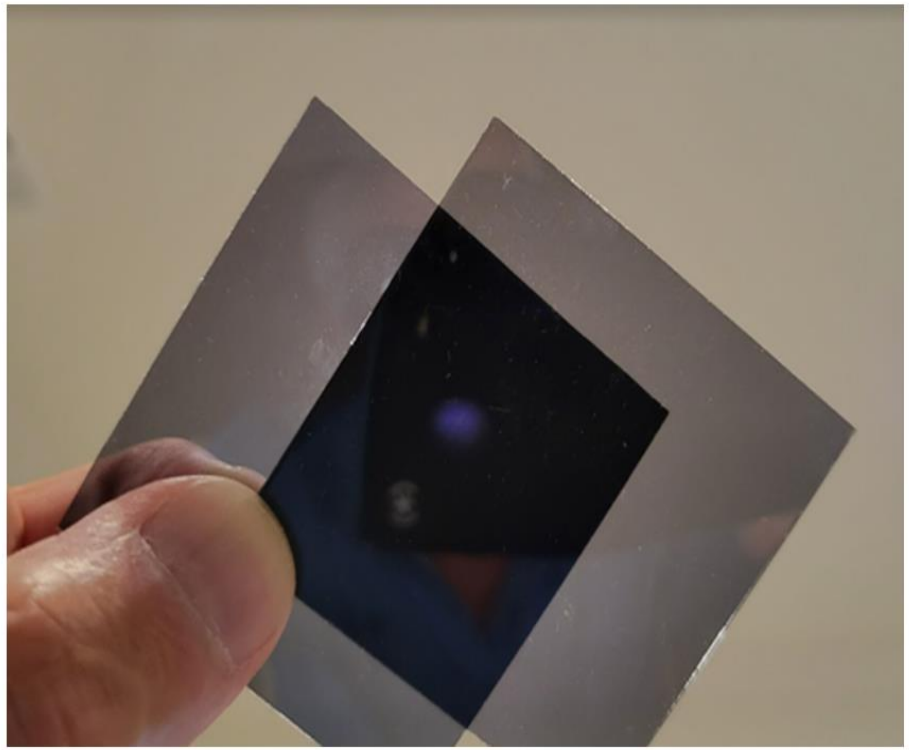
Polarization Qubits

	HV BASIS	±45° BASIS
0	→	↗
1	↑	↘

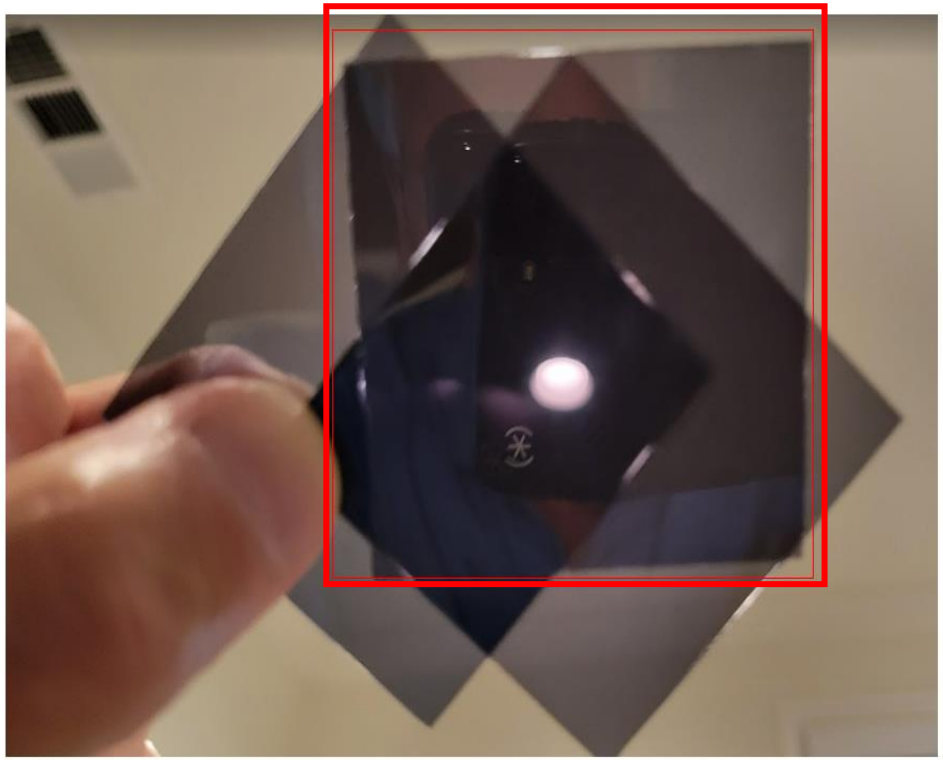
Encode binary “0” or “1” as a polarization state, with two possible bases

	H/V measurement	A/D measurement
→	H for sure	random ?
	? V for sure	random
	random ?	D for sure ?
	random	A for sure

Polarization Filters



Ceiling light – both **P(h & v)** filters



Ceiling light – both **P(h & v)** filters

Plus a third **P** filter at 45 deg !!!

(sandwiched in-between

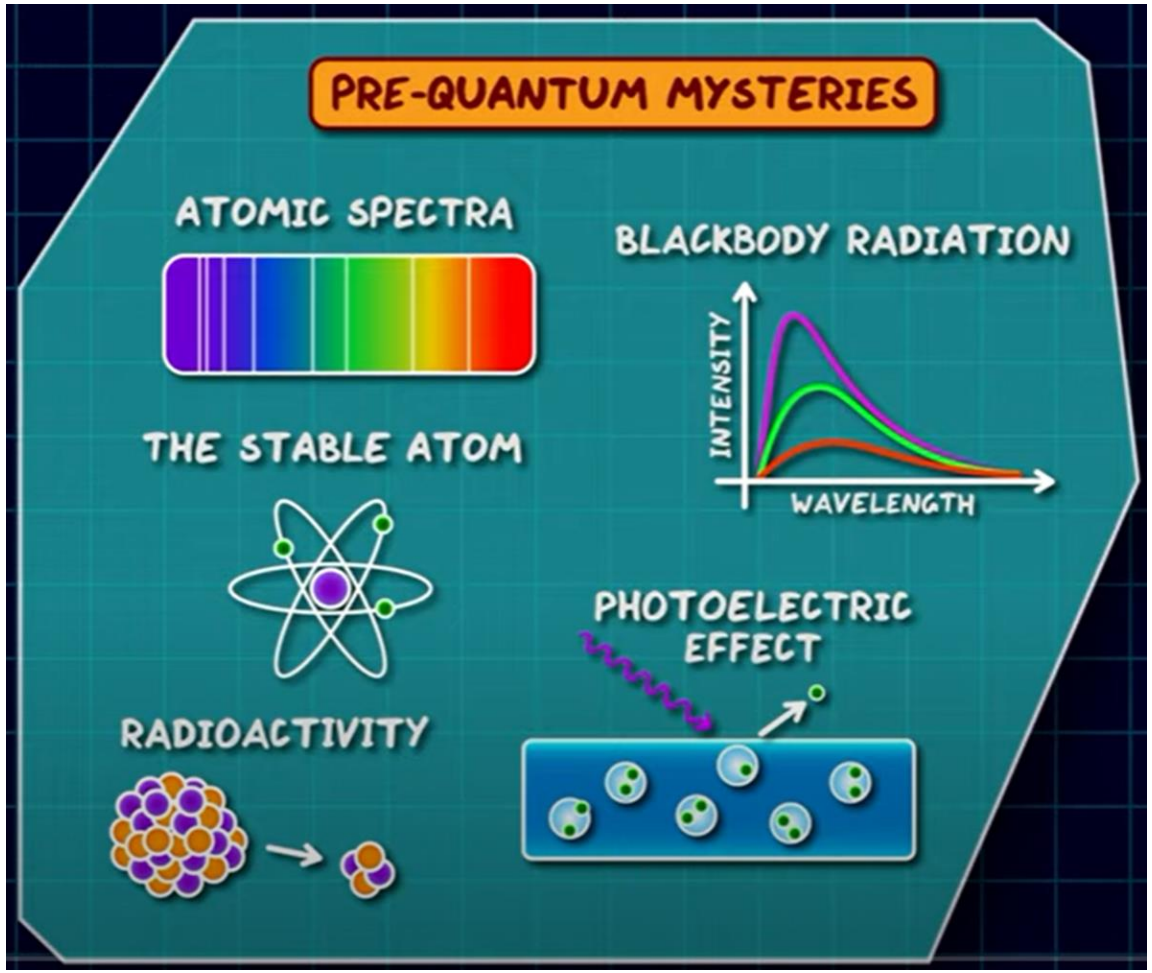
Polarization Filters with a Polarized Laser

Laser with P(h+v) filters

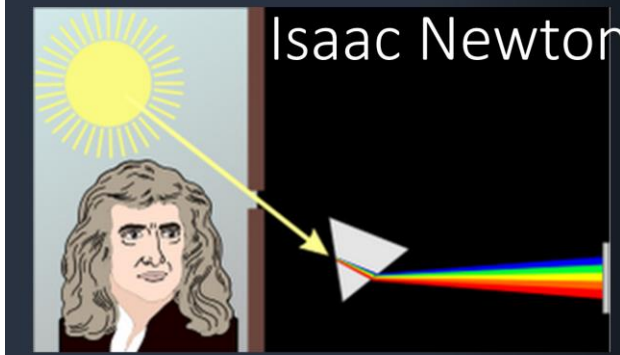
Laser with P(h+ v + 45) filters

SAMUELI ACADEMY

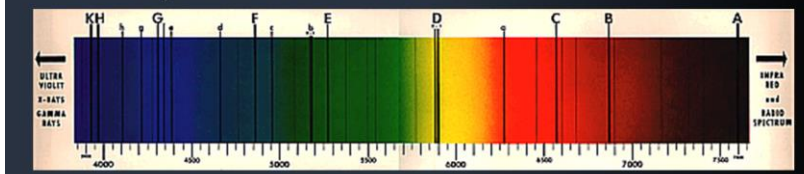
SCHRÖDINGER'S CLUB AT SAMUELI ACADEMY



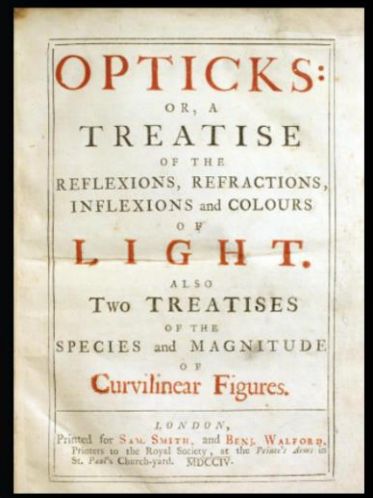
Isaac Newton & the Prism



The Solar Spectrum with Fraunhofer Lines



Discrete spectral lines correspond to the energy levels of various atoms that are burning in the Sun.


OPTICKS:
OR, A
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OF THE
REFLEXIONS, REFRACTIONS,
INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.
LONDON,
Printed for SAM. SMITH, and BENJ. WALFORD,
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St. Paul's Church-yard. MDCCIV.

The first, 1704, edition of *Opticks: or, a treatise of the reflexions, refractions, inflexions and colours of light.*

Laser Light Distribution Patterns

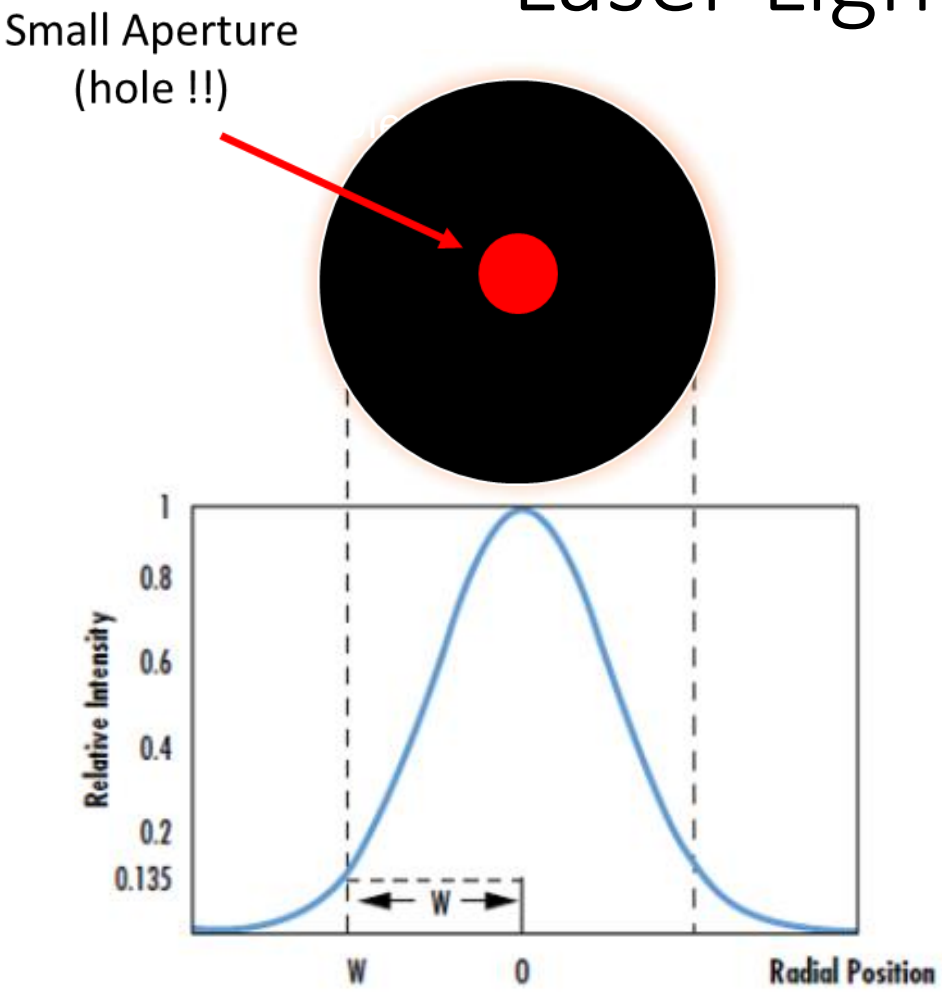
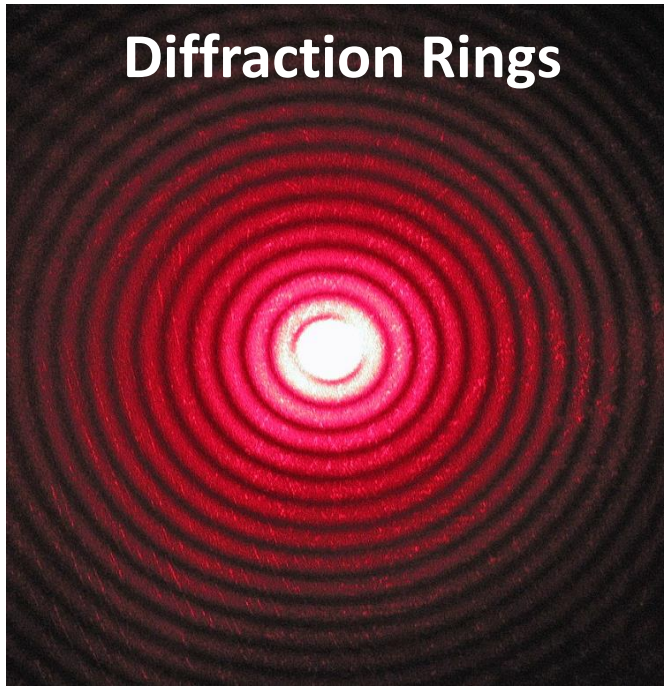


Figure 1: *The waist of a Gaussian beam is defined as the location where the irradiance is $1/e^2$ (13.5%) of its maximum value*



A diffraction pattern of a red laser beam projected onto a plate after passing through a small circular aperture in another plate

Laser Interference - Diffraction - Wikipedia

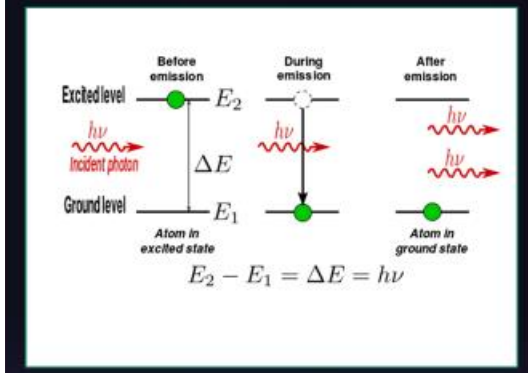
Gaussian Beam Propagation | Edmund Optics

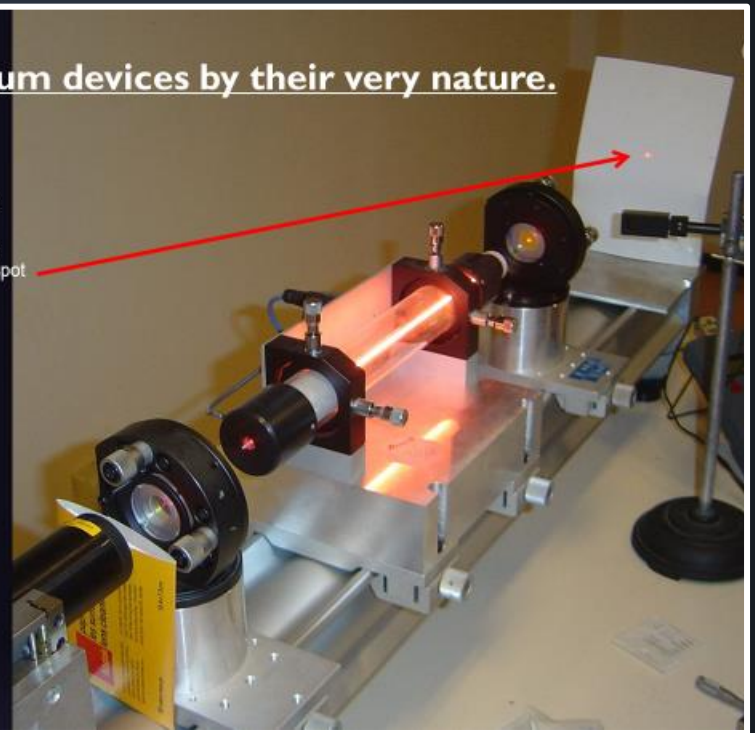
A brief introduction to lasers as quantum devices and
A nice diffractive optics demonstration to keep their attention.

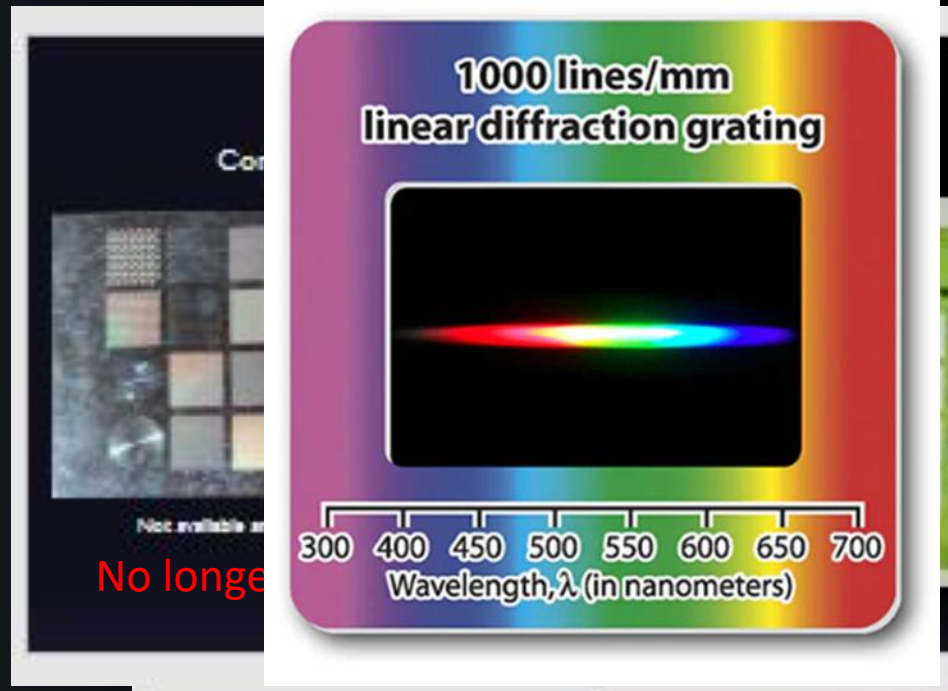
There is a video of the demonstration if presenters do not have a nice diffractive demo slide.)

Lasers are intrinsically quantum devices by their very nature.

A helium–neon laser demonstration. The glow running through the center of the tube is an electric discharge. This glowing plasma is the gain medium for the laser. The laser produces a tiny, intense spot on the screen to the right. The center of the spot appears white because the image is overexposed there.





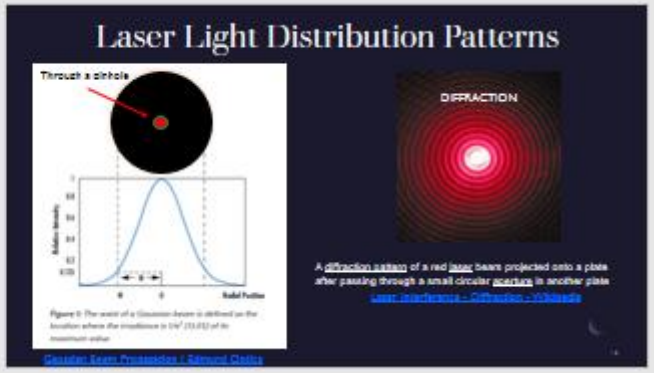


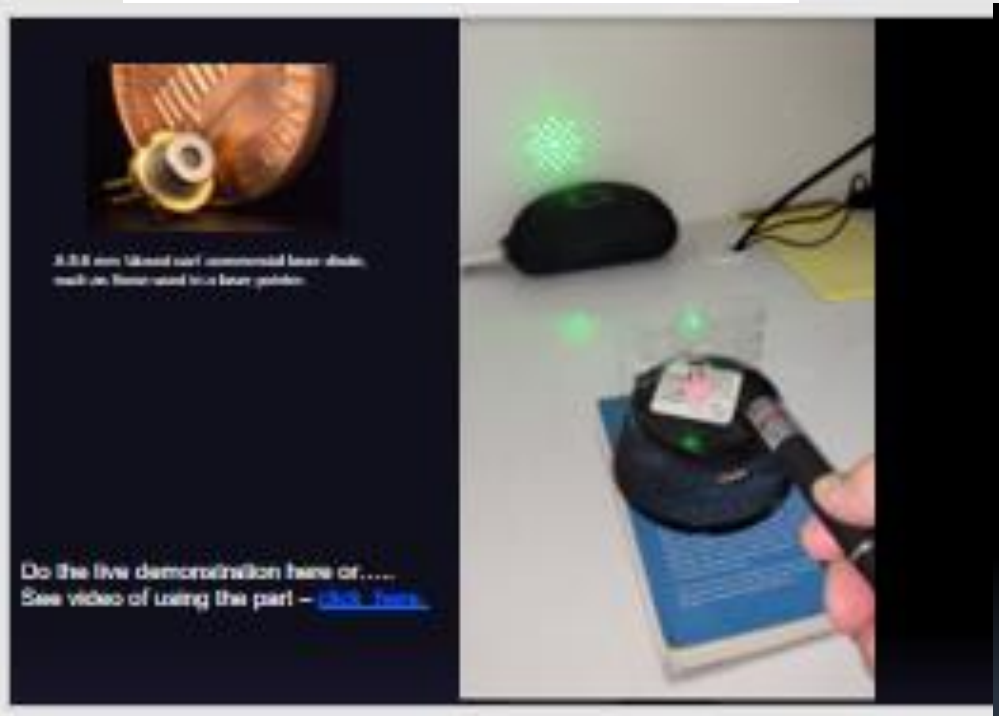
No longe

THE LASER

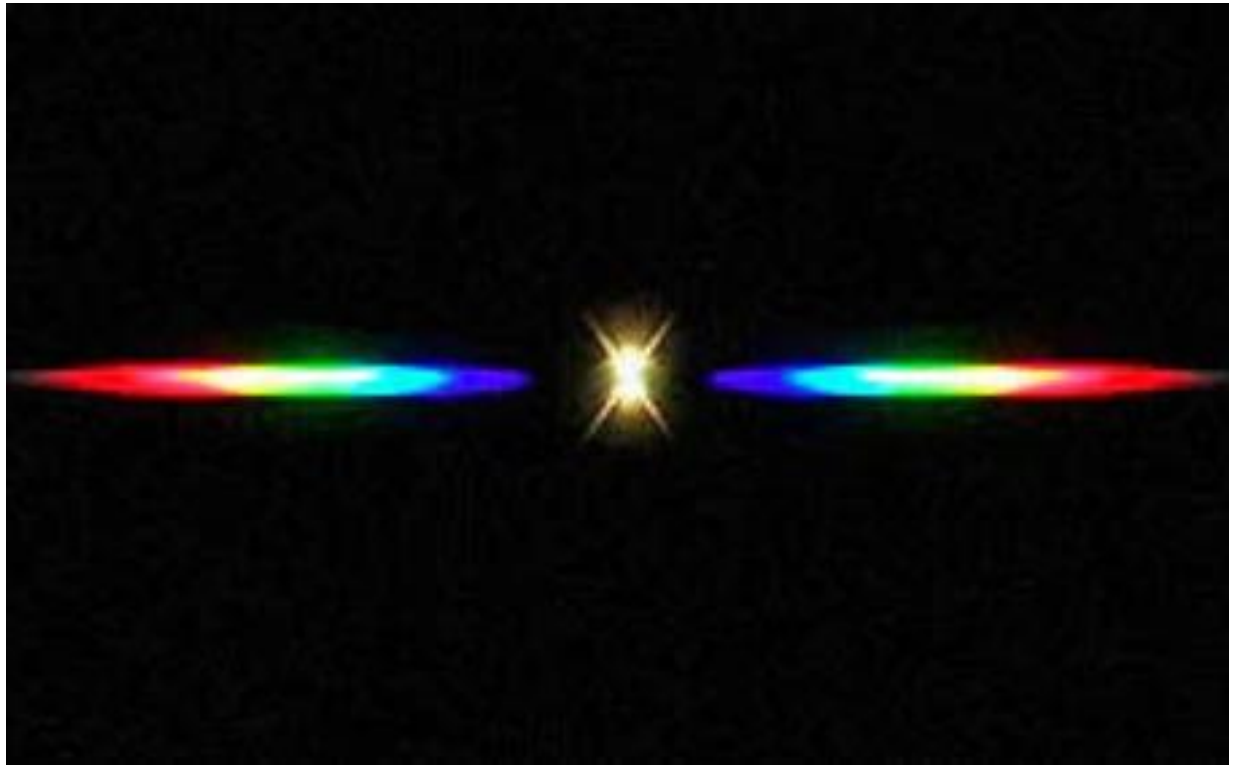
All the animations and explanations on www.toutmiquantique.fr

Also included is a short video on laser basics.





Diffraction Gratings



The grid of bumps in the plastic **diffract** the colors of the white light into the **visible spectrum**.

Diffraction Gratings

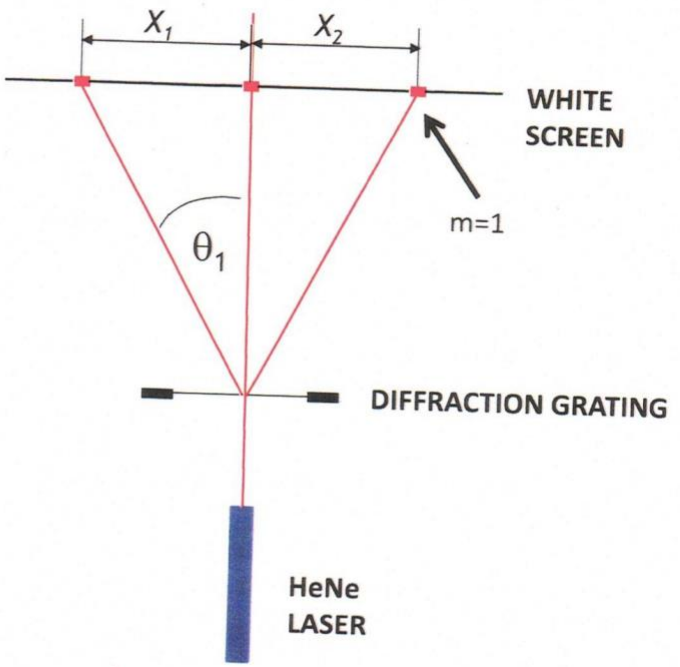
17. DETERMINING LASER WAVELENGTH USING GRATING

Perform the calculations below (see the figure).
Diffraction equation states the following:

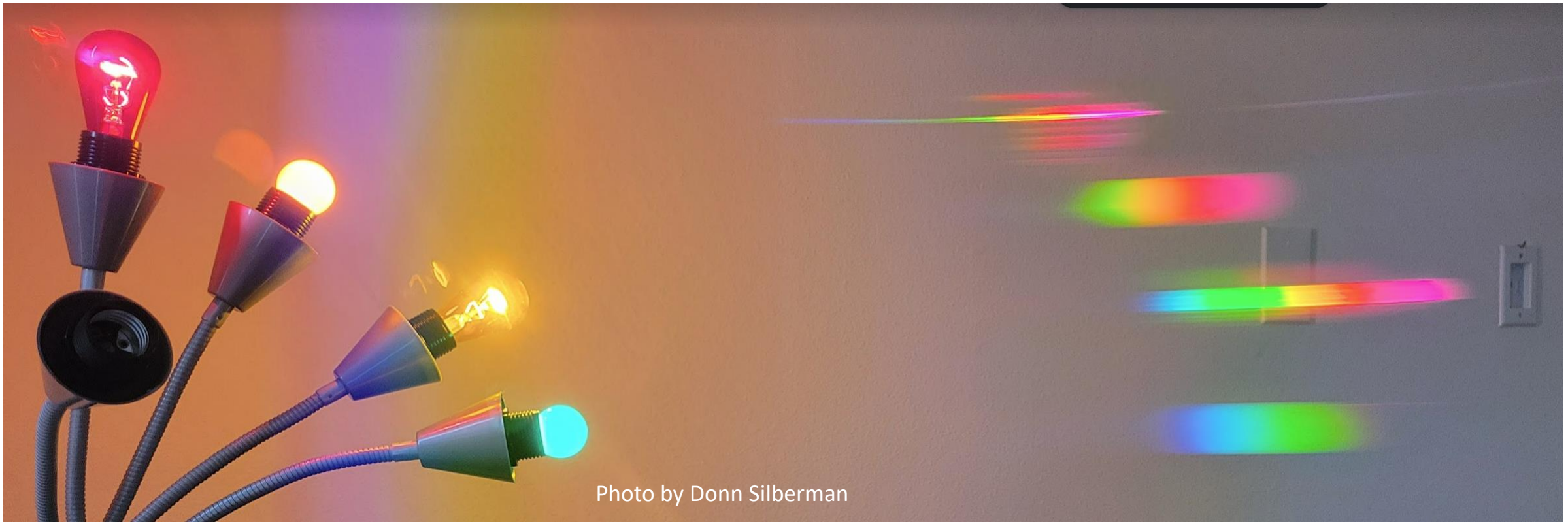
$$m\lambda = d \sin\theta_m$$

where m is the order of the dot relative to the center, θ_m is diffraction angle, and λ is wavelength of the laser beam light. In our case (since we are considering two dots immediately next to the center dot), m =1:

$$\lambda = d \sin\theta_1$$

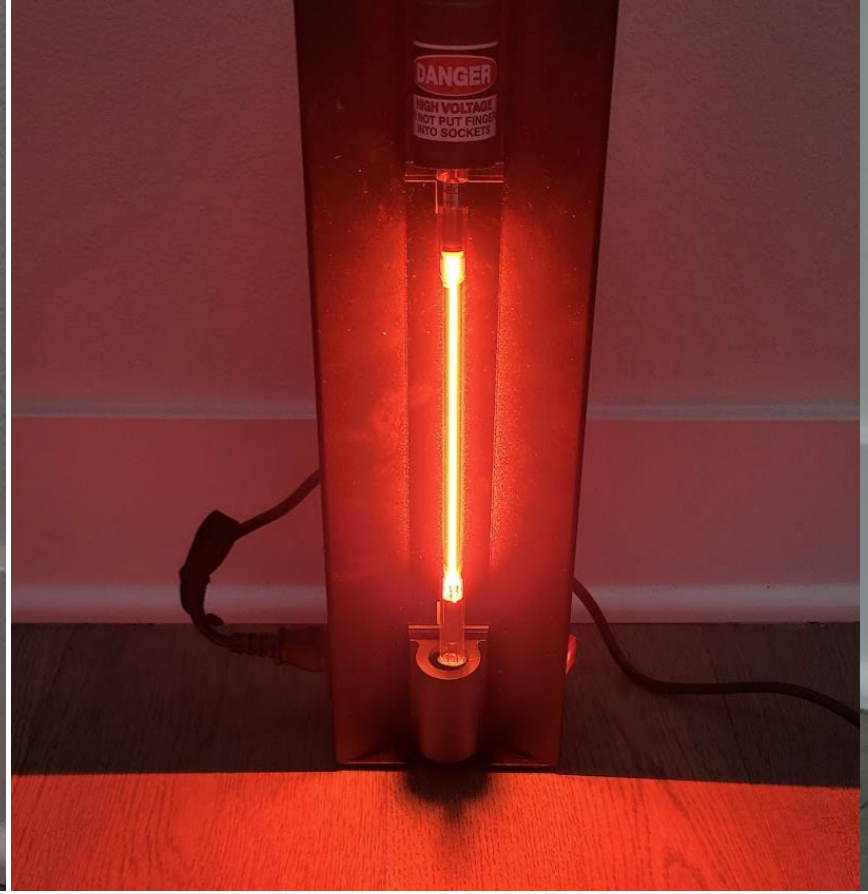


Spectroscopy & Diffraction Gratings



Specialty Light Bulbs with photo taken through a diffraction grating.

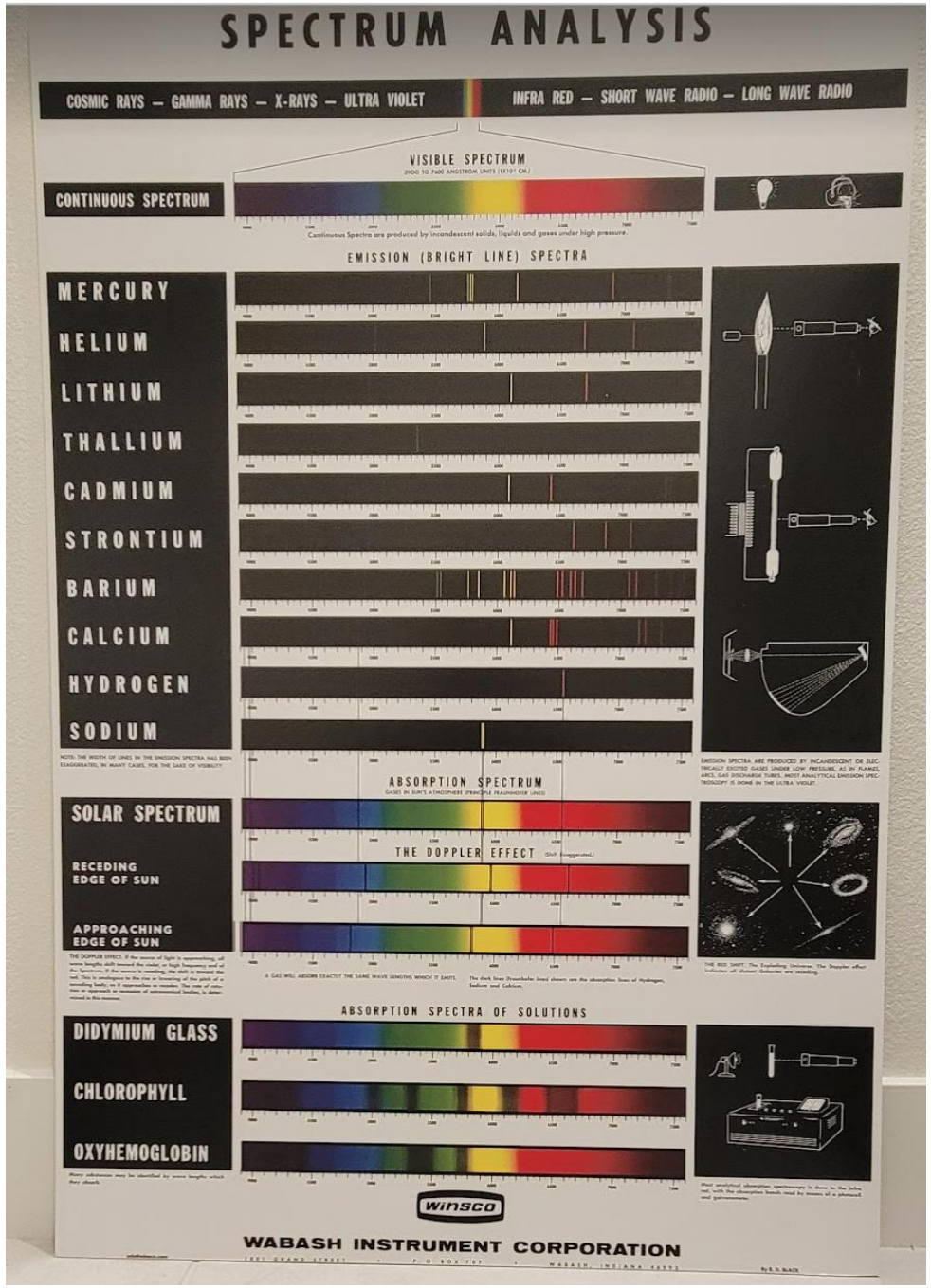
The images of the spectra are blurry compared to when you look through the grating with your eyes.
Try it on your own and draw what you see on the Spectroscopy worksheet.

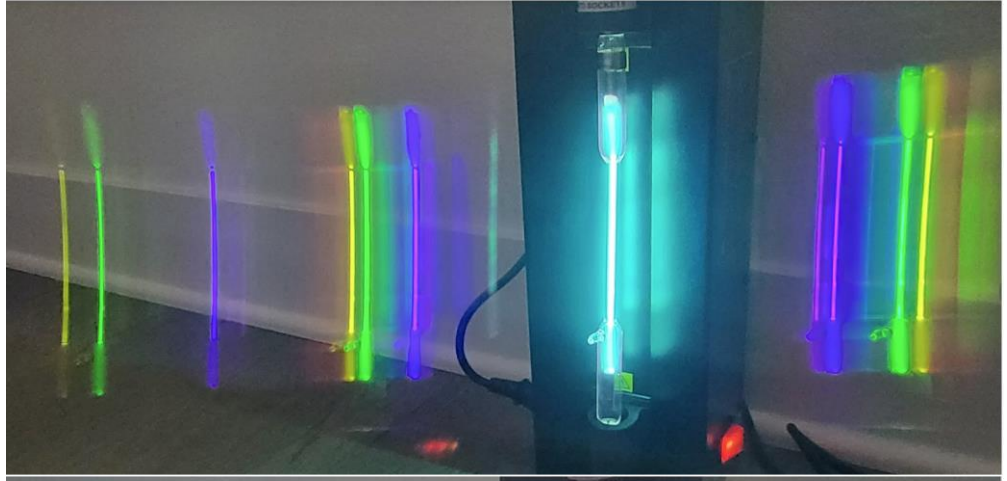


Spectroscopy & Diffraction Gratings

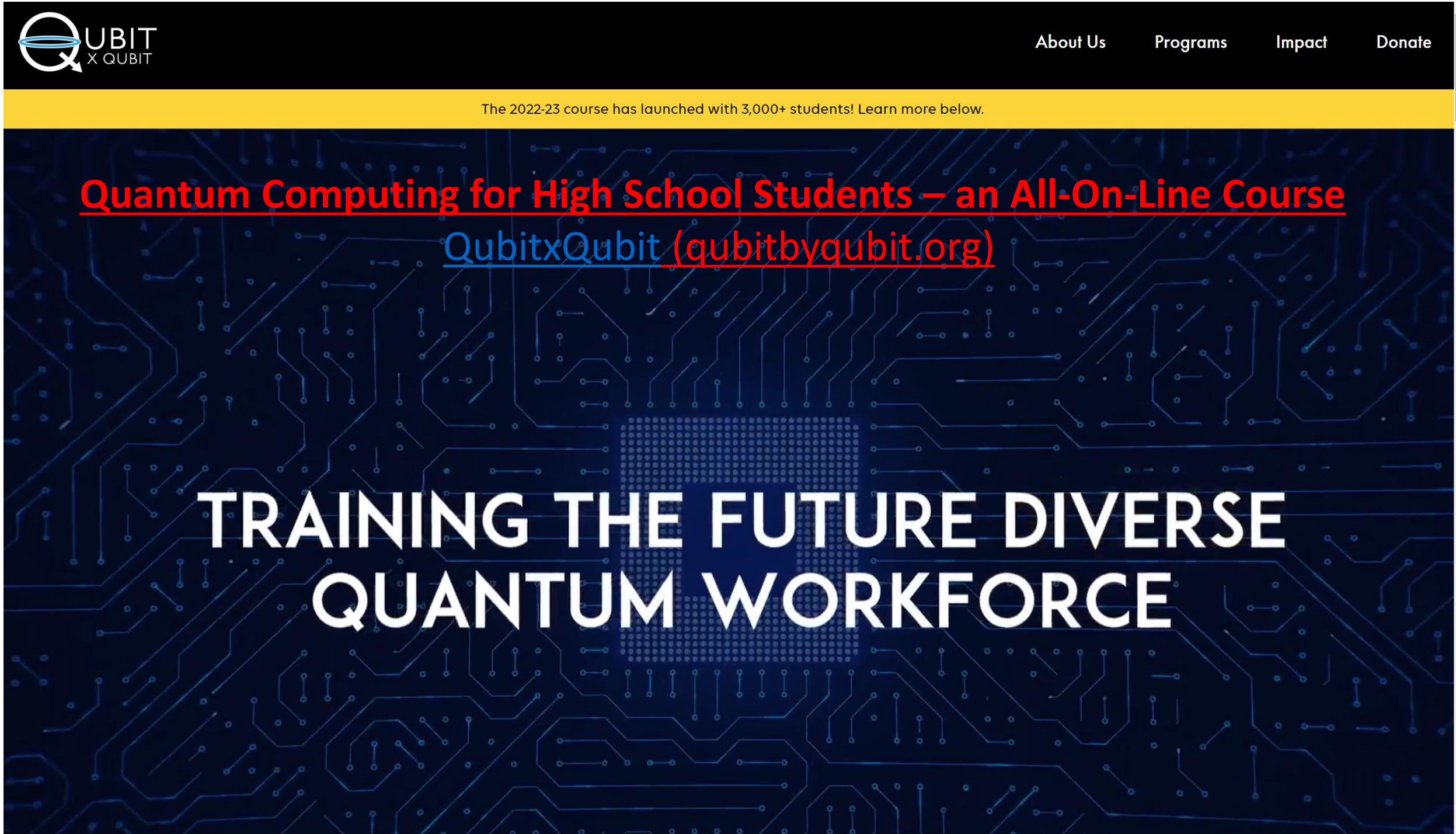
Use the Spectroscopy Worksheets to draw the spectra you see with your eyes when looking through the gratings.

Photos by Donn Silberman


SPECTRUM ANALYSIS
COSMIC RAYS — GAMMA RAYS — X-RAYS — ULTRA VIOLET
INFRA RED — SHORT WAVE RADIO — LONG WAVE RADIO
VISIBLE SPECTRUM
CONTINUOUS SPECTRUM
EMISSION (BRIGHT LINE) SPECTRA
MERCURY
HELIUM
LITHIUM
THALLIUM
CADMIUM
STRONTIUM
BARIUM
CALCIUM
HYDROGEN
SODIUM
ABSORPTION SPECTRUM
SOLAR SPECTRUM
RECEDING EDGE OF SUN
APPROACHING EDGE OF SUN
THE DOPPLER EFFECT
ABSORPTION SPECTRA OF SOLUTIONS
DIDYMIUM GLASS
CHLOROPHYLL
OXYHEMOGLOBIN
winsco
WABASH INSTRUMENT CORPORATION




Spectroscopy & Diffraction Gratings
Photo by Donn Silberman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Welcome, Donn Silberman

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- QXQ_YLC_Homework_6_STUD...
- QXQ_YLC_Lab_6_STUDENT.ipy...
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- QXQ_YLC_Homework_5_STUD...

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Example from Donn's Qubit x Qubit Week 6 Lab on IBM's Qiskit

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QXQ_YLC_Lab_6_STUDEN ×

Markdown

Python 3 (ipykernel)

Lab: Week #6 | The Z Gate and Multi-Qubit Circuits

Description: ¶

In this week's lab, we will create and simulate quantum circuits involving the Z gate, multi-qubit circuits, and mulit-qubit gates.

Cheat Sheet: Qiskit Cheat Sheet

Part 0: Importing from Qiskit

Run the cell directly below before doing anything else. This will import all of the functions that we will use today.

[1]:
```
# Importing standard Qiskit libraries
from qiskit import QuantumCircuit  #Importing the QuantumCircuit function from Qiskit. We will use this to create our quantum circuits!

# We will use these functions to run our circuit and visualize its final state
from qiskit import Aer, execute
from qiskit.visualization import *

import warnings  # We are using this library to suppress some warning messages
warnings.filterwarnings("ignore")

print("Libraries imported successfully!")
```

```
Libraries imported successfully!
```

QXQ_YLC_Lab_6_STUDEN

Markdown

Python 3 (ipykernel)

Part 2: The Z Gate

Exercise #1

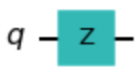
Together, let's create and draw a 1-qubit circuit with 1 Z gate.

[8]:
```
qc = QuantumCircuit(1)

qc.z(0)

qc.draw()
```

[8]:



Exercise #2

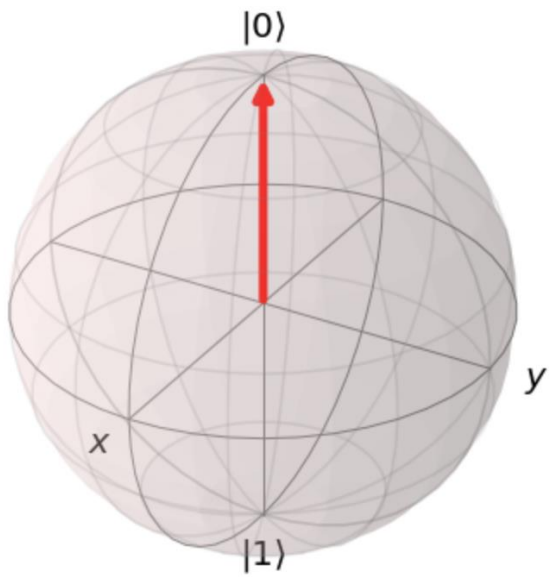
Together, let's create and run a 1-qubit circuit with 1 Z gate using `visualize_transition` with `fpg = 5`.

[9]:
```
qc = QuantumCircuit(1)

qc.z(0)

visualize_transition(qc, trace = True, fpg = 5)
```

[9]:



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Exercise #5

Create and draw a 5-qubit/5-classical bit quantum circuit where you apply the gates listed below using a loop and measure.

H gate on qubit 0

CX with qubit 0 as the control and qubit 1 as the target

H gate on qubit 1

CX with qubit 1 as the control and qubit 2 as the target

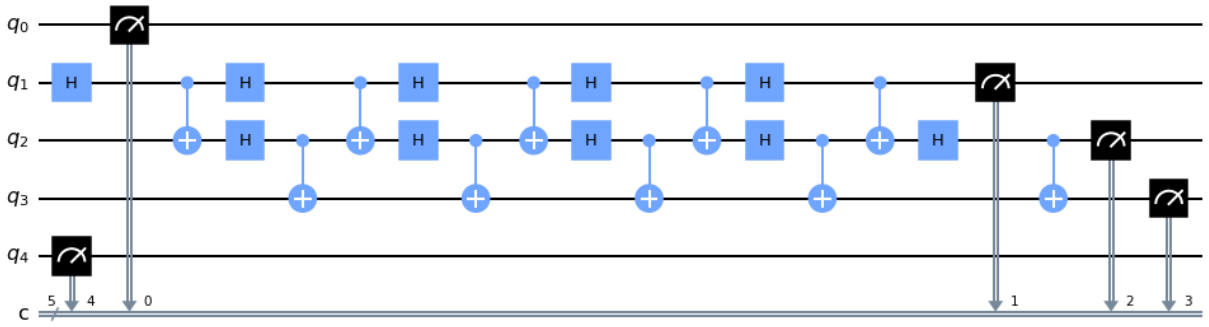
H gate on qubit 2

CX with qubit 2 as the control and qubit 3 as the target

NOTE: Be careful of going over the number of qubits in the loop.

[41]:
```
qc = QuantumCircuit(5, 5)

for qubit in range(5):

    qc.h(1)
    qc.cx(1, 2)
    qc.h(2)
    qc.cx(2, 3)

qc.measure([0, 1, 2, 3, 4], [0, 1, 2, 3, 4])

qc.draw()
```

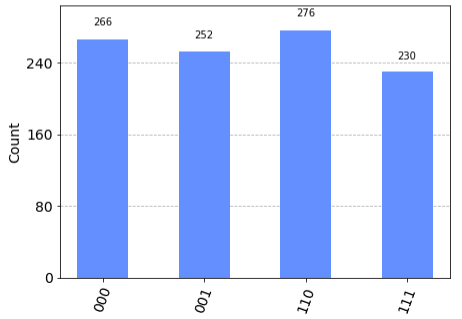
[41]:



Run the code below to simulate the measurement results using QASM.

[13]:
```
# Simulate using QASM
backend = Aer.get_backend('qasm_simulator')
job = execute(qc, backend = backend, shots = 1024)  # Make sure you change "qc" to the name of your quantum circuit in this line!
result = job.result()
counts = result.get_counts()
plot_histogram(counts)
```

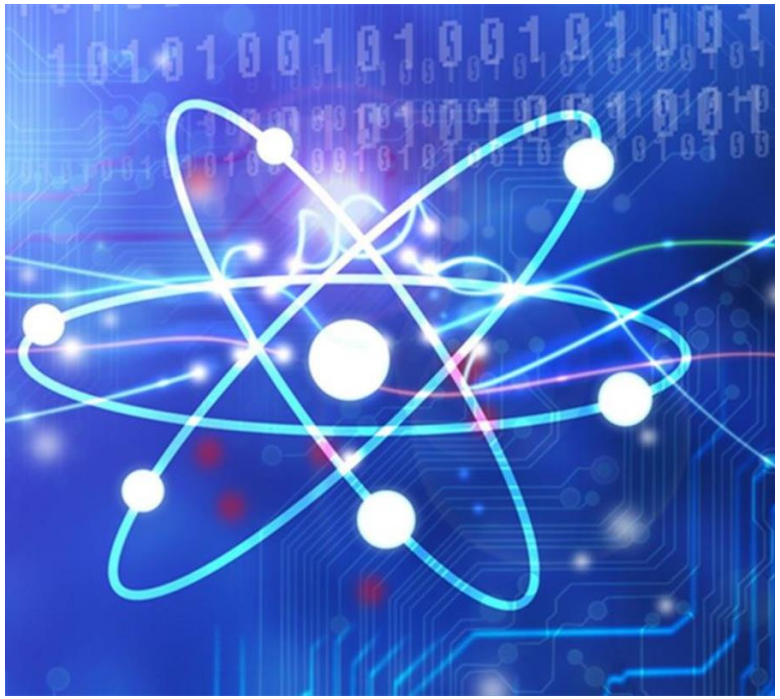
[13]:



OSSC Optical Society of Southern California EDUCATION & OUTREACH

Summary

1. Getting Oriented with Quantum Education
2. Motivation for the process described
3. Creating the “Quantum Pipeline” – Paths Forward
4. The Samueli Academy’s “Schrodinger’s Club”
5. Quantum Cryptography – Univ. of Waterloo
6. Hands-on Lab for Students
   a) Polarization
   b) Atomic Spectroscopy & Laser Diffraction Lab
   c) Qubit x Qubit – with IBM’s Qiskit
7. Q&A
8. Thank you for your attention !!



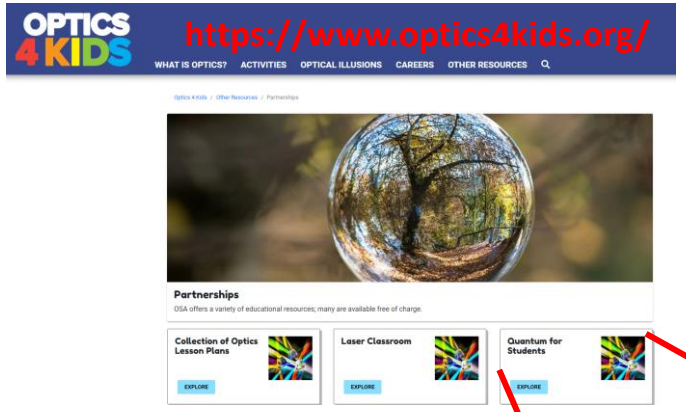
Would you like to help ??

1. SPIE / Optica Student Chapters in your area?
2. Local Non-profits & schools in your area?

Materials & guidance are available now.

Next Slide

The Quantum Education & Outreach – Paths Forward



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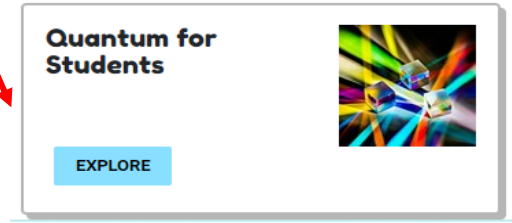
Get Involved
Student Chapters

Working with local Non-profits
Linking K-12 school districts to industry
And local colleges and universities

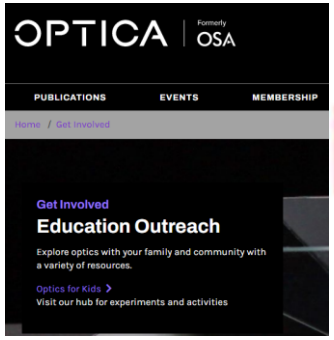
Working with local SPIE, Optica, IEEE Photonics and other College Student Clubs to reach out to local high schools



[Quantum for Students | opticsage (donn601.wixsite.com)]

SAMUELI ACADEMY
SCHRÖDINGER'S CLUB
AT SAMUELI ACADEMY

vital link
Corona Del Mar High School
Python Programming Class
Tues. Nov. 22 – Intro to Quantum Computing



Brown Bag Educational Lunch Series
Introducing optics to undergraduate ECE students and photonics outreach projects

October 5th, 2022
12 – 1 PM

Speaker:
UCSD SPIE Student Chapter

DRS DAYLIGHT SOLUTIONS

High School Quantum Workshop
Friday Nov. 18th