

Fall 2023 Course! **ECE 4060/ECE 5330:** **Quantum Physics and Engineering**

Introduction to quantum physics and engineering for advanced undergraduate and beginning graduate students. Topics covered include historical developments, quantum postulates, Schrödinger equation, quantum states and observables, measurement in quantum mechanics, quantum confined states in potential wells and atoms, quantum tunneling, uncertainty relations, Dirac notation, spin, quantum dynamics, quantum information and the qubit, quantum computation, quantum information processing, and quantum circuits, quantization of light and the photon, quantization of simple mechanical and electrical superconducting circuits. The course will enable students to take advanced courses in areas related to electronic and optical devices, solid state physics and material science, and quantum information and computation.

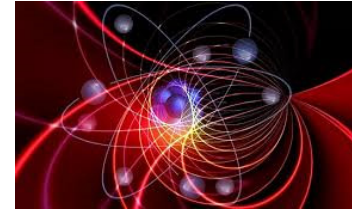


Instructor: Farhan Rana,
farhan.rana@cornell.edu

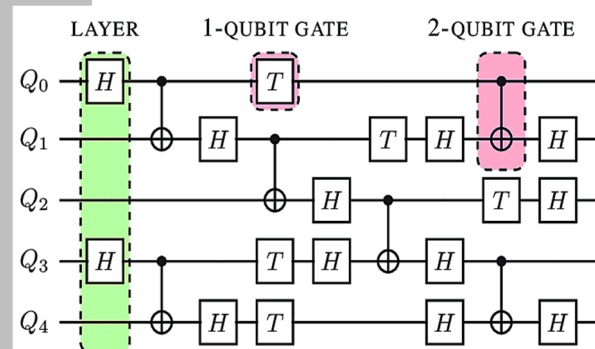
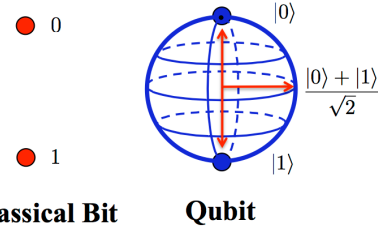
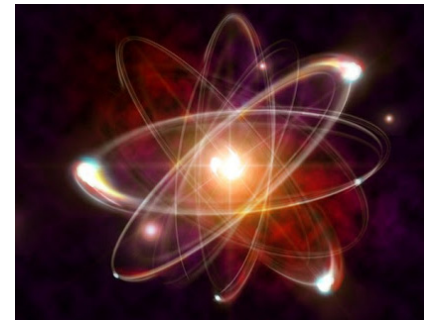
Lectures MWF 11:15 AM – 12:05 PM,
Discussion F 9:05-9:55 PM, PH 307

Pre-requisites: MATH 2930 and PHYS 2214,
or permission of instructor. **Credits Hours: 4**

Harnessing a new
frontier for engineering!



From atoms to devices to computation

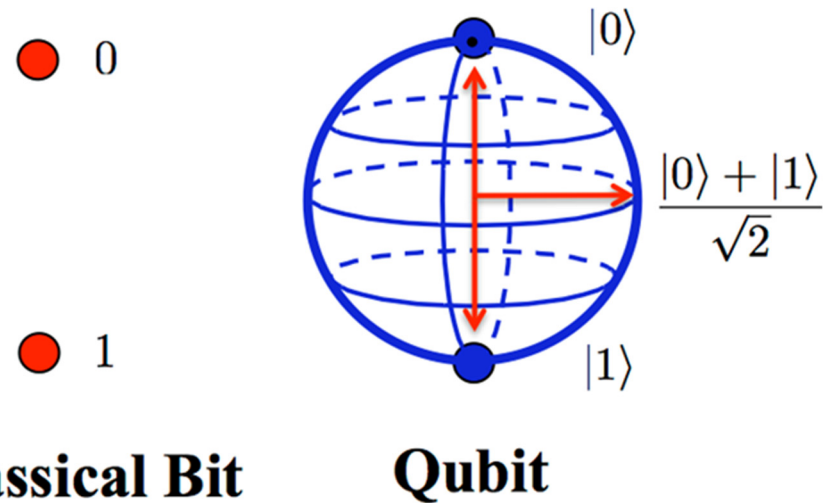


Lecture 1

Introduction to the Course ECE 4060/ECE 5330

In this lecture you will learn:

- The basic structure of the course
- Course policies
- Quantum Physics and Engineering
- Some areas in related applications and research



Course Schedule

- **Lecture Schedule:**

Monday, Wednesday, Friday 11:15 AM – 12:05 PM

- **Instructor:**

Farhan Rana (PH323)

Recitations and Office Hours

- **Recitation Schedule:**

**Friday 9:05 – 9:55 AM
PH 307**

- **Recitation Instructors:**

Arjan Singh, Farhan Rana



Text Books

There is no required text book

Lecture handouts will be provided instead

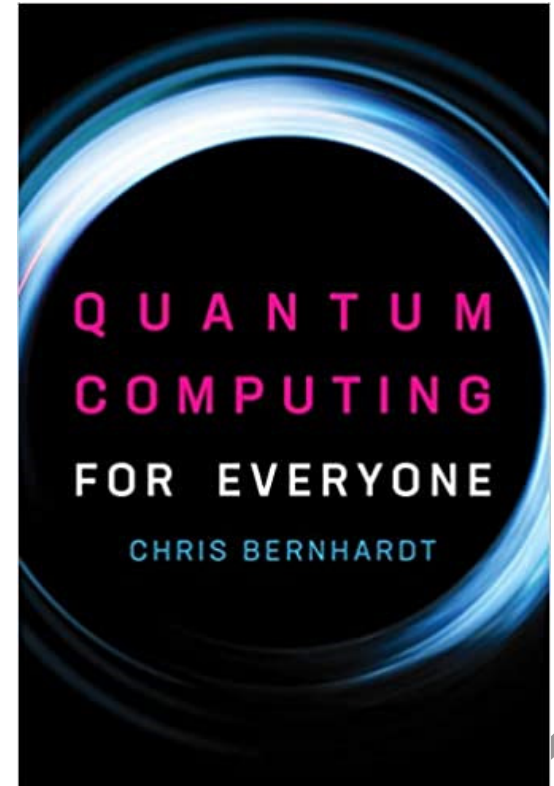
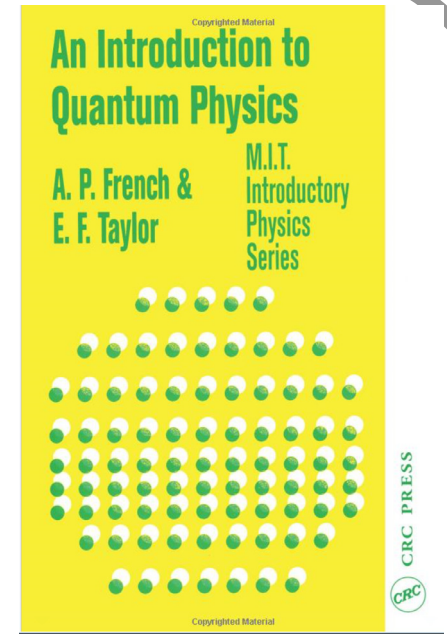
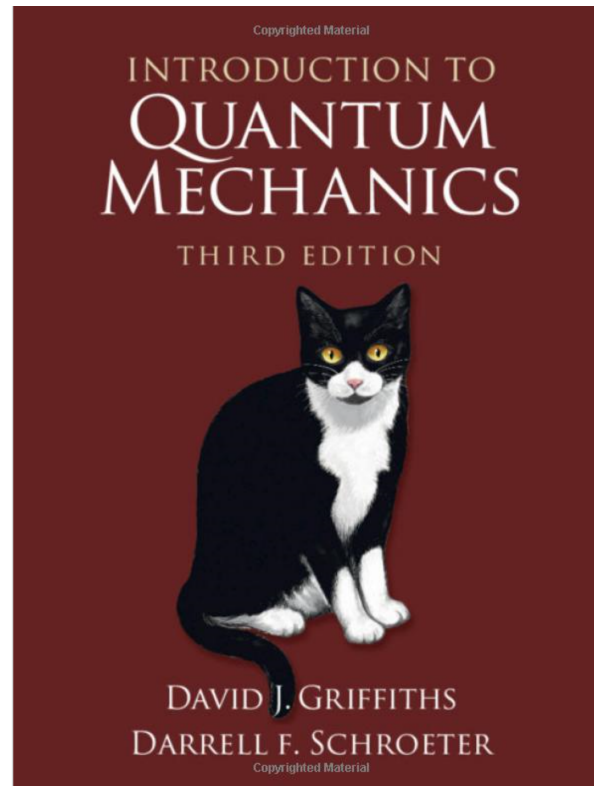
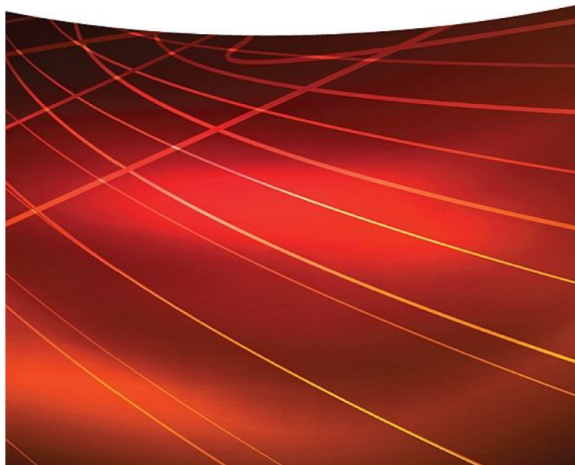
Recommended texts:



Claude Cohen-Tannoudji, Bernard Diu, and Franck Lalœ

Quantum Mechanics

Volume I: Basic Concepts, Tools, and Applications
Second Edition



Course Prereqs

Strong Prereqs:

MATH 2930 (Differential equations)

PHYS 2214 (Physics of Oscillations and Waves)

or Permission of Instructor

Recommended Prereqs:

MATH 2940 (Linear Algebra)

Homeworks

- Roughly 1 homework per week:

- Given out on Monday and due on the following Monday

All homeworks are due by 5:00 PM (on Wednesday, after self-grading) via email to the course admin person:

Dr. Christina Manolatos: cm285@cornell.edu

- Self-grading, what is it?

Homeworks must be emailed in a SINGLE-PDF-FILE format

DO NOT SEND IMAGES

DO NOT SEND MULTIPLE FILES ATTACHED TO THE SAME EMAIL

Exams

- **Tentative exam schedule:**

- **Take Home Midterm**
- **Take Home Final**

Course Grading

- **Homeworks: 30%**
- **Midterm: 30%**
- **Final exam: 35%**
- **Instructors' discretion: 5%**

Course Website

- All course documents, including:
 - Lecture notes
 - Homeworks and solutions
 - Exam solutions
 - Extra course related material

will appear on the course website:

Piazza website:

<http://piazza.com/cornell/fall2023/ece4060>

Please enroll yourself on the website asap!

Course ECE 5330

- **Will meet with ECE 4060**
- **Is open for enrollment to graduate students only**
- **Will require students to do additional problems and/or write a paper**

Course Rules

Academic Integrity Statement (From the Cornell Faculty Handbook)

For all assignments, students are required to abide by Cornell University's Code of Academic Integrity. A copy of the code can be found at the following URL:

<https://cuinfo.cornell.edu/aic.cfm>

Violations of the Code of Academic Integrity, especially plagiarism, may result in a failing grade in the course. Students are urged to read and complete the exercises on "Recognizing and Avoiding Plagiarism" at:

<http://plagiarism.arts.cornell.edu/tutorial/index.cfm>

Disabilities Statement (From the Cornell Faculty Handbook)

Note to students with disabilities: If you have a disability-related need for reasonable academic adjustments in this course, provide Instructor with an accommodation letter from Student Disability Services. Students are expected to give two weeks' notice of the need for accommodations. If you need immediate accommodation, please arrange to meet with the Instructor within the first two class meetings.

Schrödinger Equation

Same equation written in two different ways:

$$i\hbar \frac{\partial \psi(\vec{r}, t)}{\partial t} = -\frac{\hbar^2 \nabla^2}{2m} \psi(\vec{r}, t) + V(\vec{r}) \psi(\vec{r}, t)$$

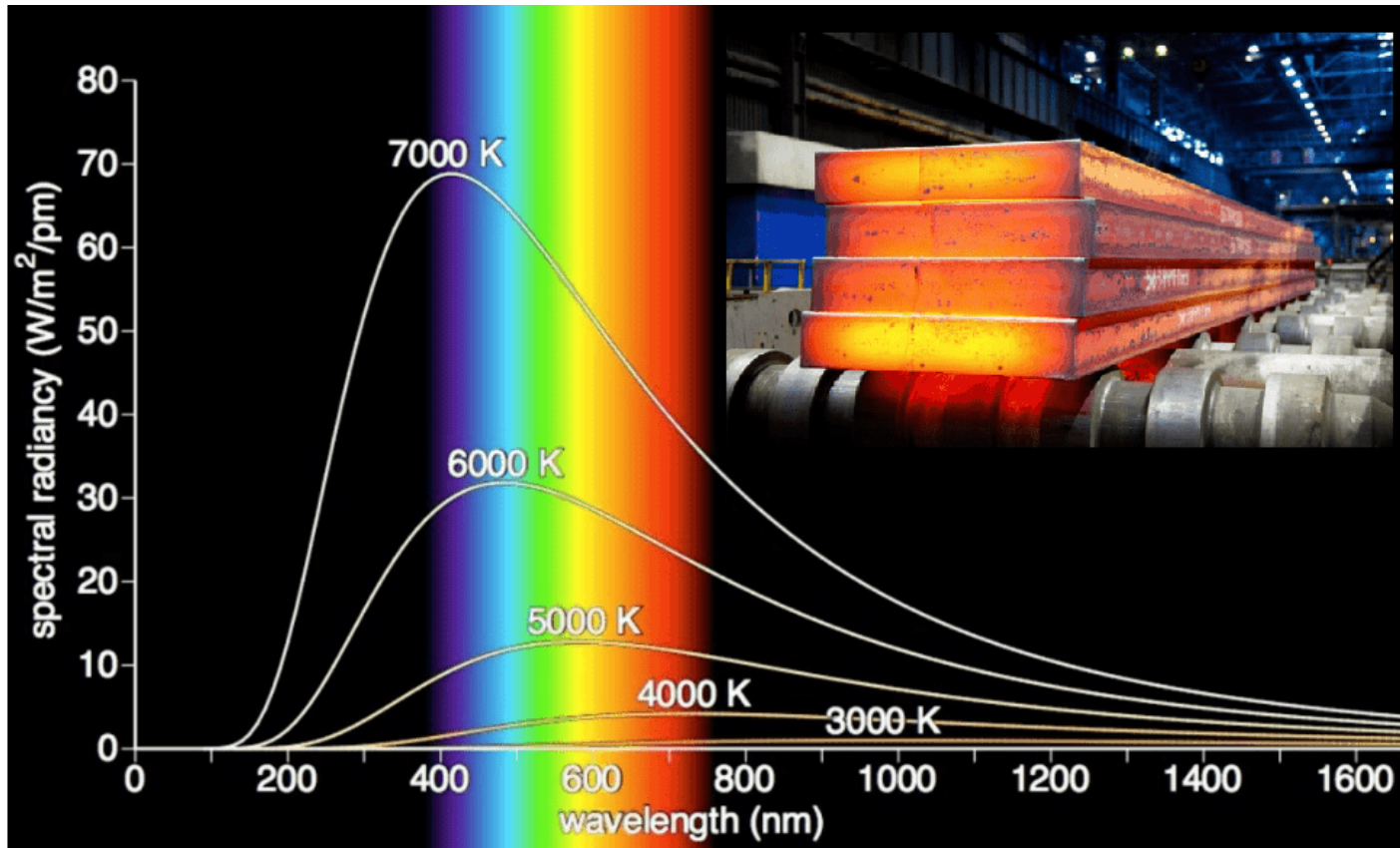
$$i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle = \hat{H} |\psi(t)\rangle$$

The entire course is about one equation but a whole lot of new concepts!!



Erwin Schrödinger
(1887-1961)

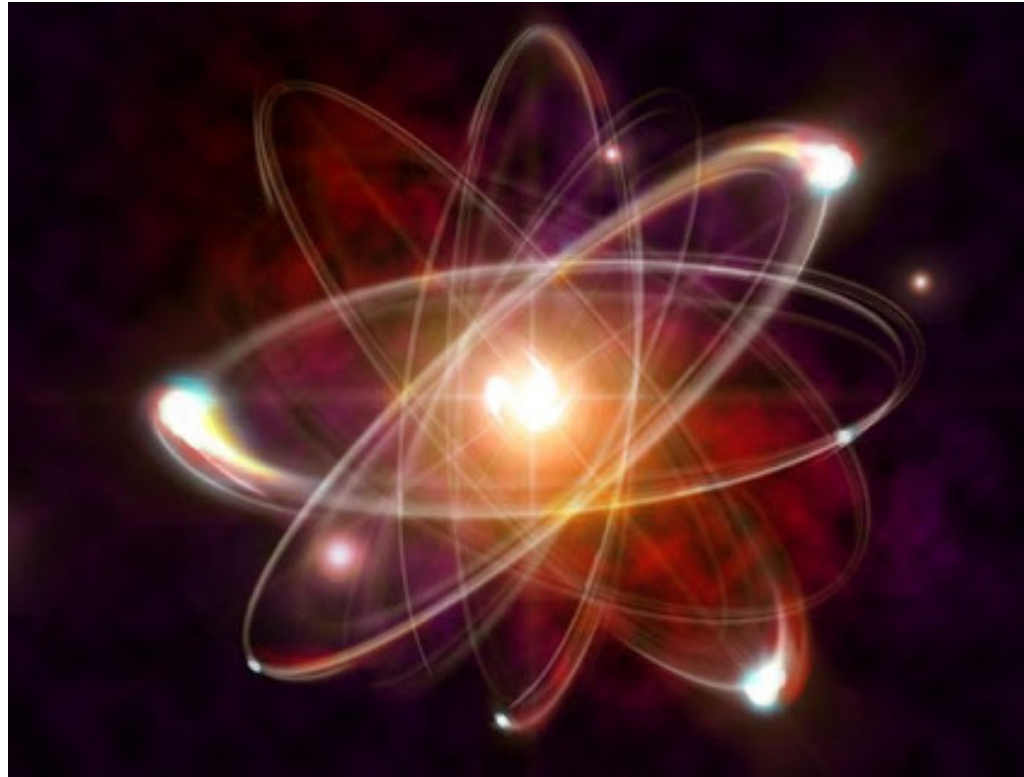
Mysteries of Light



Can anyone explain the spectrum of light emitted from hot black bodies???

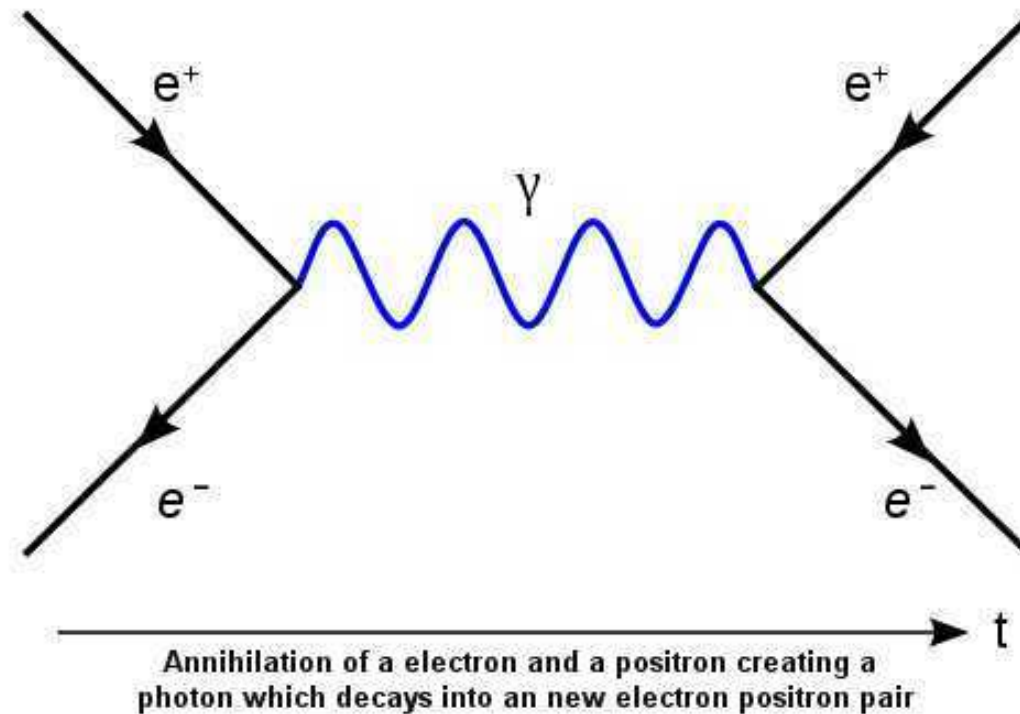
Plank answered the question – partially!

Mysteries of the Atom



The story of quantum mechanics started with the attempts to explain the light emitted from atoms!

Mysteries of Matter and Light: Quantum Field Theory

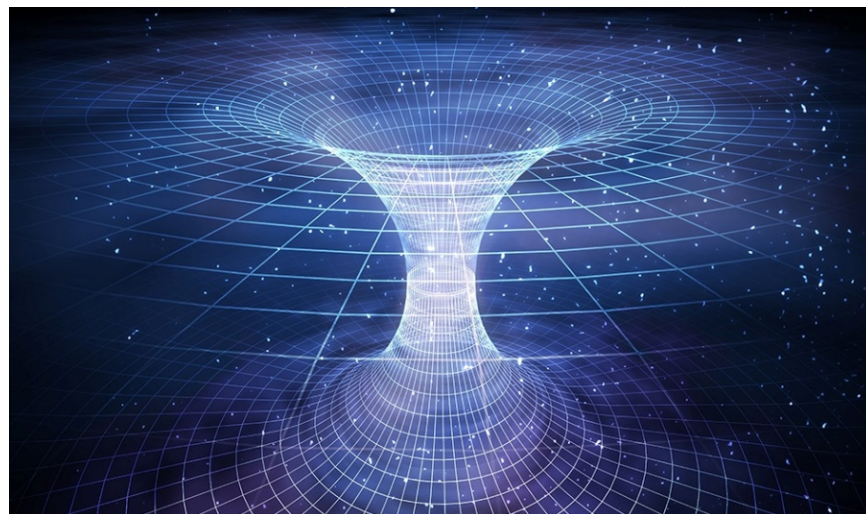
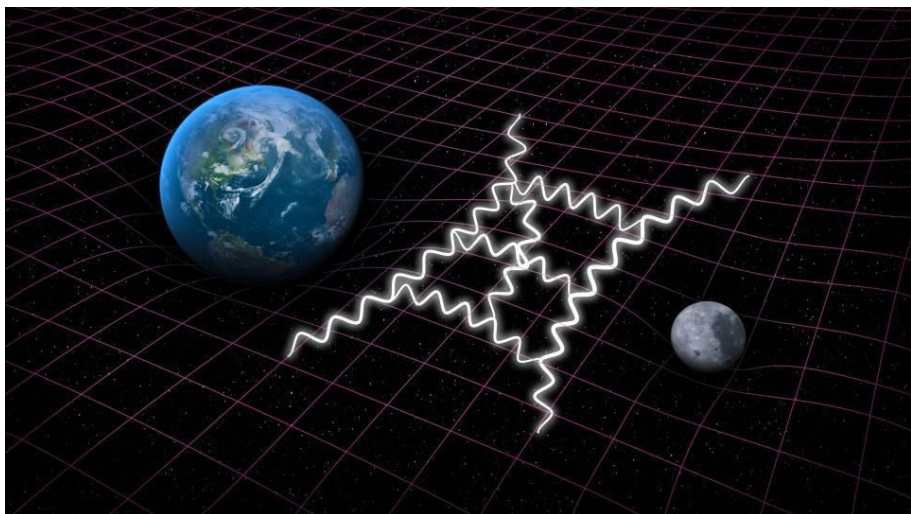


Predicting and discovering fundamental particles – both massive and massless

Developing and/or discovering quantum equations for all particles

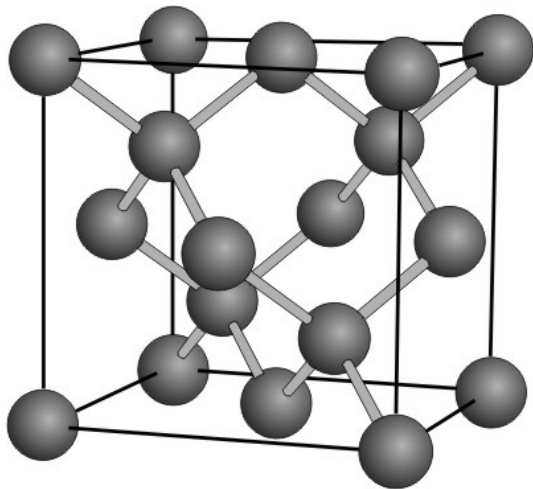
The Standard Model of particle physics

Mysteries of Gravitation, Black Holes, and Parallel Universes

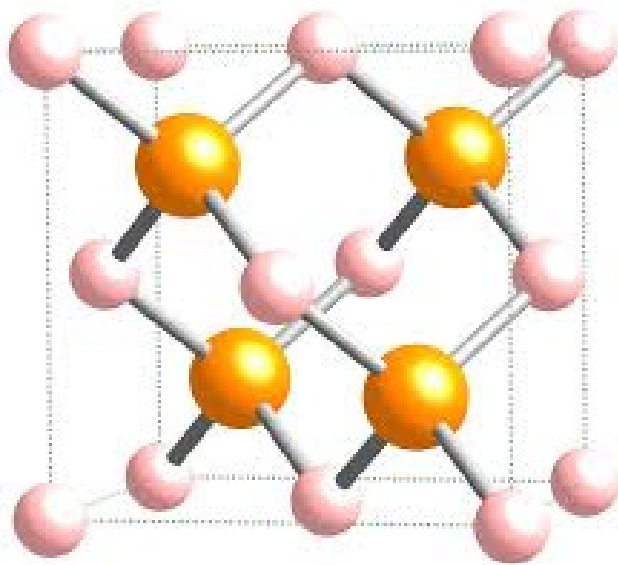
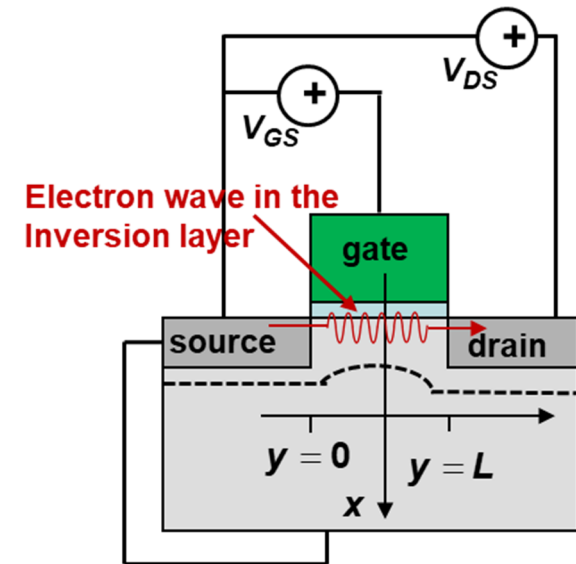
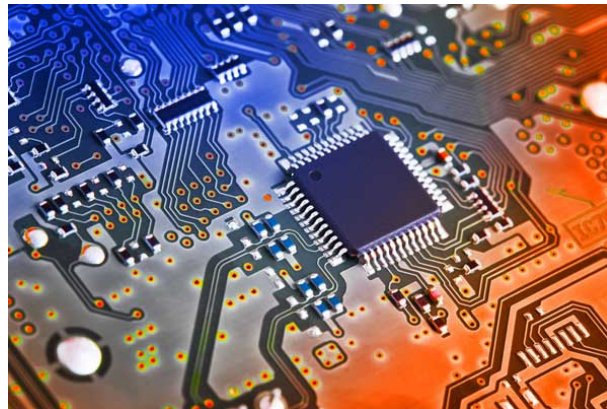


Stephen Hawking (1942-2018)

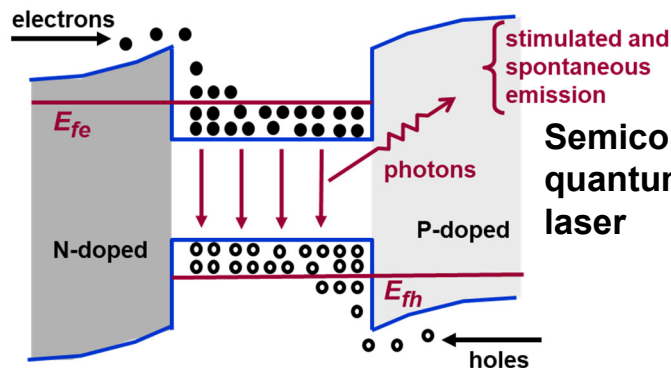
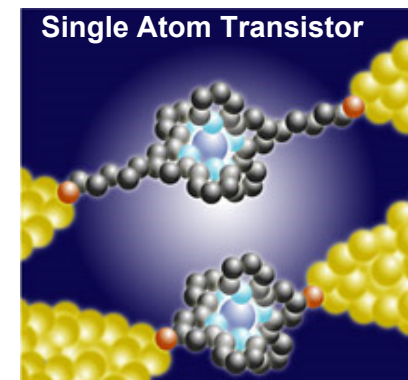
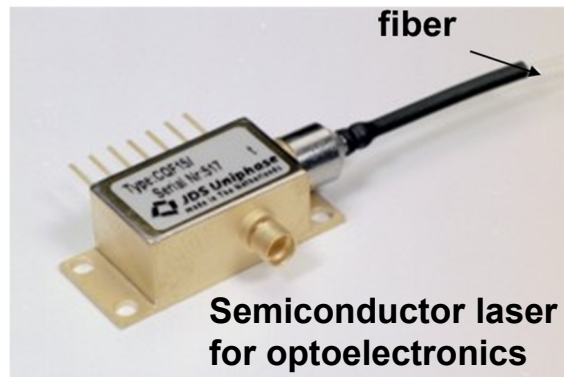
Solid State Physics, Microelectronics, and Photonics



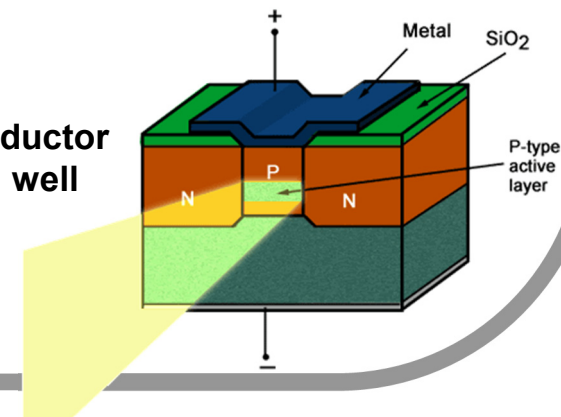
Silicon



GaAs

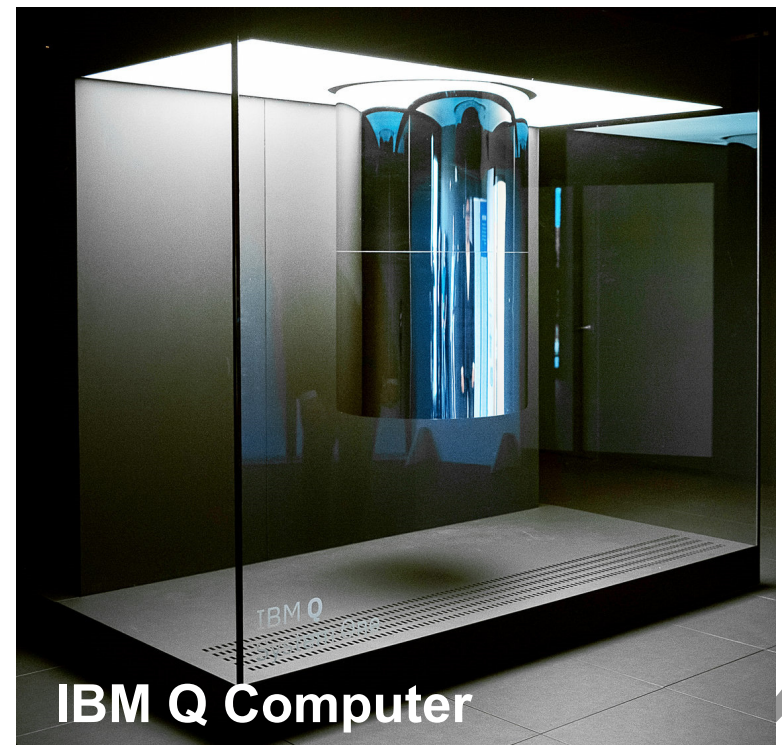
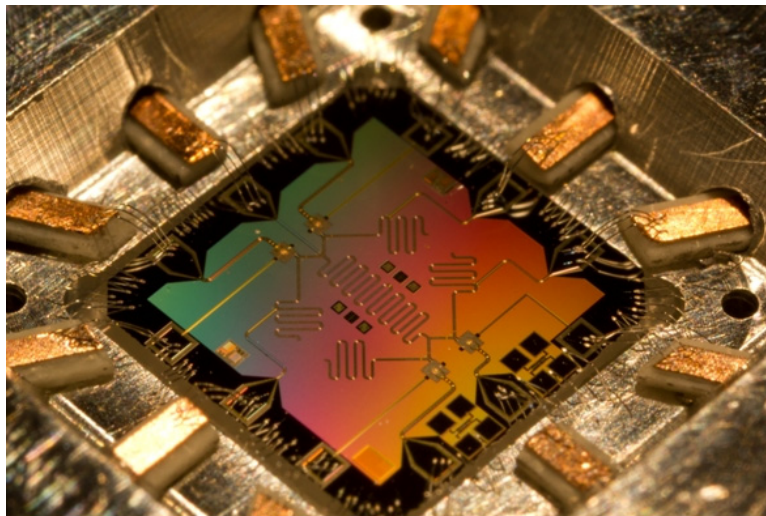
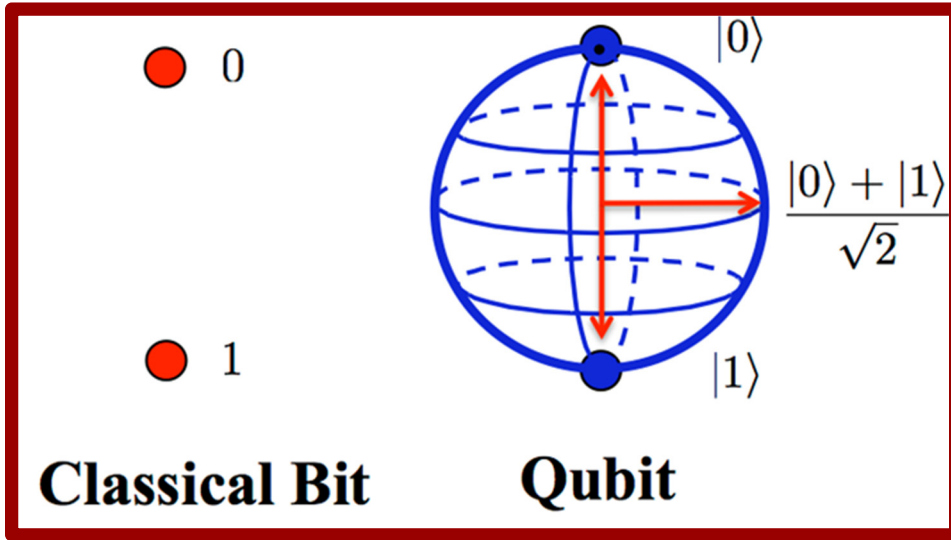


Semiconductor quantum well laser



A New Frontier: Quantum Information Processing

Quantum Computation and Quantum Communication



A New Frontier: Quantum Circuits

Quantum Computation and Quantum Communication

