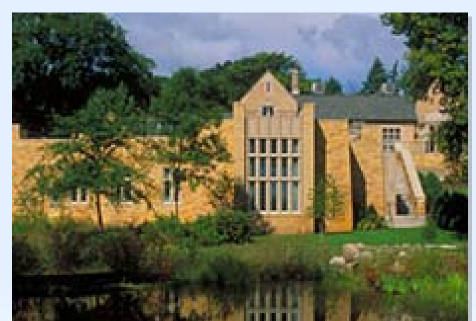
Entering the 2009 Raab Contest

Steve Brehmer
stbrehmer70@gmail.com

Mayo High School
Rochester, Minnesota

The Bakken Museum
Minneapolis, Minnesota



Enjoy the Day

Absorb as much as you can from the lectures

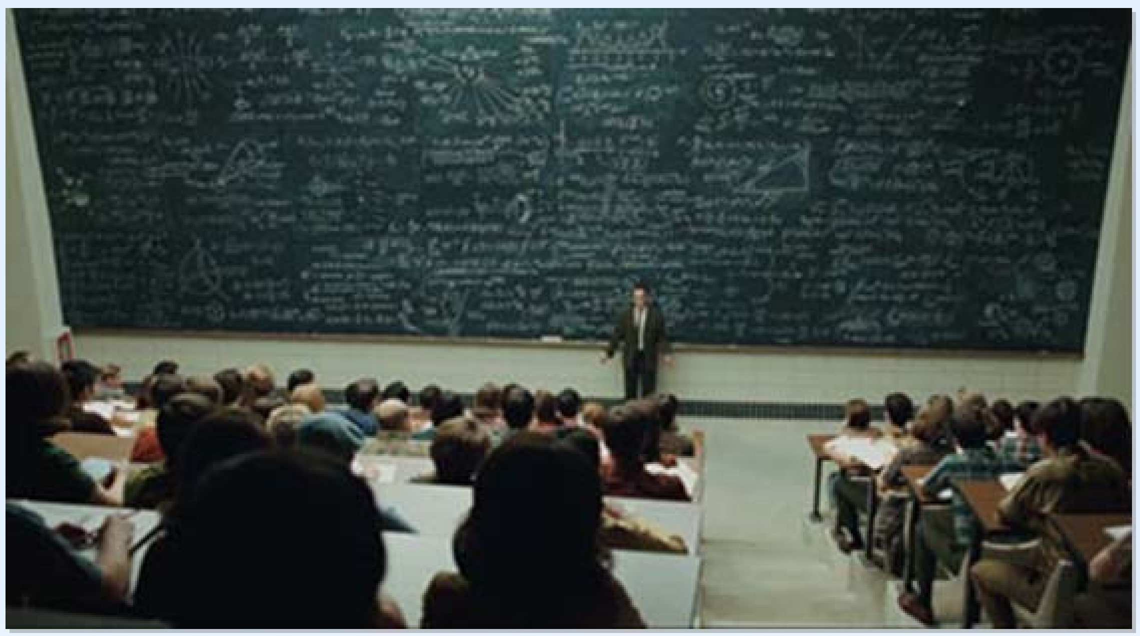
Ask questions

Hobnob with prize winners

Network

“Even if you can’t figure it out, you’re still responsible for it on the midterm.”

Larry Gopnik, “A Serious Man”



Read the Rules

The Kavli Institute for Theoretical Physics
University of California, Santa Barbara

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Home › Planets Beyond the Solar System: The New Astronomical Revolution | Raab Contest

Planets Beyond the Solar System: The New Astronomical Revolution | Raab Contest

Activities - Planets Beyond the Solar System: The New Astronomical Revolution
(Adam Burrows)
March 27, 2010

FOR THE 2010 KITP TEACHERS' CONFERENCE
PRIZES FOR PRESENTATION CONTEST!

Apply | Registration Info | Las Cumbres Obs. | Main | Schedule

PRIZES
Simon and Diana Raab have made a generous gift to the KITP to establish the Simon and Diana Raab Presentation Prizes to be awarded for winning presentations by Teachers' Conference attendees.

First Prize	$3,000
Second Prize	$2,500
Third Prize	$1,500

CONTEST RULES
Applications should create a talk summarizing the 2010 Teachers' Conference lectures and the accompanying discussions, **suitable for presentation as a single science class period.** It should include a PowerPoint (or equivalent) presentation, with supporting slide notes, and must include a set of practical analytical problems in each of the areas of presentation. Materials should be sufficiently self-contained to allow ready classroom use by science teachers other than the author.

JUDGING & EVALUATION
All winning presentations will be posted on the KITP Teachers' Conference webpage on the KITP site. Judging is undertaken by a jury of 2 teacher peers plus one scientist.

Presentations will be graded on scale of 1-5, against a total of the 25 points on following attributes:

1. *Graphic quality; animation*
2. *Logic flow and coherence*
3. *Slide note clarity and accuracy*
4. *Motivation and Excitement factor*
5. *Analytical problems' interest as relating to conference subject and as illustrative of fundamental laws of physics*

SUBMISSIONS
Applicants are requested to upload their presentations between June 1, 2010 and August 27, 2010 to: Contest.

Inquiries can be addressed to Professor Daniel Hone.

WINNING PRESENTATIONS
Winners will be notified directly by email and prizes mailed no later than September 30, 2010, and their presentations posted on the KITP web site.

Void where prohibited.

Use the website

The Kavli Institute for Theoretical Physics
University of California, Santa Barbara

HOME | ABOUT KITP | FOR SCIENTISTS | TALKS | NEWS | EVENTS | VISITOR INFO | OUTREACH | HELP | Feb 20, 2010

KITP Teachers' Conference: Light Meets Matter: Atoms and Lasers (May 16, 2009)
Coordinator: Mikhail Ivanov

Overview | **talks** | Podcast | Pictures | Registration Info | Contest | Las Cumbres Obs. | Reception | Conference Schedule

Friday, May 15, 2009

6:30pm WINE AND CHEESE RECEPTION	Best Western South Coast Inn More Information on this Event

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Saturday, May 16, 2009

8:00am REGISTRATION	Coffee and Light Refreshments

Morning Session Chair: Almut Beige (Univ. of Leeds)

8:45am David Gross (KITP Director)	Welcome [Podcast][Aud][Cam]
9:00am Martin Plenio (Imperial College, London)	Clocks and Entanglement [Slides][Podcast][Aud][Cam]
9:50am QUESTIONS/DISCUSSION	
10:00am MORNING BREAK	
10:30am Peter Knight (Imperial College, London)	Quanta and Non-Classicality [Podcast][Aud][Cam]
11:20am QUESTIONS/DISCUSSION	
11:30am Jon Anderson (Teacher, Circle Pines, MN)	Entering the Contest: A View from One of Last Year's Prize Winners [Slides][Podcast][Aud][Cam]
11:50am TOWN HALL DISCUSSION	Led by David Gross [Podcast][Aud][Cam]
12:30pm LUNCH BREAK	

Afternoon Session Chair: Serguei Patchkovskii (Nat'l Research Council Canada)

2:00pm Yaron Silberberg (Weizmann Inst., Israel)	Lasers and Microscopy [Slides][Podcast][Aud][Cam]
2:50pm QUESTIONS/DISCUSSION	
3:00pm AFTERNOON BREAK	
3:30pm Paul Corkum (Nat'l Research Council of Canada)	Attosecond Science [Slides][Podcast][Aud][Cam]
4:20pm QUESTIONS/DISCUSSION	
4:30pm Rachel Ross (Las Cumbres Observatory)	Overview of the LCOGT: A Network of 0.4-1.0 Meter Telescopes for Education [Slides][Podcast][Aud][Cam]
5:00pm CONFERENCE END	Shuttle Available to BWSCI, SB Airport, SB Airbus *See Jocelyn to Sign Up

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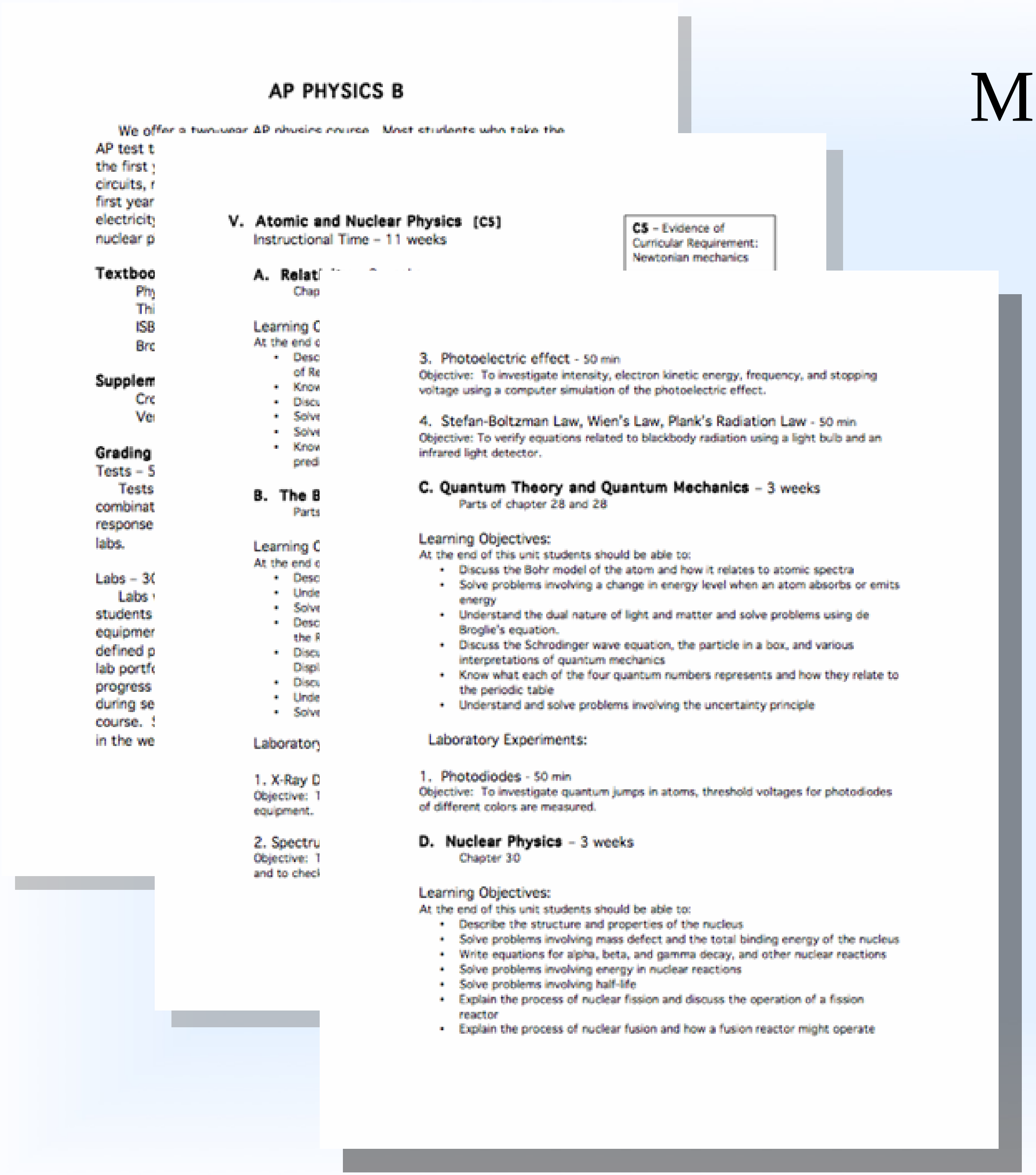
Make it useful


AP PHYSICS B

V. Atomic and Nuclear Physics [C5]
Instructional Time – 11 weeks

C5 – Evidence of Curricular Requirement: Newtonian mechanics

3. Photoelectric effect - 50 min
Objective: To investigate intensity, electron kinetic energy, frequency, and stopping voltage using a computer simulation of the photoelectric effect.

4. Stefan-Boltzman Law, Wien's Law, Plank's Radiation Law - 50 min
Objective: To verify equations related to blackbody radiation using a light bulb and an infrared light detector.

C. Quantum Theory and Quantum Mechanics – 3 weeks
Parts of chapter 28 and 28

Learning Objectives:
At the end of this unit students should be able to:
- Discuss the Bohr model of the atom and how it relates to atomic spectra
- Solve problems involving a change in energy level when an atom absorbs or emits energy
- Understand the dual nature of light and matter and solve problems using de Broglie's equation.
- Discuss the Schrodinger wave equation, the particle in a box, and various interpretations of quantum mechanics
- Know what each of the four quantum numbers represents and how they relate to the periodic table
- Understand and solve problems involving the uncertainty principle

Laboratory Experiments:

1. Photodiodes - 50 min
Objective: To investigate quantum jumps in atoms, threshold voltages for photodiodes of different colors are measured.

D. Nuclear Physics – 3 weeks
Chapter 30

Learning Objectives:
At the end of this unit students should be able to:
- Describe the structure and properties of the nucleus
- Solve problems involving mass defect and the total binding energy of the nucleus
- Write equations for alpha, beta, and gamma decay, and other nuclear reactions
- Solve problems involving energy in nuclear reactions
- Solve problems involving half-life
- Explain the process of nuclear fission and discuss the operation of a fission reactor
- Explain the process of nuclear fusion and how a fusion reactor might operate

Standards & Curriculum

Student Interest

Placement
- New or review
- Enrichment or requirement

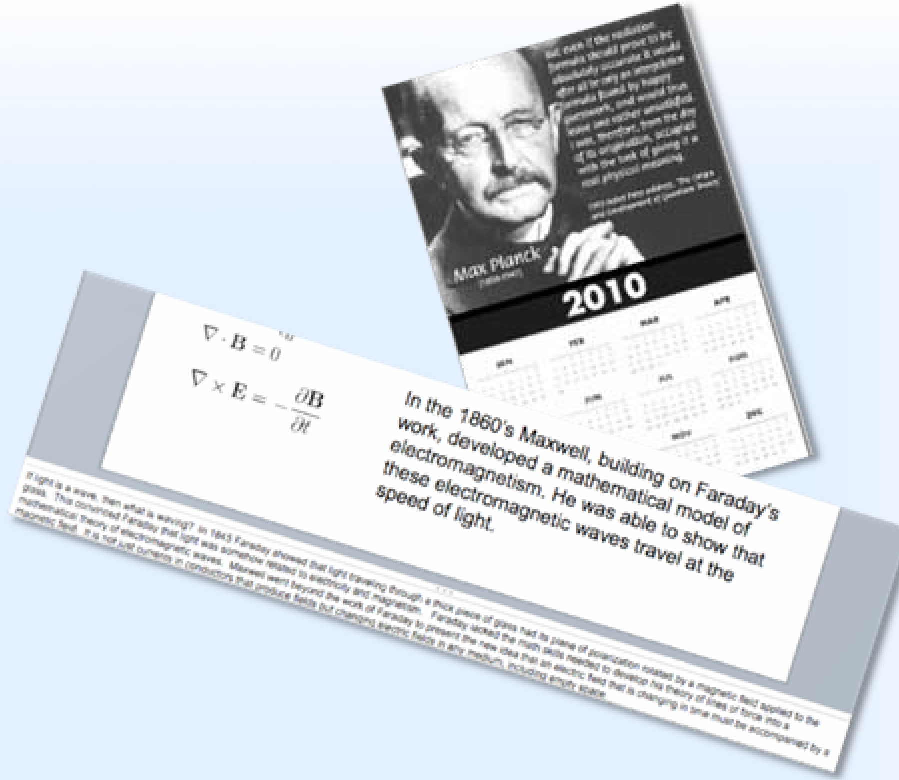
Portability

Part or whole

Be practical

Set a time limit

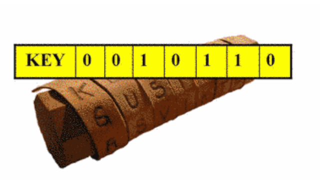
- Cover the conference
- Animation –
  Don’t go crazy
- Problem set
- Teacher notes



Don’t reinvent the wheel

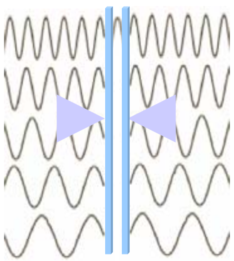
- Integrate your curriculum materials
- Use the presenters materials
- Discover new materials

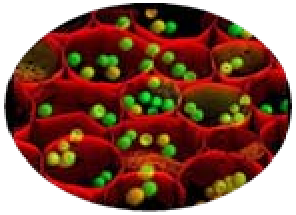
Light Meets Matter: Atoms and Lasers



Martin Plenio - Clocks and Entanglement

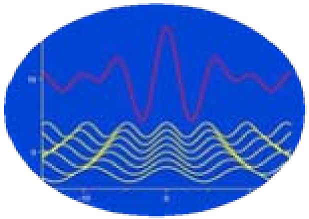
Peter Knight - Quanta and Non-Classicality





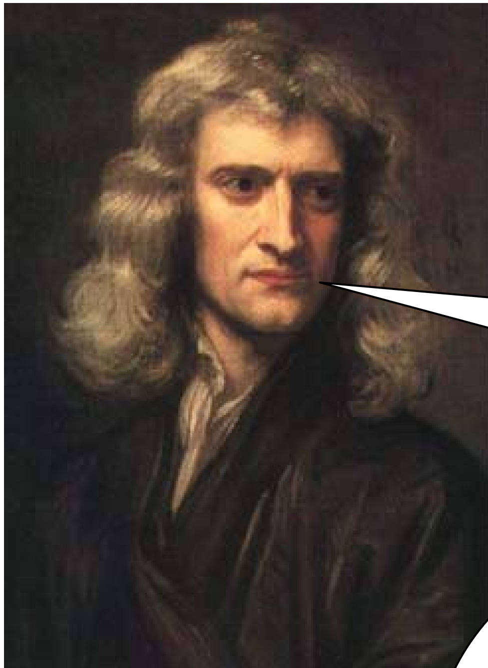
Yaron Silberberg - Lasers and Microscopy

Paul Corkum - Attosecond Science



Steve Brehmer - Mayo High School
Rochester, Minnesota

What is light?



In the late 1600's Newton explained many of the properties of light by assuming it was made of particles. ↑

"Tis true, that from my theory I argue the corporeity of light; but I do it without any absolute positiveness..."

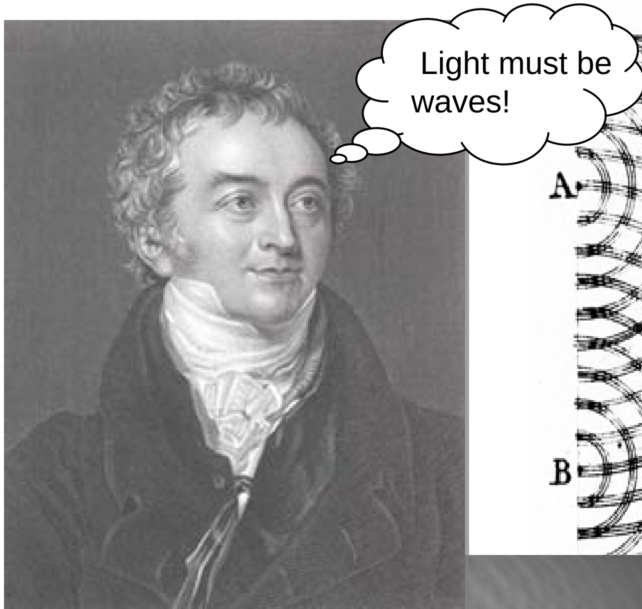
"The waves on the surface of stagnating water, passing by the sides of a broad obstacle which stops part of them, bend afterwards and dilate themselves gradually into the quiet water behind the obstacle. But light is never known to follow crooked passages, nor to bend into the shadow."

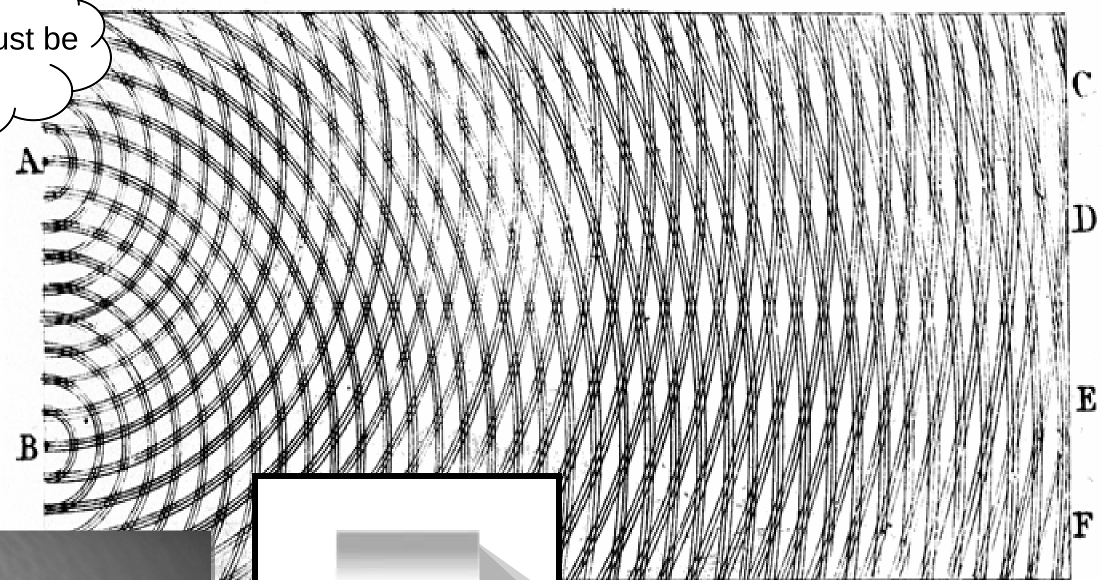
I'm thinking waves.

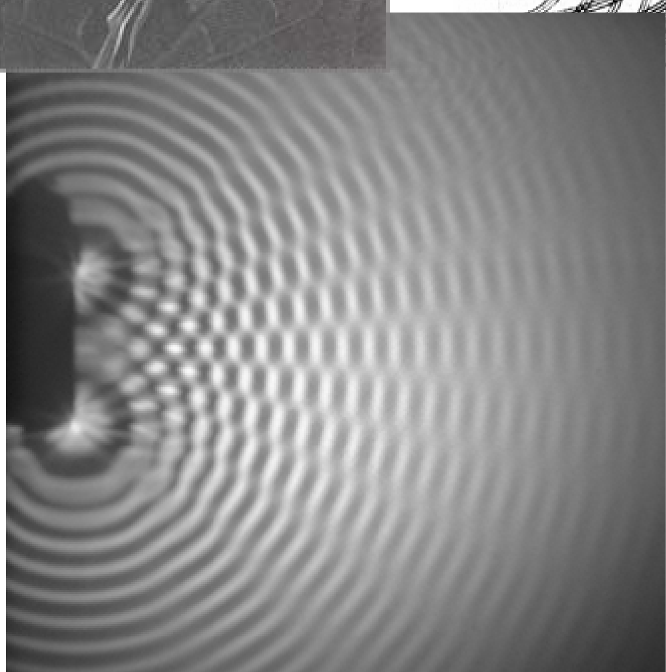
Because of Newton's enormous prestige, his support of the particle theory of light tended to suppress other points of view.

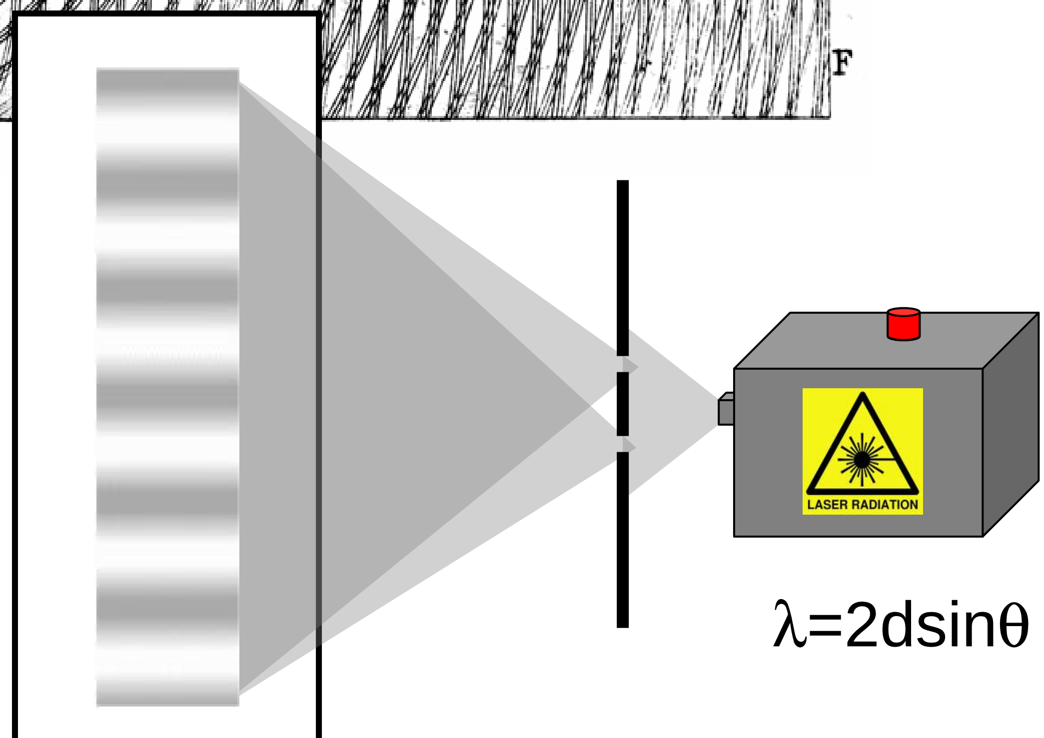
In 1678 Christian Huygens argued that light was a pulse traveling through a medium, or as we would say, a wave.

In 1803 Thomas Young's double slit experiment showed that, much like water waves, light diffracts and produces an interference pattern.









$$\lambda = 2d\sin\theta$$

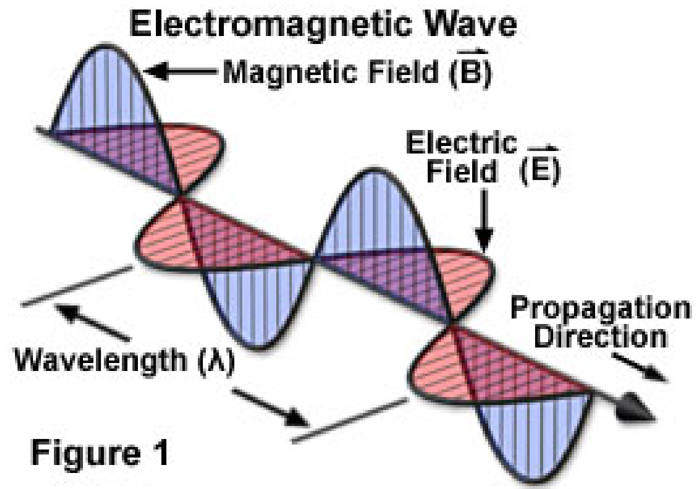


Figure 1

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

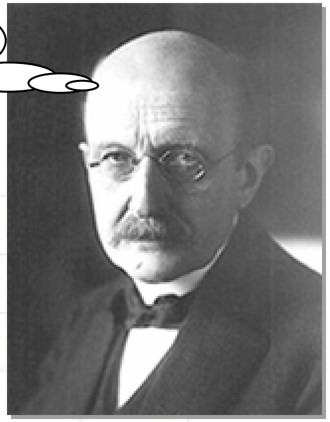
$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

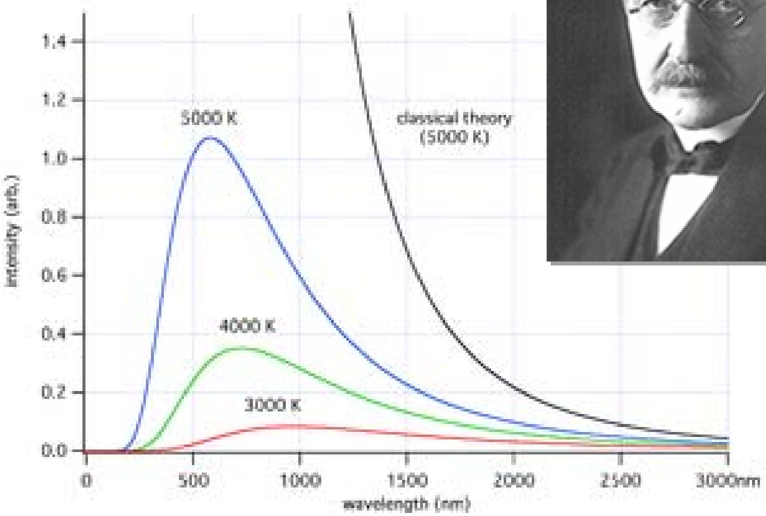
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

In the 1860's Maxwell, building on Faraday's work, developed a mathematical model of electromagnetism. He was able to show that these electromagnetic waves travel at the speed of light.

I don't like that!



In 1900 Max Planck was able to explain the spectrum of a "blackbody" radiator by assuming that light energy is quantized. That quantum of light energy was later named a photon.

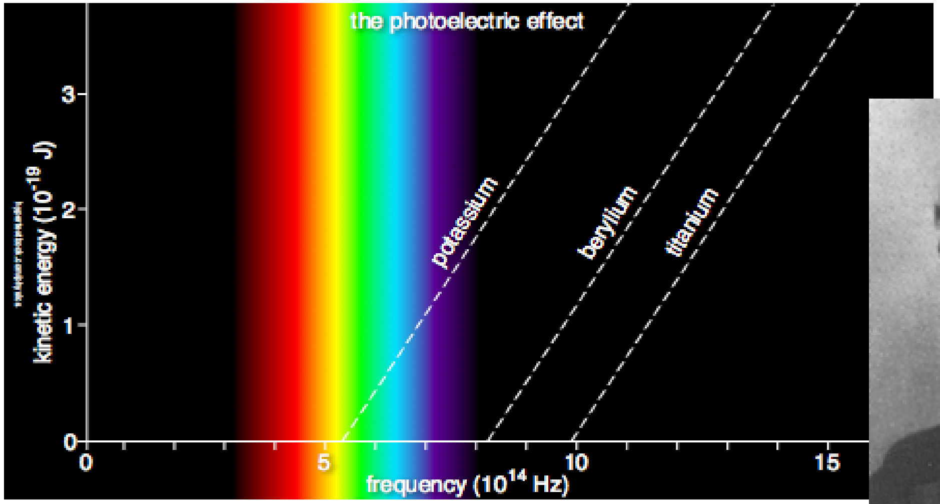


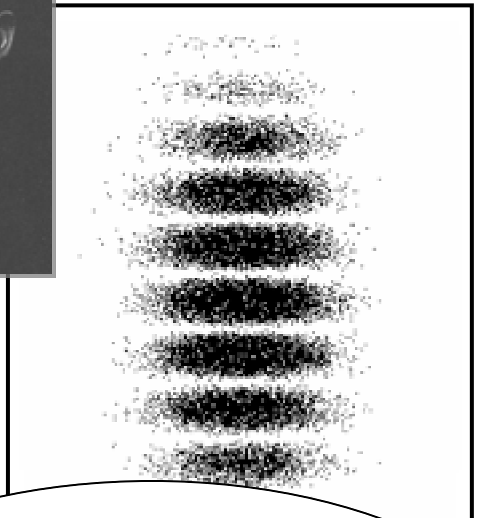
$$E=hf$$

$$E=hf+\phi$$

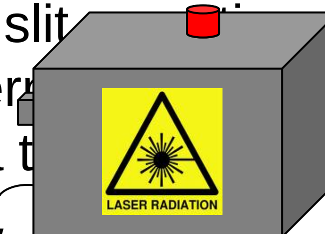
That quantum of light energy seems particle-like!

A few years later, in 1905, Einstein used Planck's idea to explain the photoelectric effect.





In 1909 G.I. Taylor experimented with a very dim light source. His work, and many modern experiments show that even though only one photon passes through a double slit … an interference patter… …uced - one “particle” at a t…



$\lambda = h/p$

“It would seem that the basic idea of the quantum theory is the impossibility of imagining an isolated quantity of energy without associating with it a certain frequency.”

Louis de Broglie, in 1923, reasoned that if light waves could behave like particles then particles should have a wavelength.

$n\lambda = 2d\sin\theta$

Soon after, an experiment by C. J. Davisson and L. H. Germer showed that electrons could produce interference patterns just like those produced by light.

$$\Delta p \, \Delta x \geq \frac{1}{2} \hbar$$

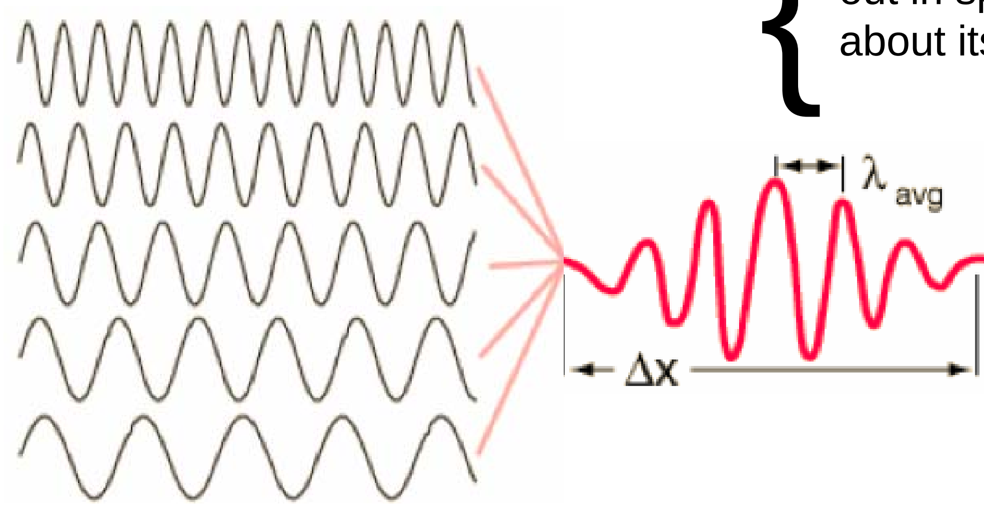
Heisenberg's Uncertainty Principle helps us examine the dual nature of light, electrons, and other particles.

If we know the wavelength we are certain about the momentum.

→ $p=\lambda/h$

But, because a wave is spread out in space, we are uncertain about its position.

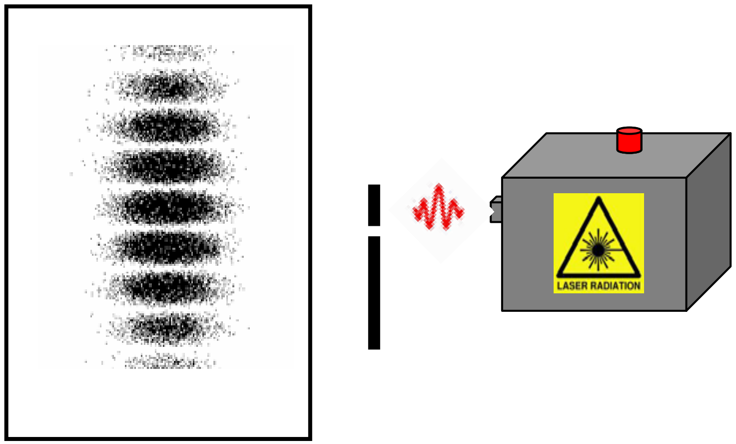
If we add together many wavelengths...



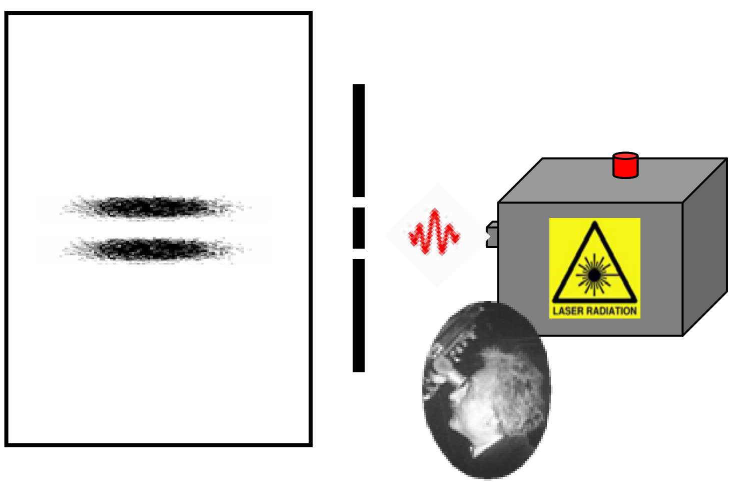
We are uncertain about the momentum.

But, we are now more certain about position.

Photons striking a double slit, one at a time, produce interference.

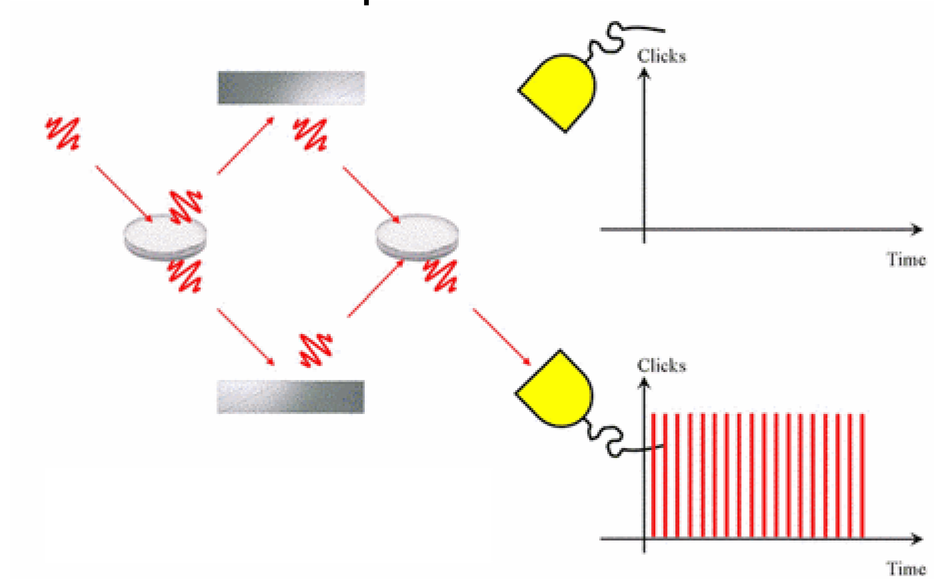


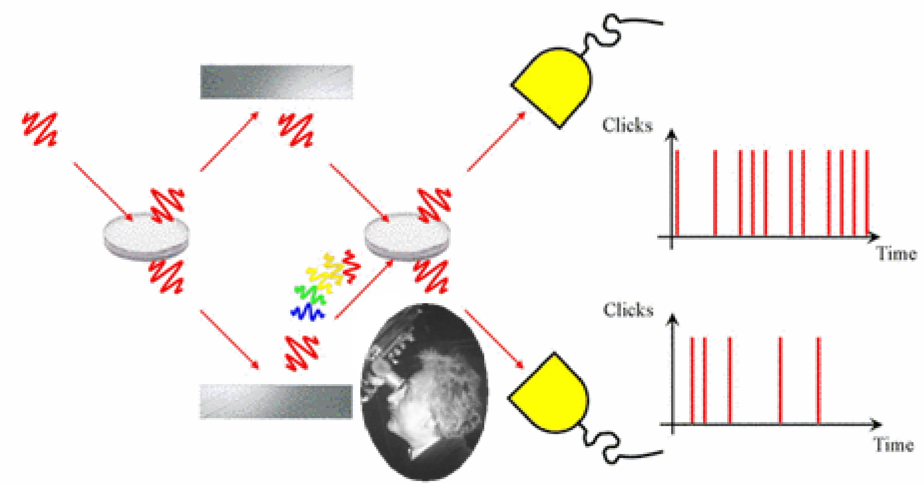
If we observe which slit the photon chooses…



the interference pattern disappears.

A similar experiment can be done with beam splitters and mirrors.

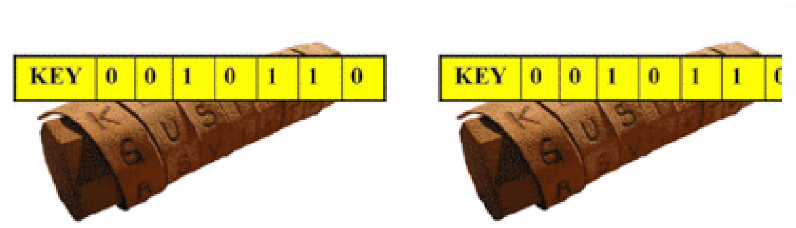




We can tell when someone is watching.

Quantum Keys

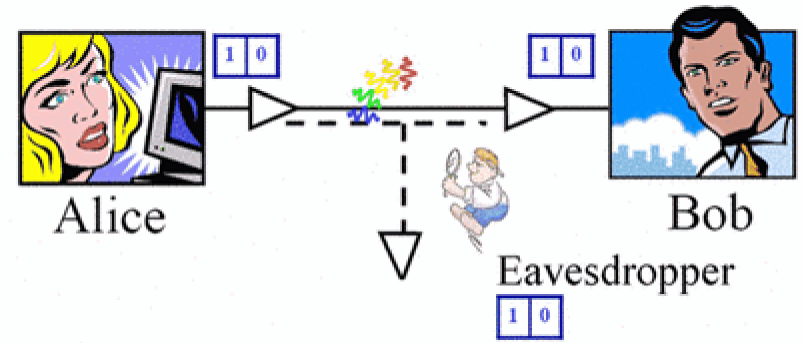
How can Alice and Bob know that their communications will remain private?



When evolving freely, quantum systems exhibit wave character.

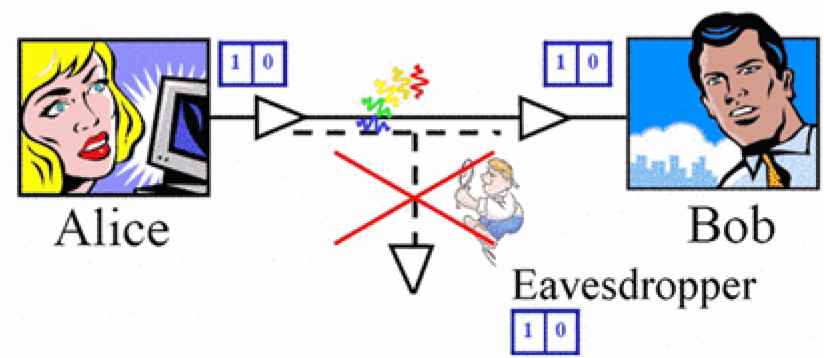
When measured, quantum systems exhibit particle character.

Measurements that acquire information perturb the quantum system.



Eve may measure a classical signal without detection.

We do not know how much Eve has learnt about the key!

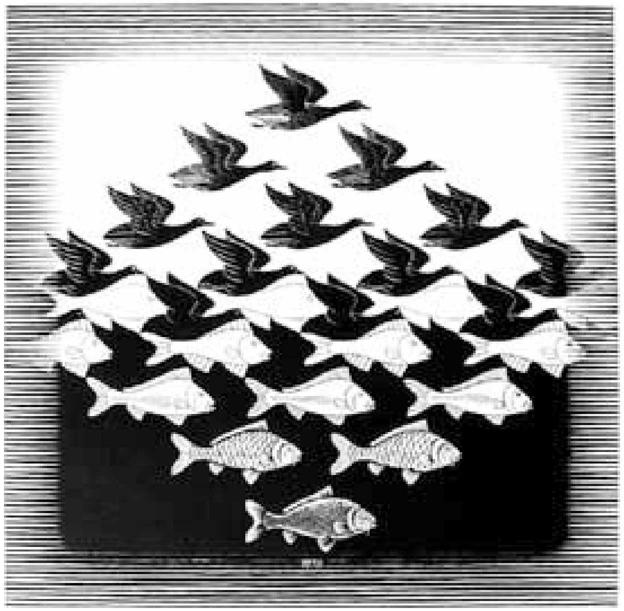


Eve's measurements of a quantum signal causes perturbation and can be detected.

Problem Set

1. Young's experiment is performed with blue-green light of wavelength 500 nm. If the slits are 120 mm apart, and the viewing screen is 5.40 m from the slits, how far apart are the bright fringes near the center of the interference pattern? 2.25 mm
2. The cosmic background radiation follows a black body curve. If the radiation peaks at a wavelength of 2.2 mm, what is our temperature? 2.6 K If the universe was 2970 K 379000 years after the big bang when the universe became transparent to electromagnetic radiation, what was the peak wavelength of the curve? 976 nm
3. Photoelectrons are ejected from the surface of sodium metal when illuminated. The stopping potential for the ejected electrons is 5.0 V, and the sodium work function is 2.2 eV. What is the wavelength of the incident light? 170 nm
4. If you double the kinetic energy of a nonrelativistic particle, what happens to its de Broglie wavelength? Cut by a factor of $(1/2)^{0.5}$ What if you double its speed? Cut by a factor of 1/2
5. If we assume the sun's emission rate is 3.9×10^{26} W and that all of its light has a single wavelength of 550 nm, at what rate does it emit photons? 1×10^{45} photons/s
6. In a tube television electrons are accelerated through a 25.0 kV potential difference. If they are nonrelativistic, what is their de Broglie wavelength? 7.75 pm
7. How far would a beam of light travel in 1 μs? 900 m In 1 attosecond? 0.30 nm

8. Discuss M.C. Escher's print and its relationship to the dual nature of light and Heisenberg Uncertainty Principle.



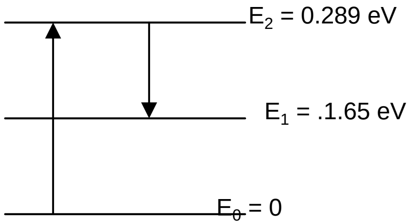
9. The Uncertainty in the position of an electron is 50 pm or about the radius of a hydrogen atom. What is the uncertainty in the measurement of the momentum for that electron? 2.1×10^{-21} kgm/s

10. Starting with the idea that an electron is a wave, prove that $E_n = n^2h^2/8mL^2$ for an electron trapped as a standing wave in a one-dimensional box. Assume the length of the box is L and that m is the mass of the electron (hint: use de Broglie's equation and find momentum in terms of kinetic energy).

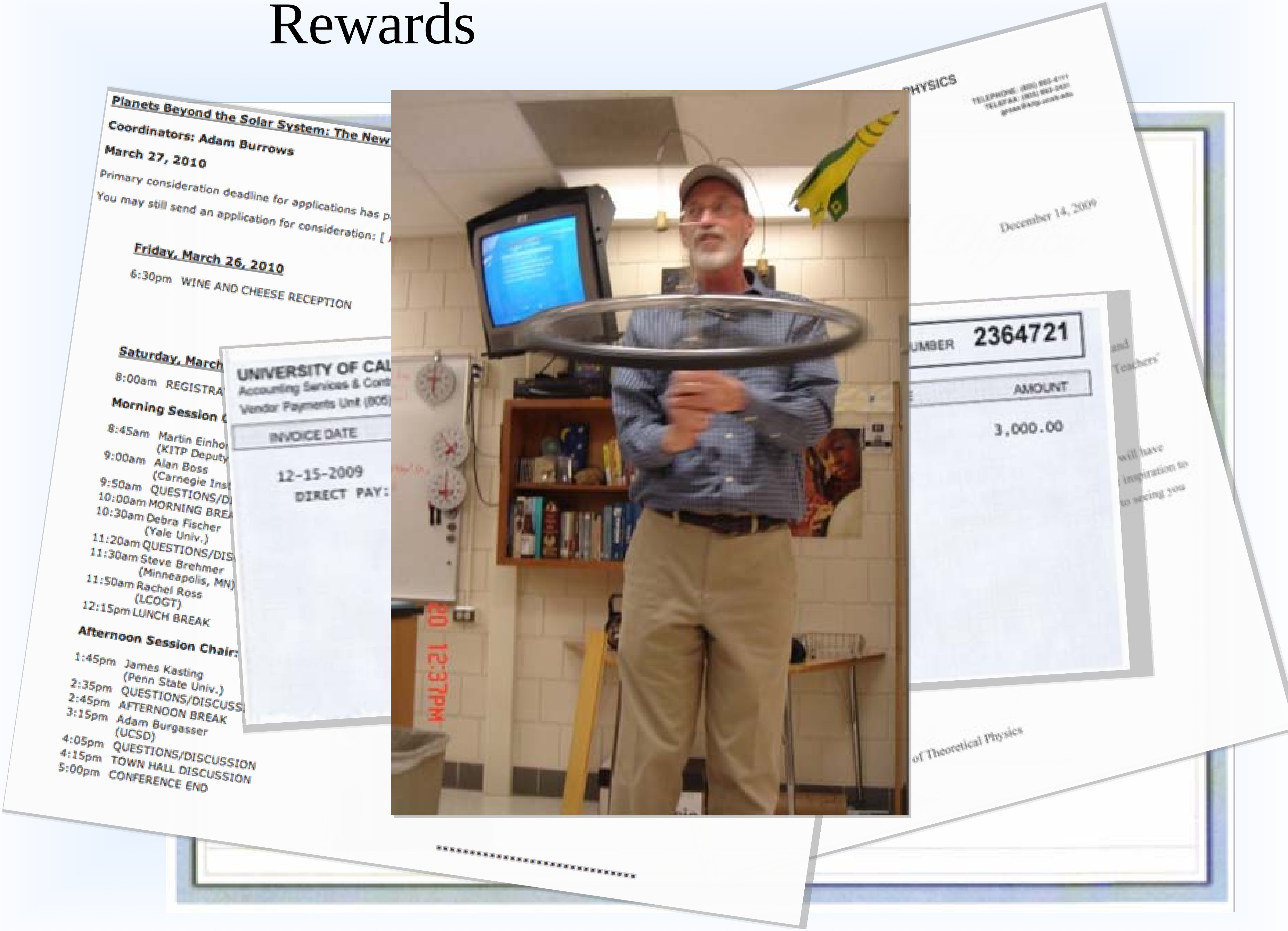
11. What would be the smallest diameter object you might expect to resolve with a microscope if the wavelength of light being used is 500 nm, the index of refraction is 1.4 and the total angle seen by the lens is 5° ? 2×10^{-6} m = 2 µm

12. A pulsed laser emitting 694.4 nm light produces a 12 ps, 0.150 J pulse. What is the length of the pulse? 3.60 mm How many photons are emitted during each pulse? 5.24×10^{17} photons

13. The diagram at the right shows the energy levels in a substance. What wavelength of light is required to excite the electron. 4.29 µm What wavelength of light is emitted? 0.100 µm



Rewards


Planets Beyond the Solar System: The New
Coordinators: Adam Burrows
March 27, 2010
Primary consideration deadline for applications has p
You may still send an application for consideration: [
Friday, March 26, 2010
6:30pm WINE AND CHEESE RECEPTION
Saturday, March
8:00am REGISTRA
Morning Session
8:45am Martin Einhor
(KITP Deputy
9:00am Alan Boss
(Carnegie Inst
9:50am QUESTIONS/D
10:00am MORNING BREA
10:30am Debra Fischer
(Yale Univ.)
11:20am QUESTIONS/DIS
11:30am Steve Brehmer
(Minneapolis, MN)
11:50am Rachel Ross
(LCOGT)
12:15pm LUNCH BREAK
Afternoon Session Chair:
1:45pm James Kasting
(Penn State Univ.)
2:35pm QUESTIONS/DISCUSS
2:45pm AFTERNOON BREAK
3:15pm Adam Burgasser
(UCSD)
4:05pm QUESTIONS/DISCUSSION
4:15pm TOWN HALL DISCUSSION
5:00pm CONFERENCE END
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Questions?