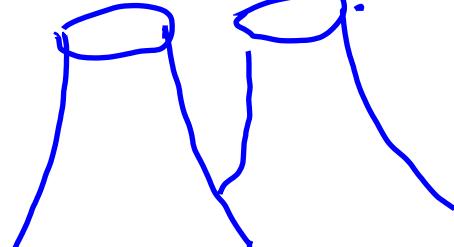


What do you think of when  
you talk about nuclear  
technology?

3 clouds radioactive?



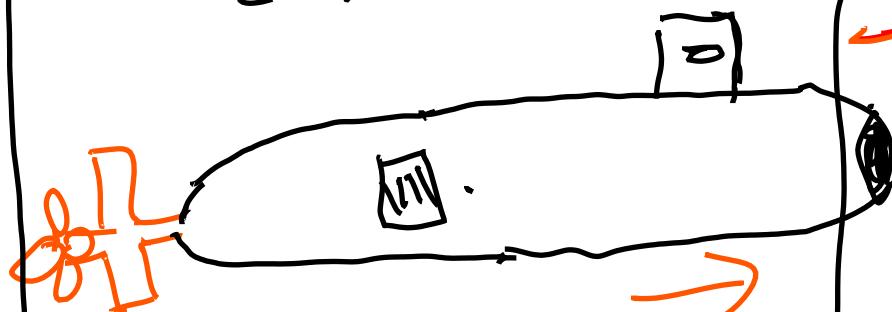
Picture 1



Picture 2

- Gen Y
- Red Alert 2
  - Yuri's Range
  - C & C
    - ↳ Generals
    - ↳ Tiberium Wars

Cold War



Picture 3

26 knots

- Starcraft II
- Dune Part II
  - ↳ Atomics

))))

Sonar

# What's in the cold war?

## - Nuclear tests

↳ USA

↳ Castle Bravo

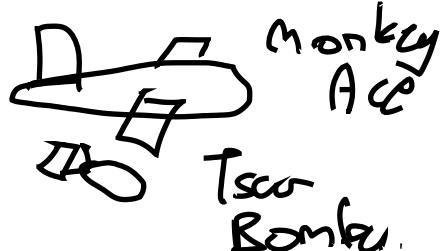
↳ Ivy Mike

↳ ~~Operation~~ Baker (Bikini Atoll)

↳ Russia

↳ Tsar Bomba.

Bloons TDB.



↳ China

↳ India

↳ France

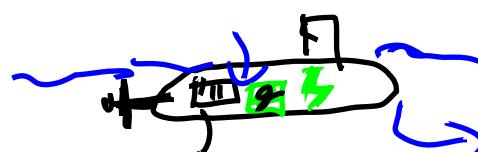
↳ UK.

Submarines

↳ reactors

↳ mobile missile sites (SLBMs)

U-boats.



Petrol/Diesel

above  
water  
speed >

Underwater  
speed.

## Nuclear Submarine mias.

U-571

↳ Hunt for the Red October

↳ Crimson Tide

Pop culture

- Nuclear is dangerous

- Nuclear → scary

- Nuclear is exotic

## Nuclear accidents.

↳ Three Mile Island

↳ Chernobyl

↳ Fukushima Daiichi?

↳ check spelling

Nuclear safety.

For next lecture

① Accidents + pop culture

↳ BBC's Chernobyl.

② Nuclear security & cold war  
arms race

③ Outline of technical stuff.

# Cold War

1945

2x atomic bombs  
plane

1945 - 1949 " US → major nuclear power

1949

USSR → explodes 1<sup>st</sup> atomic bomb.



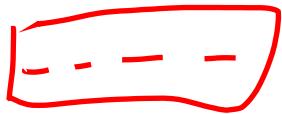
Counter-value  
drop bombs on  
cities

Counter-force

drop bombs to  
kill opponents nuclear  
capability



Red Alert  
Red Alert 2



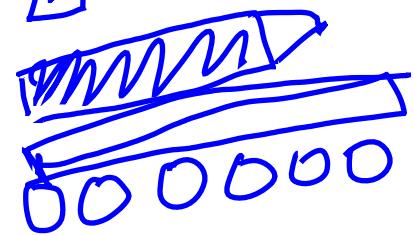
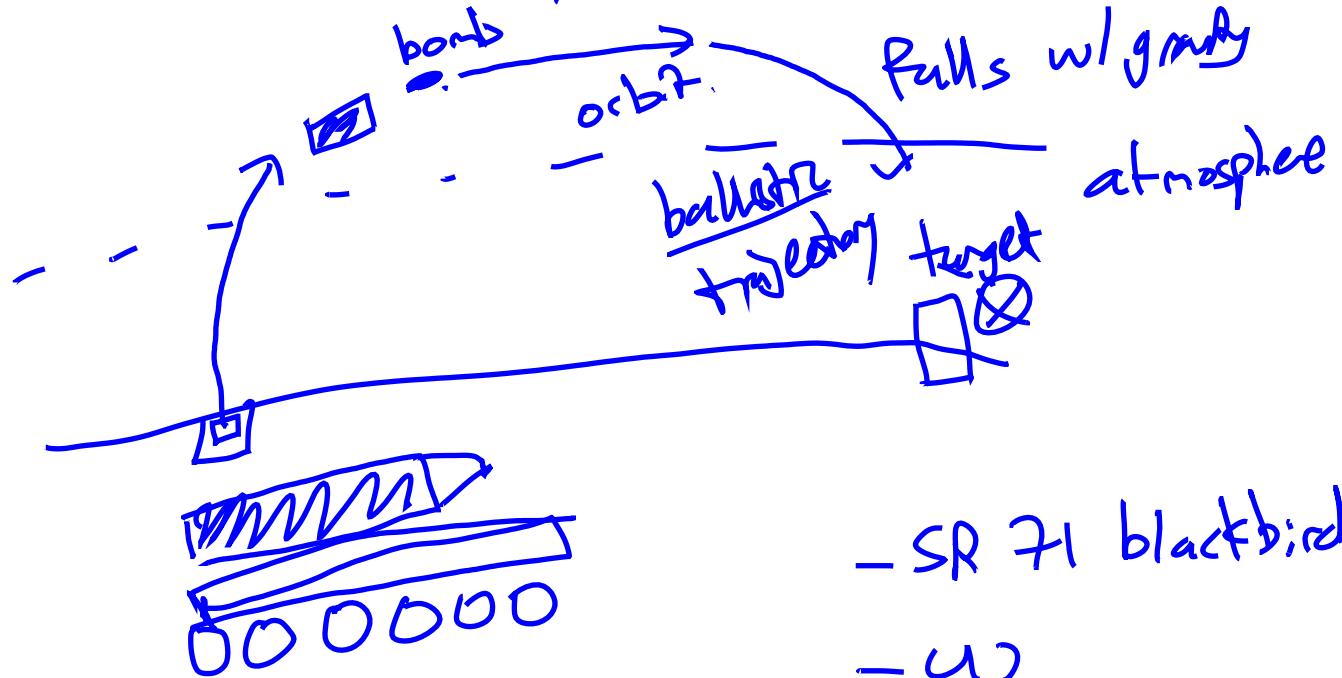
ICBMs



Intercontinental

Ballistic  
missile

(ICBMs)



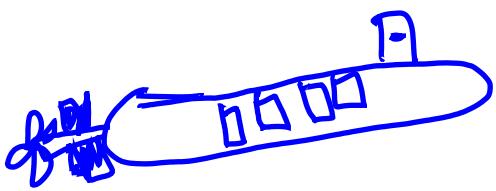
- SR 71 blackbird  
- U2

mobile ICBM

nuclear  
deterrence

mutually  
assured  
destruction

MAP



Submarine launched  
ballistic missiles  
(SLBMs)

accuracy  $\rightarrow$  a

~~big~~ problem

for SLBMs.

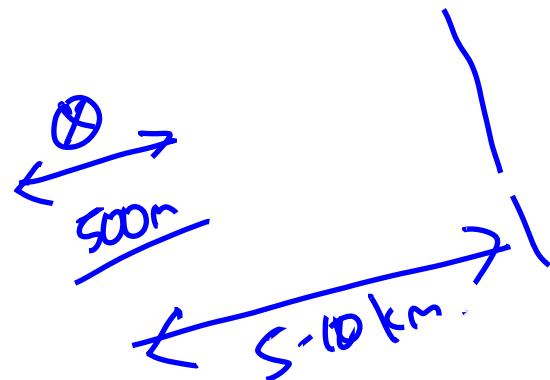
① stay underwater very long



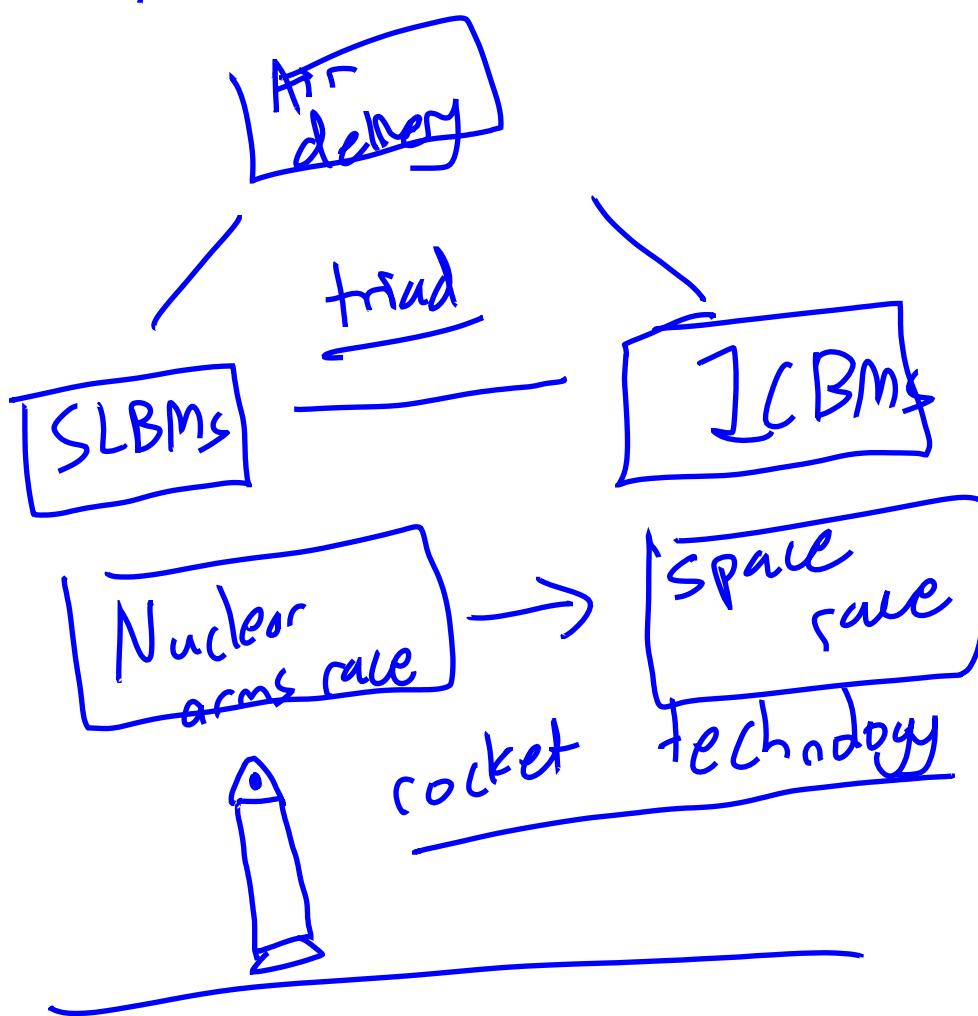
② Big big explosions,  
much bigger than Hiroshima.



↑  
tech.



nuclear triad.



- GPS
- Lunar explorations
- Communications networks → SpaceX
- Telescopes → Hubble space telescope
- Advanced science & technology

# Lecture 3

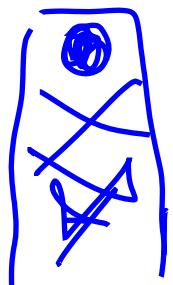
## Manhattan project.

1942

\* Oppenheimer  
cooked

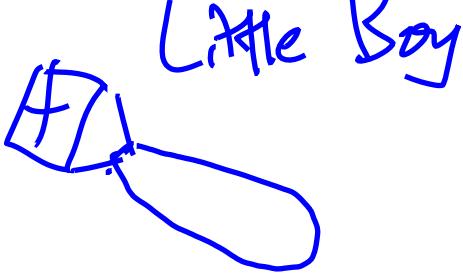
Nazi Germany

trinity



Pu-239

New Mexico



Little Boy

Hiroshima  
Bomb

U-235



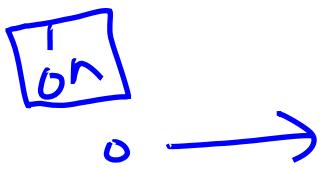
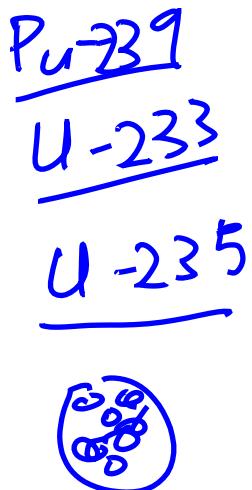
Fat man

Nagasaki:

Pu-239

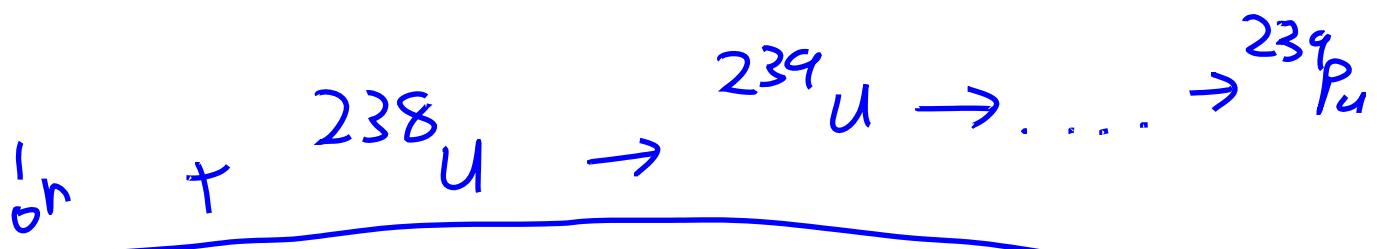
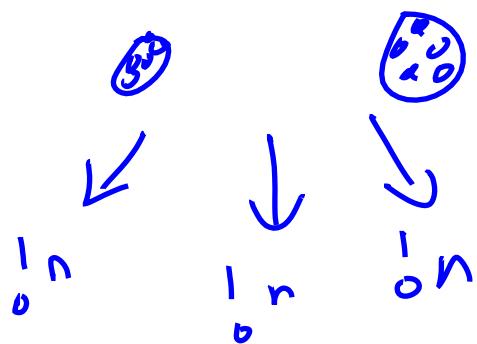
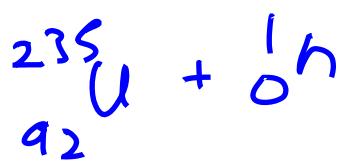
Concepts w/ as little mathematics as possible

Physics



↓ fission

A (total no. of neutrons + protons)  
 $\frac{235}{92} U$   
Z (proton number)



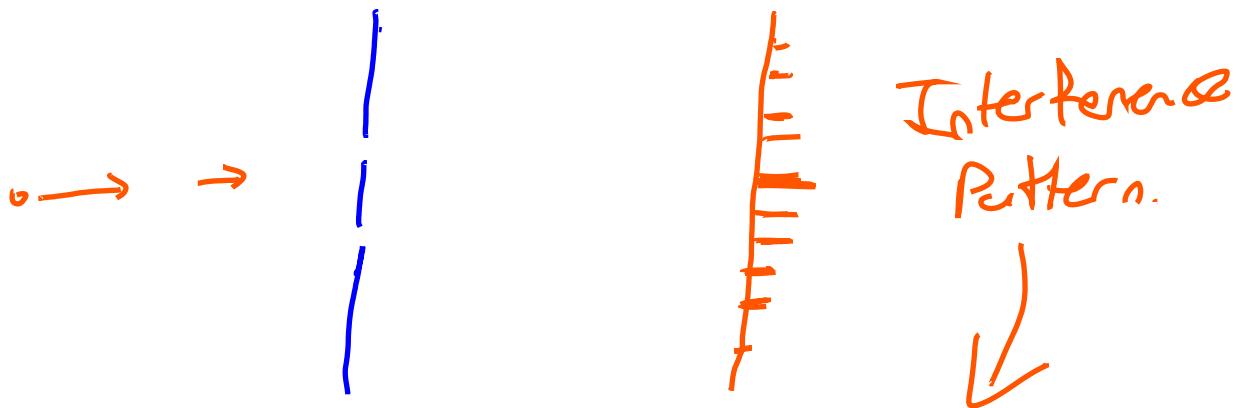
# Quantum Physics

key Idea of Quantum Physics.

matter (protons, neutrons, electrons)

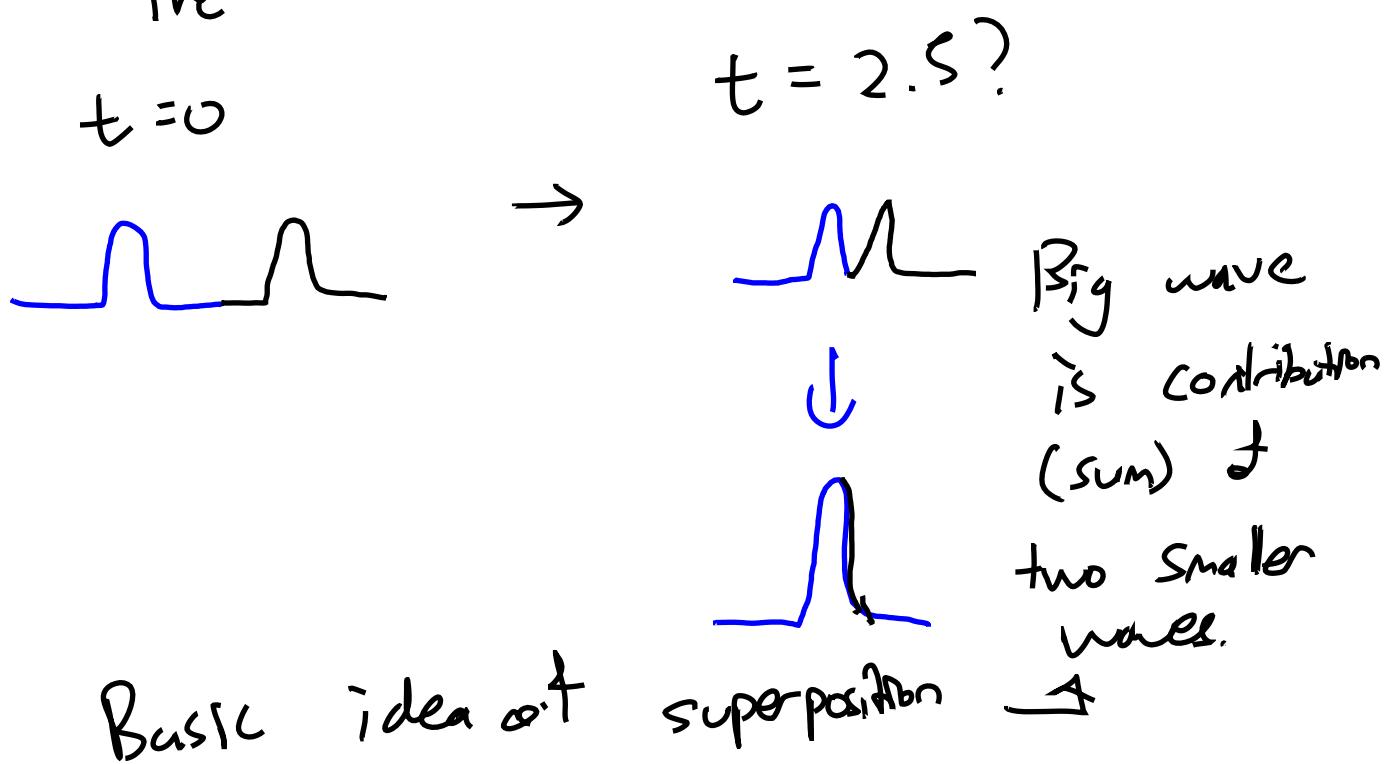
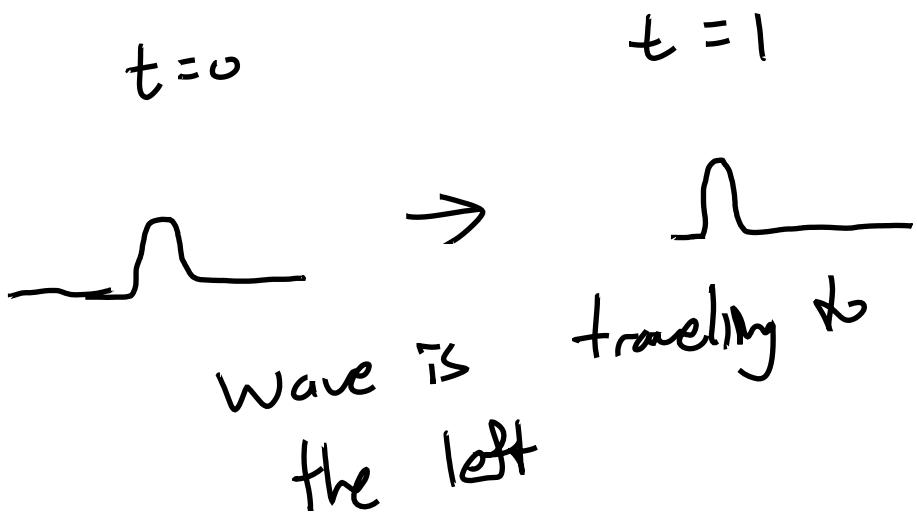
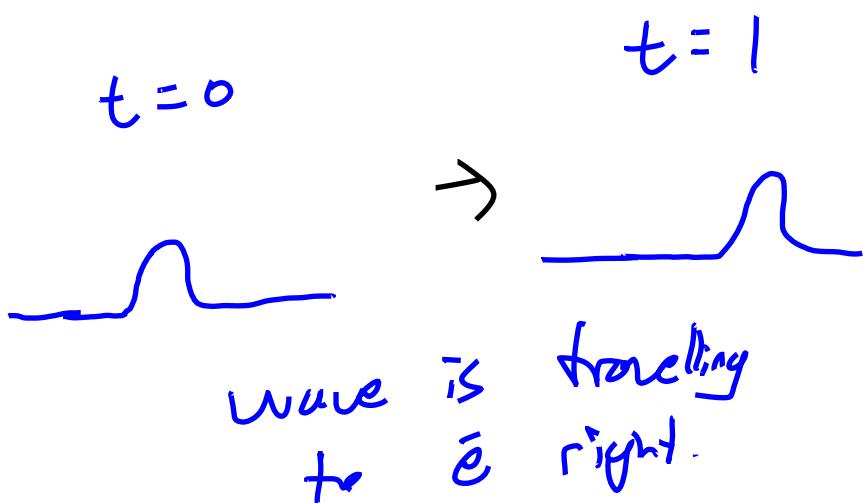
• particle "billiard balls."  
— wave

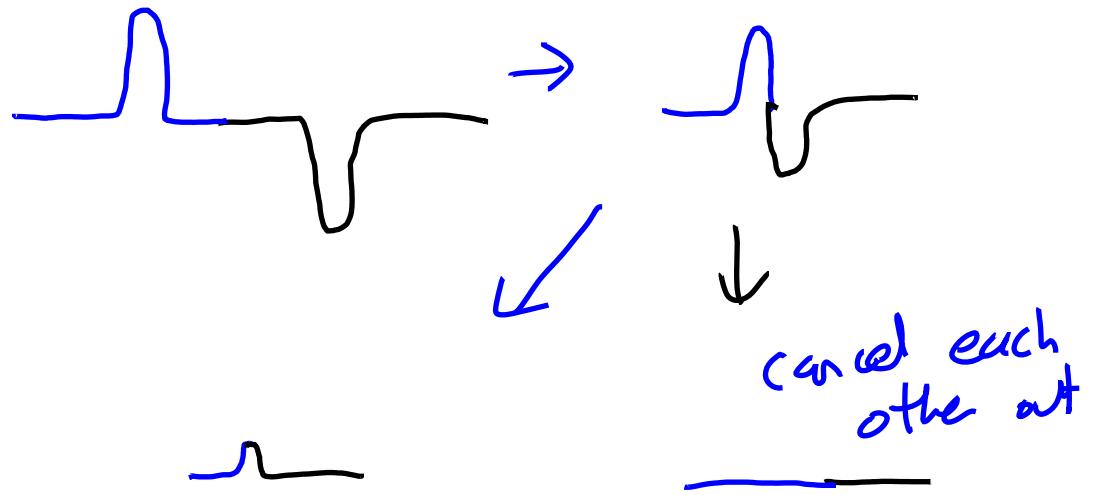
Young's Double slit experiment.



Light  $\rightarrow$  electromagnetic wave

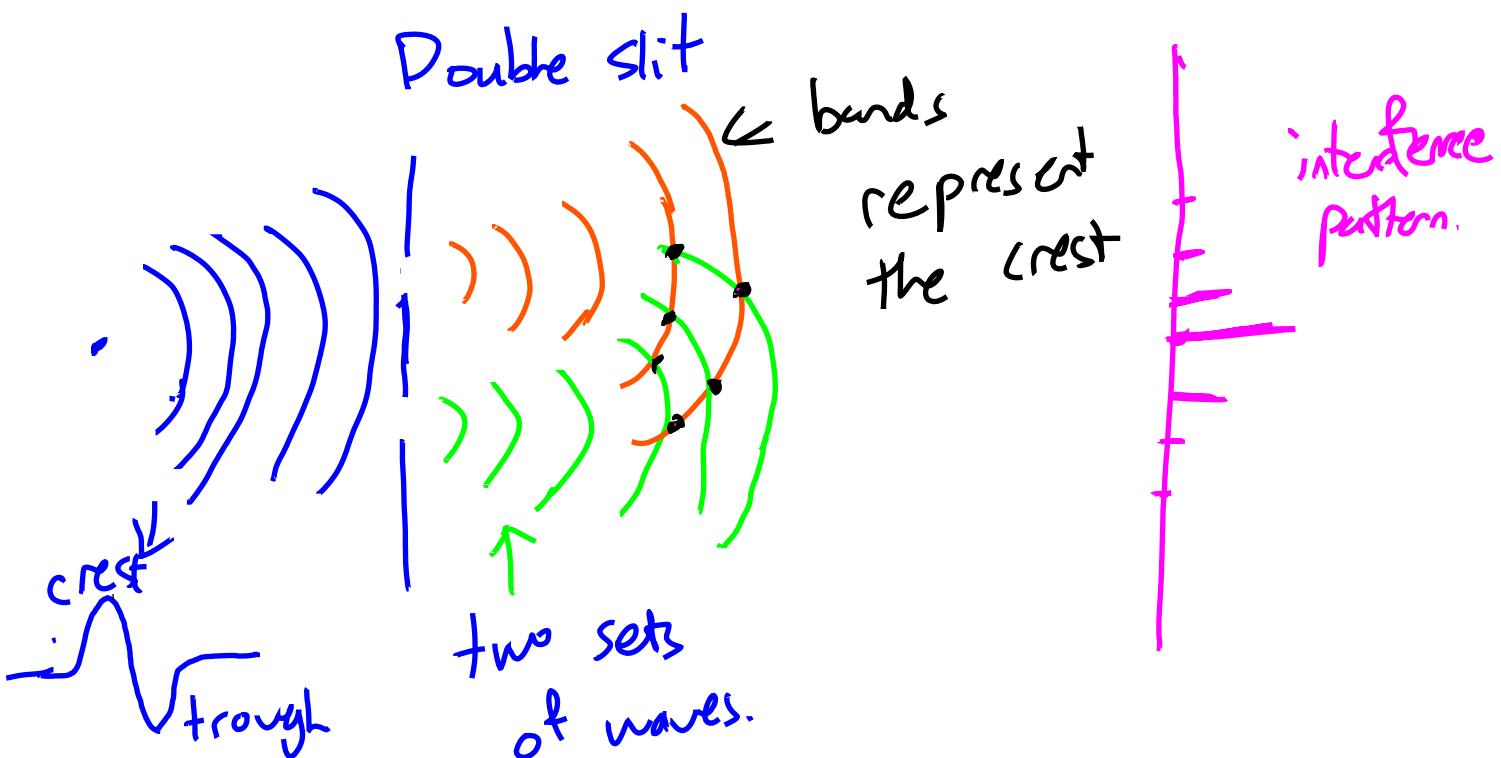
# Waves & Superposition





① when waves build on each other → constructive interference

② when waves cancel each other out → destructive interference.



# Lecture 4

Lot's of things in nuclear physics  
can be explained by waves.

---

Consequences of wave behaviour

- electrons in atoms have discrete energy levels
- protons & neutrons in the nucleus have discrete energy levels



in quantum physics, the act of observation changes the experimental

results

---

Discrete Energy levels

---

wave behaviour  $\rightarrow$  discrete energy levels.

standing waves.

wave on water



"free"

I make the wave "not free"

make the ends "stuck"



wave bounces back & forth &

interferes with itself.

Guitar string

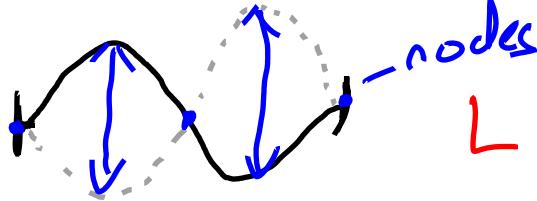


$$n = 1$$



You can have  
a certain number  
of peaks  $L$

$$n = 2$$



$$n = 3$$

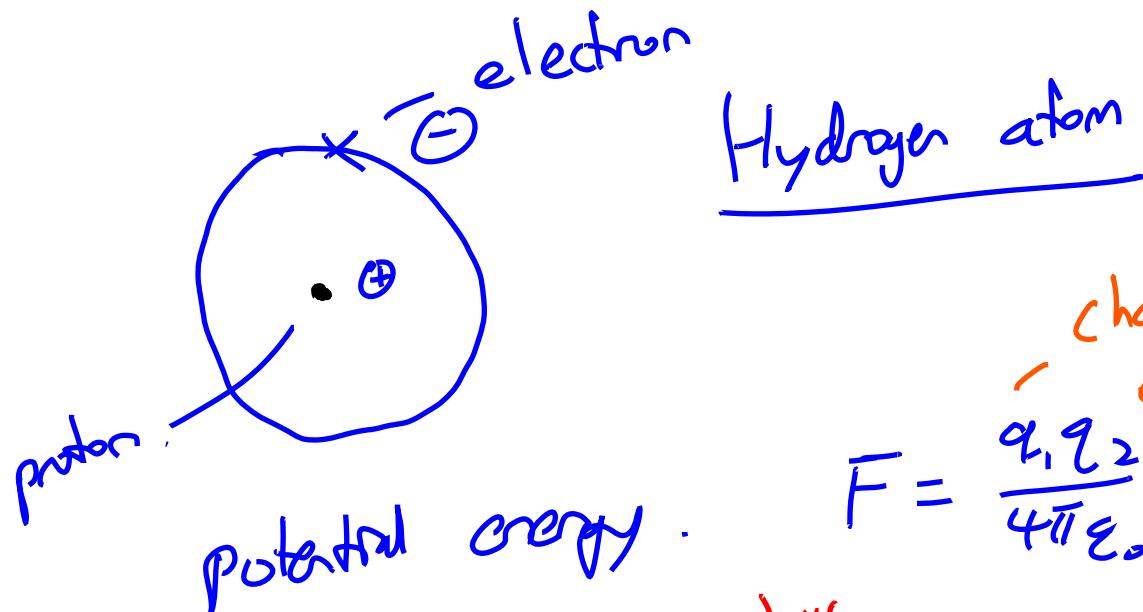


nodes

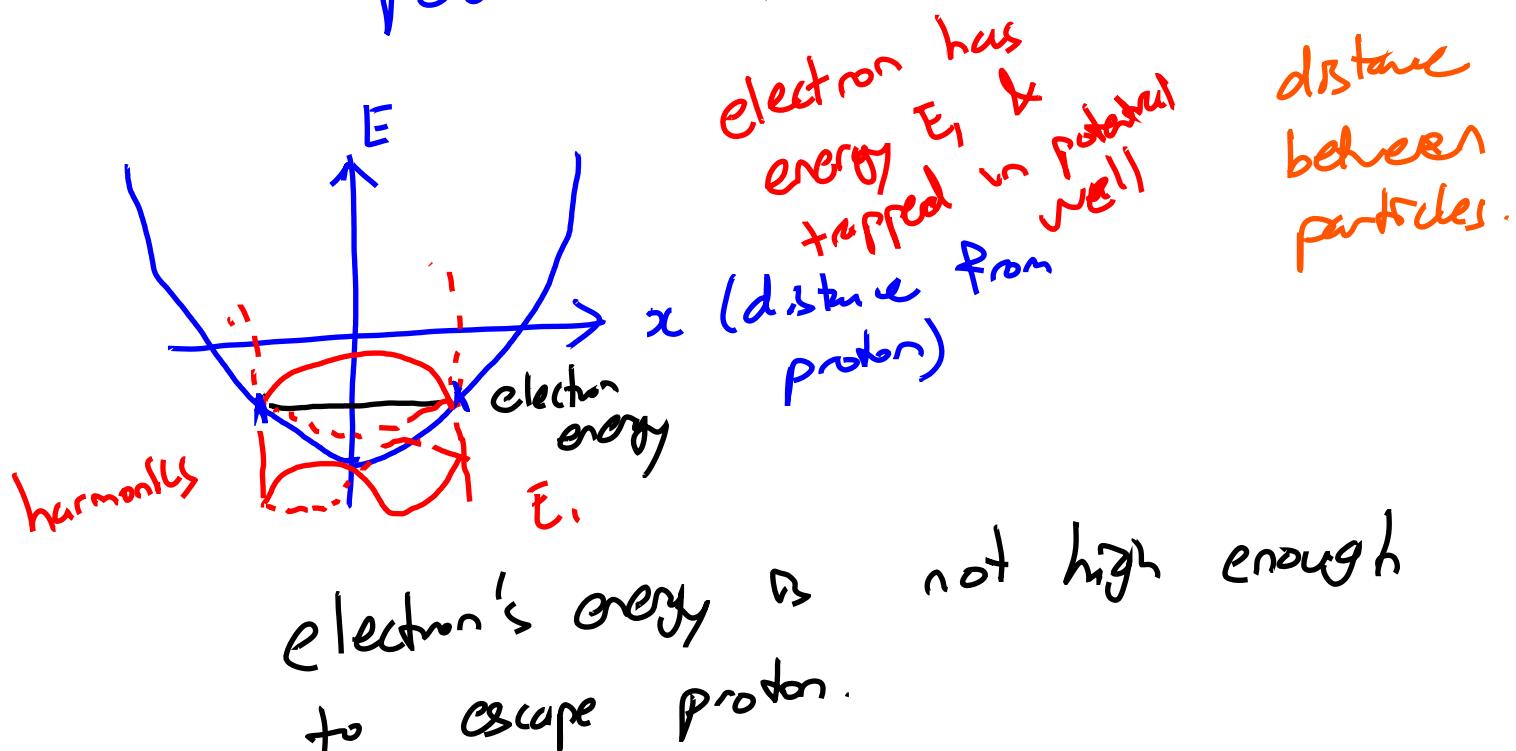
You can store energy at  
different frequencies.

$$V = f\lambda$$

The frequencies (wavelengths) where you can store energy is fixed.



$$F = \frac{q_1 q_2}{4\pi \epsilon_0 r^2} = \text{charge of each particle}$$



electron's energy is not high enough to escape proton.

① Electrons behave as waves

② movement of electron waves is

Standing electron

restricted as electron energy < walls.  
potential energy req'd to escape.

---

↳ Standing waves consequence

- ① frequency / wavelength is restricted
  - ② Energy is correlated to frequency
  - ③ Energy levels are therefore restricted.
- 

What is the of electrons is also  
the of the nucleus.

- ① protons/neutrons behave as waves
- ② movement of proton/neutron waves restricted by attractive forces in nucleus  $\rightarrow$  strong nuclear force

↳ give rise to fixed energy levels with  $\infty$  nucleus.

Energy is "quantized"

↳ fixed energy levels.

If you are interested in the math.

Go read up:

- Schrodinger's equation

- Wave function

$$\boxed{\Psi(x)}$$

$\Psi$  = "psi"

↳ "probability waves"

$$|\Psi(x)|^2$$

↳  $\Psi(x) \times \Psi^*(x) \Rightarrow \underline{\text{probability}}$

# Lecture 5

Schrodinger's equation

↳ implications

① Guitar string analogy

↳ Infinite square well.

↳ 1D

↳ "free field" is infinite

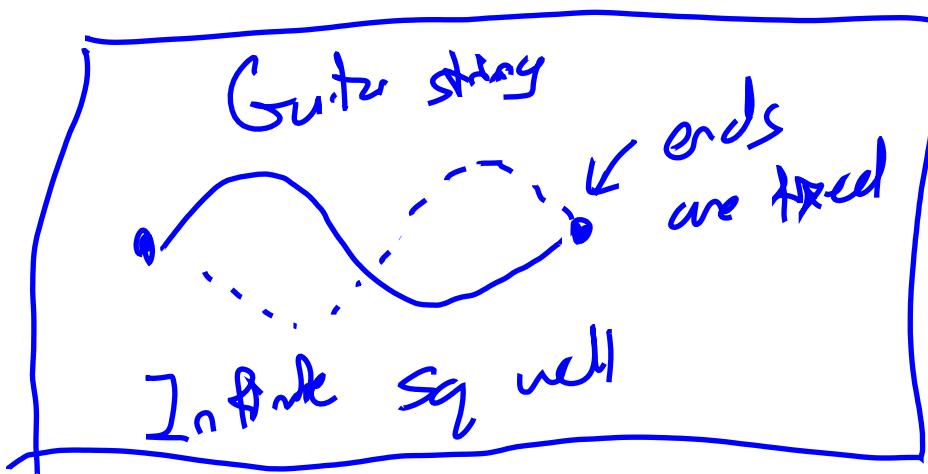
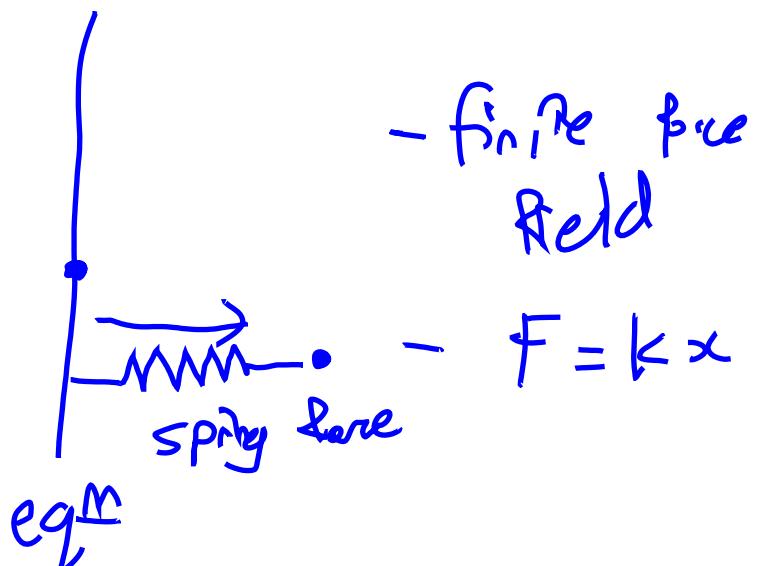
In real life, force fields  
are finite

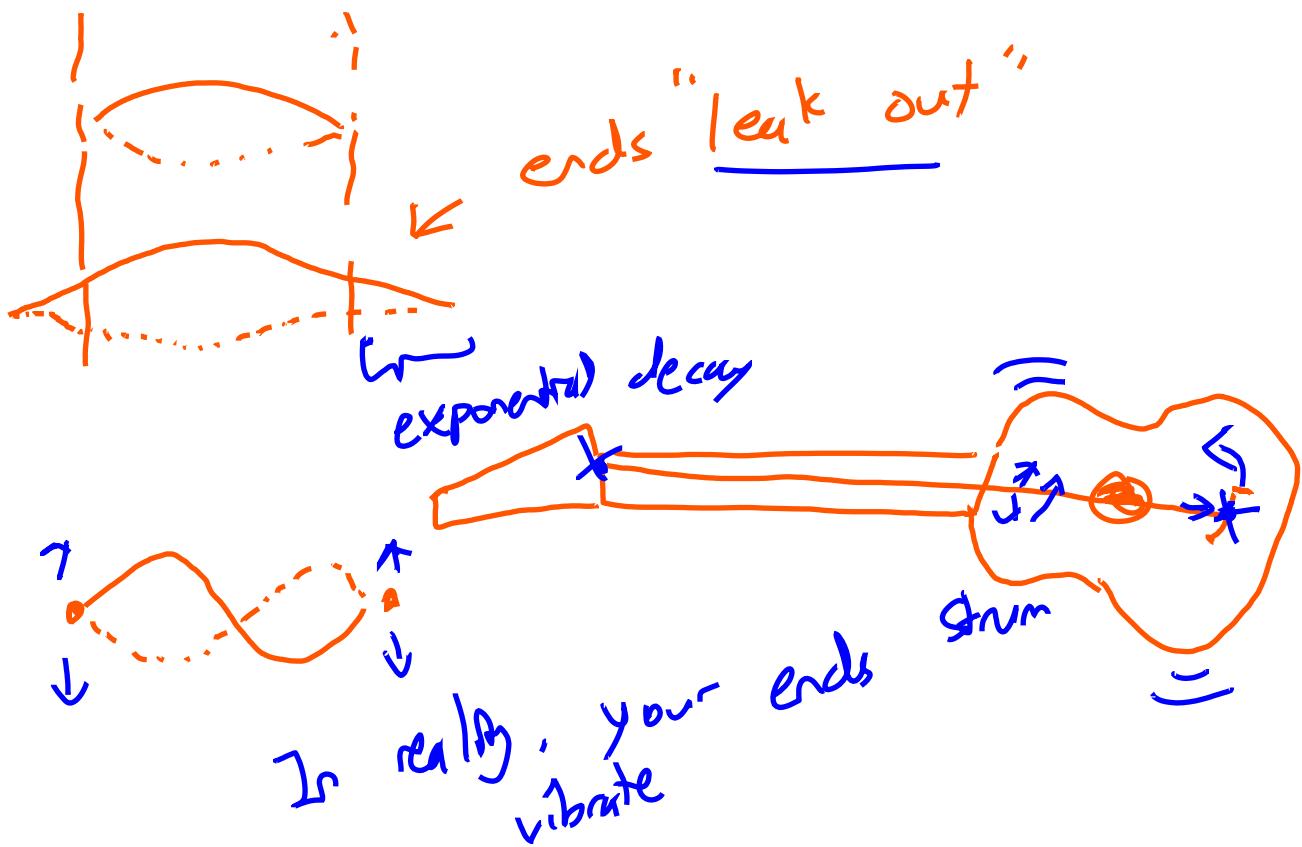
② Finite force fields

↳ 1D

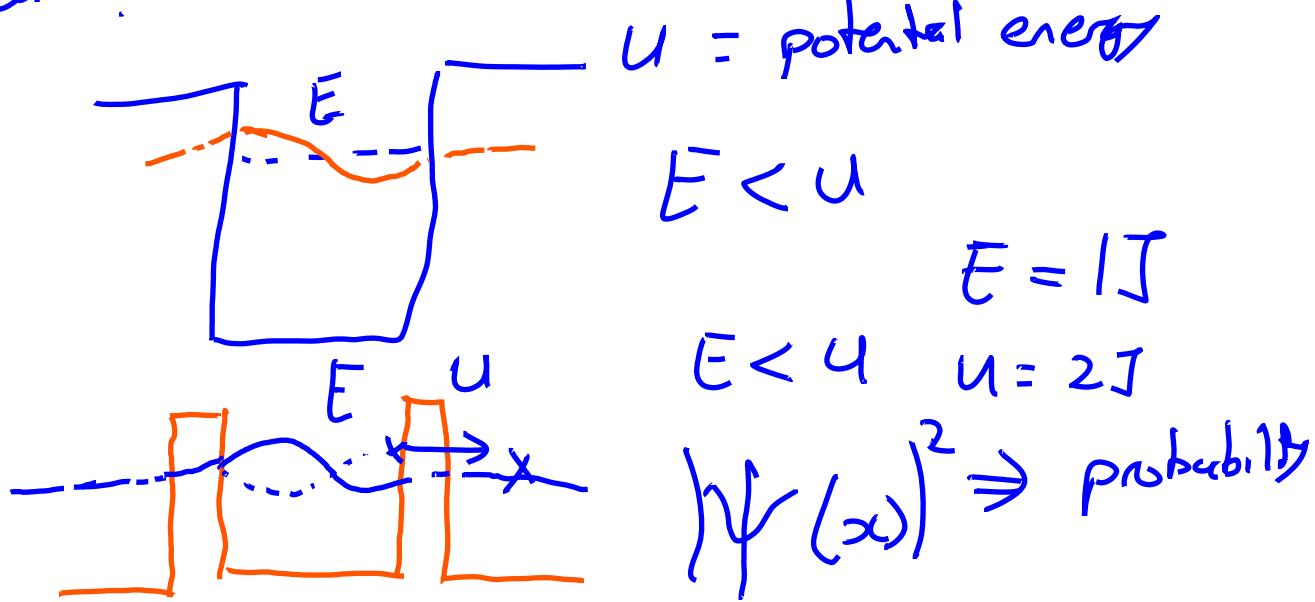
↳ finite force field,  
finite well

↳ simple harmonic oscillator





what do waves "leaking out"  
mean?



particles leak through barrier

## Quantum Tunneling

- ↳ Alpha decay
- ↳ Fusion process in the sun.

