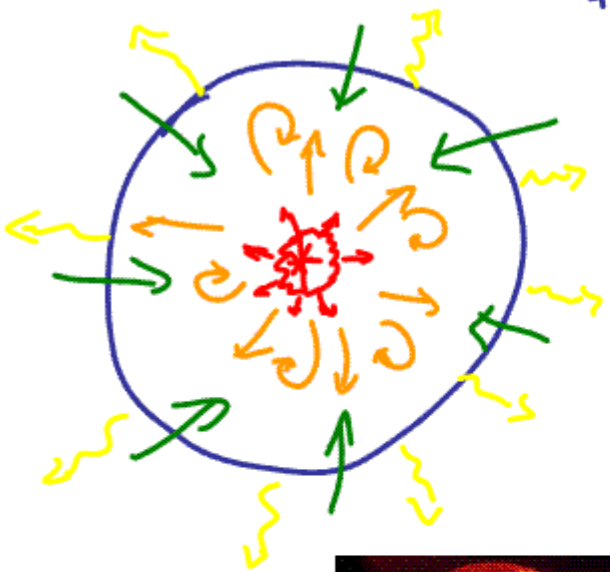
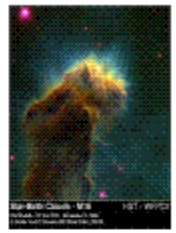
Physics 100 – Nov. 5, 2007

- Exam 2 – Nov. 14
  One week from Wednesday
  - Hoyt during regular class slot
  - Calculator
  - Notecard
  - Material from last time thru STARS (last lecture) — nuclear phys.
  - Will email w/ material coverage soon
  - Q + A session . . . will do

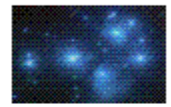
- Would like to meet w/ presentation groups
  --- All before Thanksgiving
  - Select spokesperson + get in touch w/ me to set up time

Last time intimate relation between the large + small drive the stars and synthesize the elements

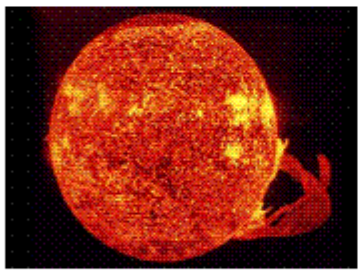




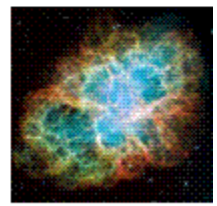
- gravity pulls in
- heat (radiation pressure) pushes out



- "Thenonuclear" fusion reactions in core

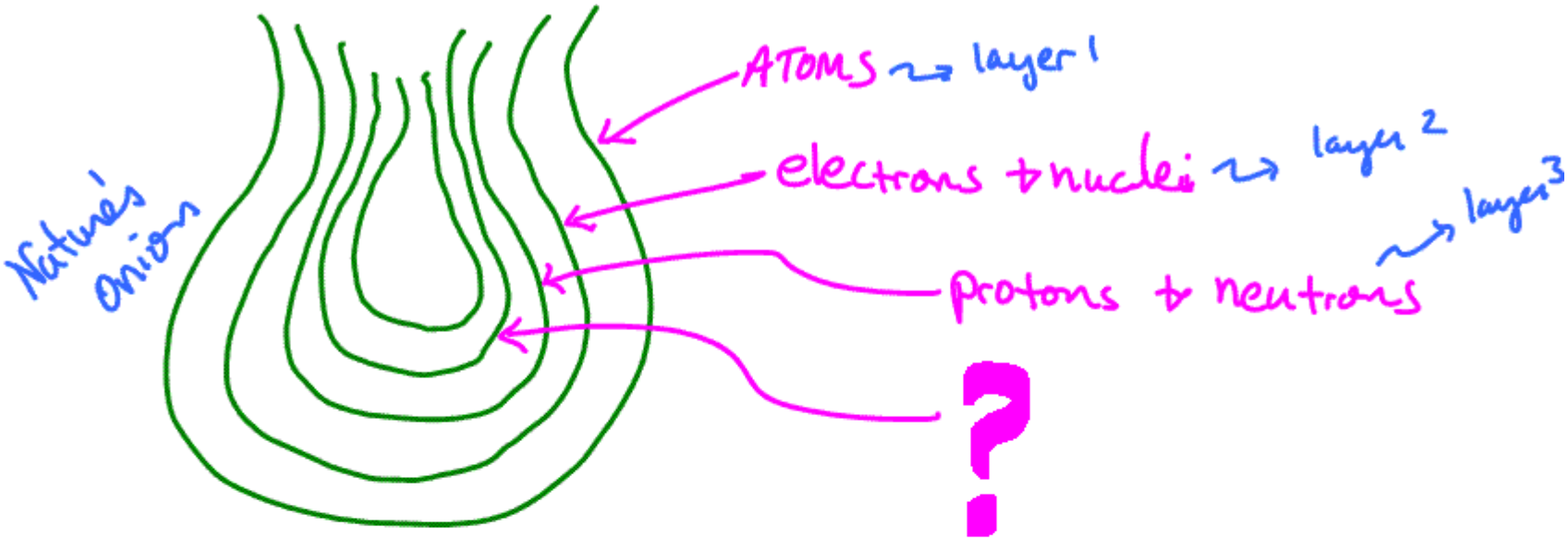


- starts w/ H → He but can work way up to ^{56}Fe

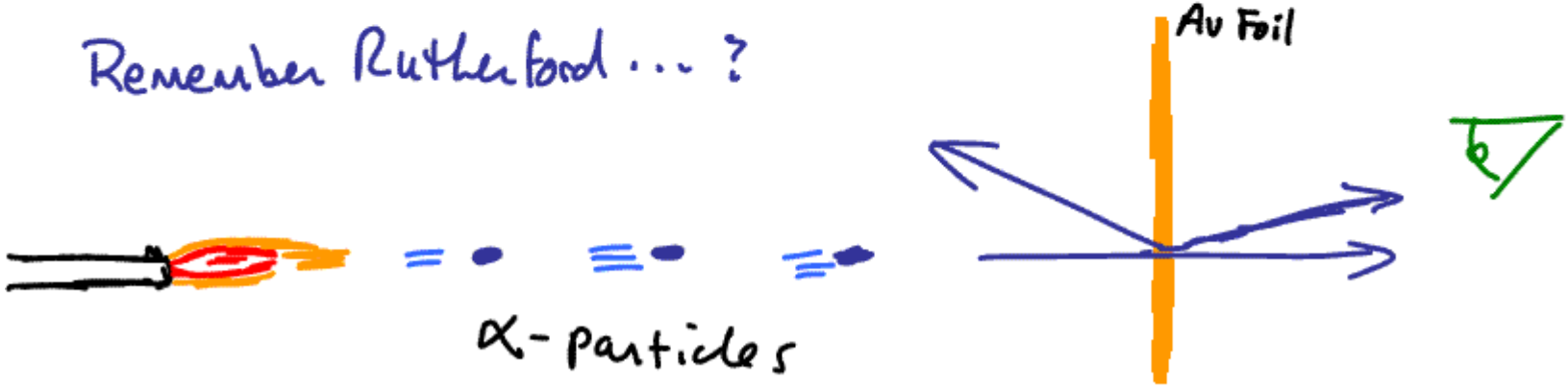


- Heavier elements formed in supernovae
- white dwarfs, neutron stars, Black Holes

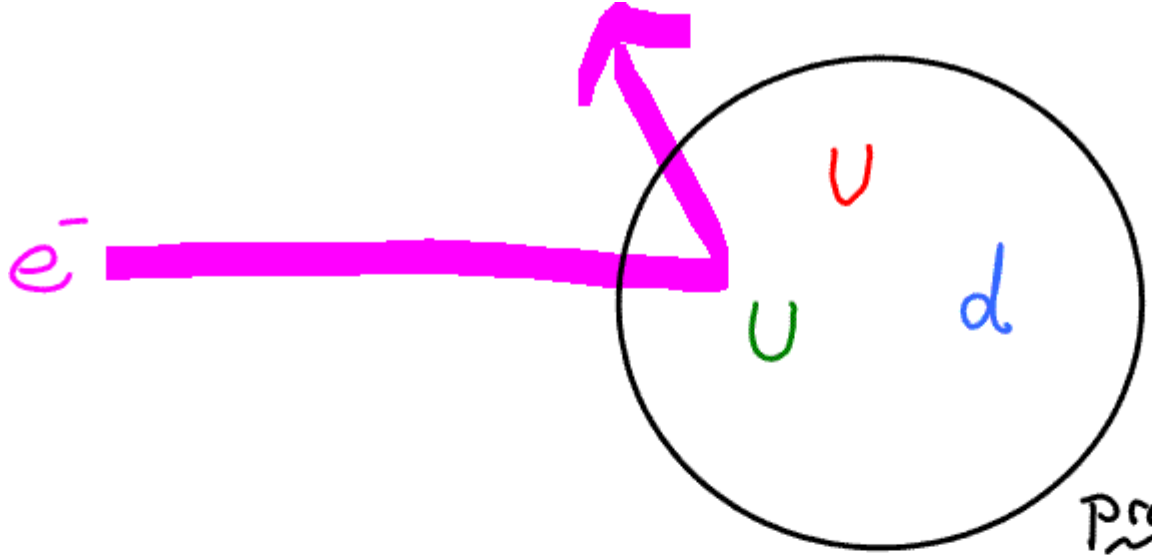
Rotation comes from Conservation of "Angular Momentum"



Remember Rutherford ... ?



→ Nuclear model of atom



Layer 4

The Subnuclear World

U ≡ up quark $q = +\frac{2}{3}|e|$

d ≡ down quark $q = -\frac{1}{3}|e|$

Particle (high energy) Physics

New Taxonomy of Particles
New way of looking at forces

The STANDard Model!

a little overwhelming at 1st ...

Places to learn more: Particle and nuclear physics links

http://pdg.lbl.gov

http://particleadventure.org

http://www.slac.stanford.edu/gen/edu/aboutslac.html

http://www.bnl.gov/bnlweb/sciindex.html

http://www.bnl.gov/rhic/

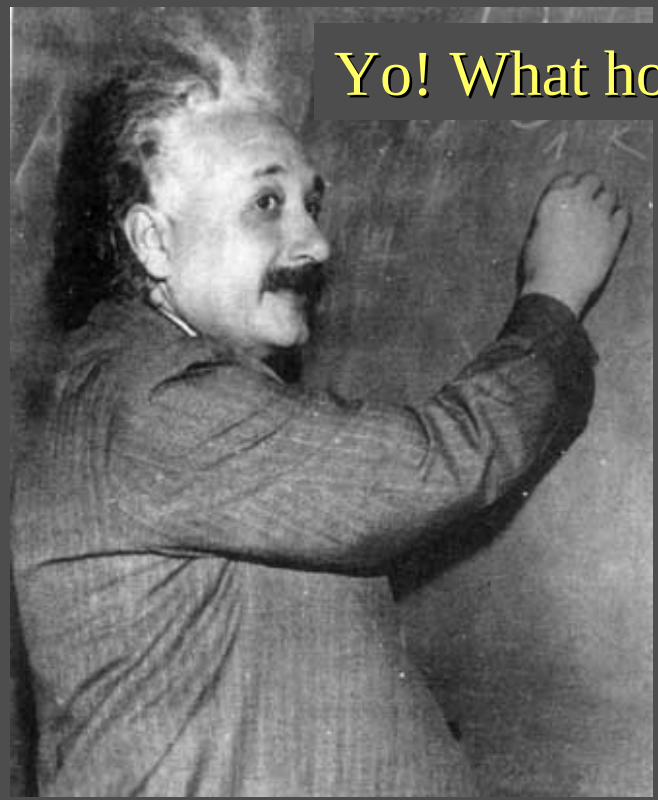
http://public.web.cern.ch/public/

http://www.fnal.gov/

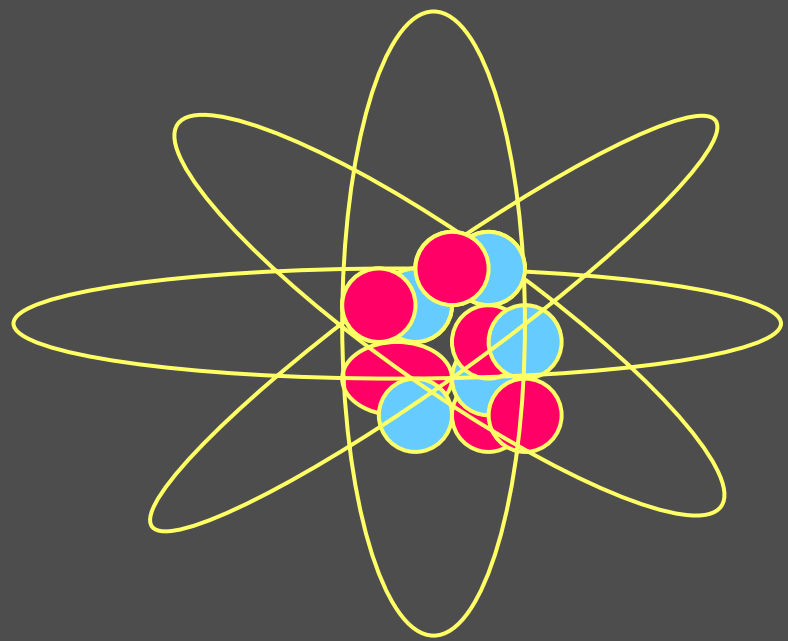
http://www.er.doe.gov/production/henp/np/index.html

http://www.science.doe.gov/hep/index.shtm

Inquiring minds want to know ...



Yo! What holds it together?




52
46
ACXIOM
27
HASTINGS

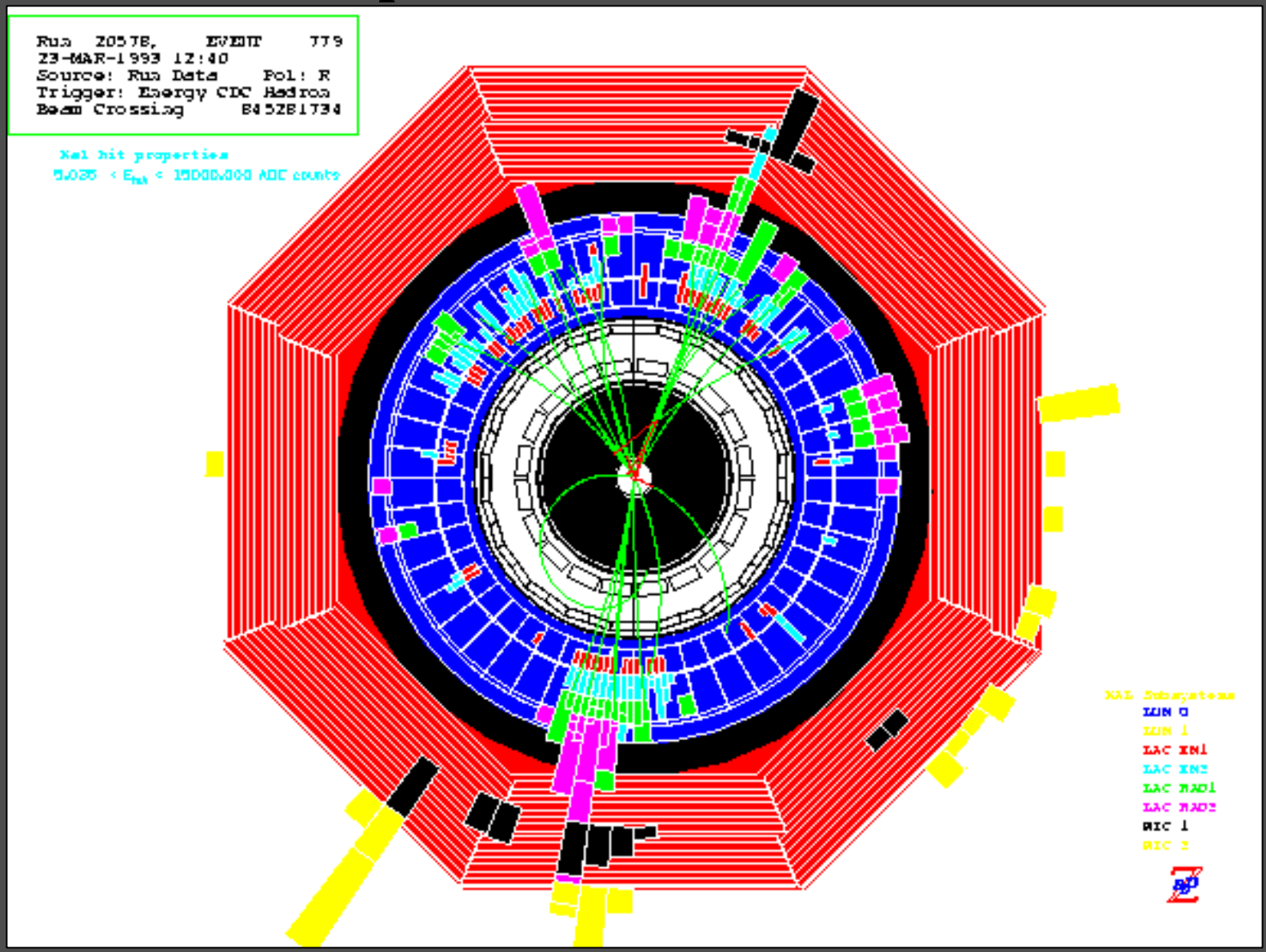
Fermi National Accelerator Laboratory (near Chicago)

CDF

Minos

Stanford Linear Accelerator Center

Event display from the SLD experiment at SLAC



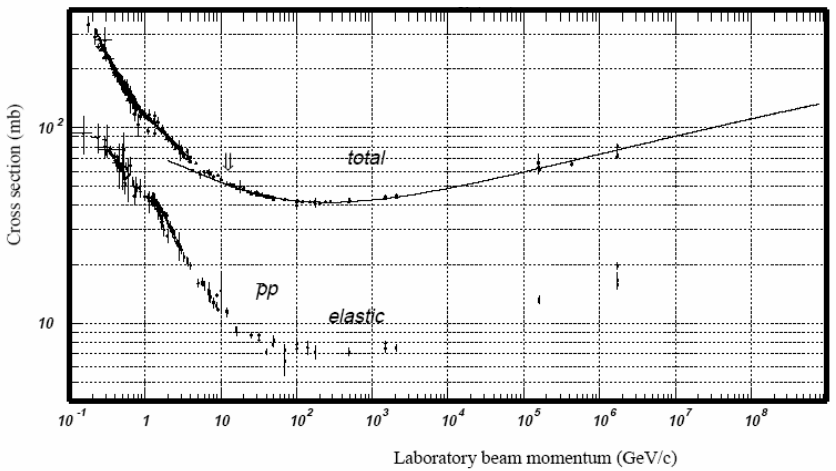
π^0

$I^G(J^{PC}) = 1^-(0^{-+})$

Mass $m = 134.9766 \pm 0.0006$ MeV (S = 1.1)
$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.4 \pm 0.6) \times 10^{-17}$ s (S = 3.0)
$c\tau = 25.1$ nm

For decay limits to particles which are not established, see the appropriate Search sections (A^0 (axion), and Other Light Boson (X^0) Searches, etc.).

π^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
2γ		(98.798 ± 0.032) %	S=1.1	67
$e^+e^-\gamma$		(1.198 ± 0.032) %	S=1.1	67
γ positronium		(1.82 ± 0.29) $\times 10^{-9}$		67
$e^+e^+e^-e^-$		(3.14 ± 0.30) $\times 10^{-5}$		67
e^+e^-		(6.2 ± 0.5) $\times 10^{-8}$		67
4γ		< 2 $\times 10^{-8}$	CL=90%	67
$\nu\overline{\nu}$	[a]	< 8.3 $\times 10^{-7}$	CL=90%	67
$\nu_e\overline{\nu}_e$		< 1.7 $\times 10^{-6}$	CL=90%	67
$\nu_\mu\overline{\nu}_\mu$		< 3.1 $\times 10^{-6}$	CL=90%	67
$\nu_\tau\overline{\nu}_\tau$		< 2.1 $\times 10^{-6}$	CL=90%	67
$\gamma\nu\overline{\nu}$		< 6 $\times 10^{-4}$	CL=90%	–
Charge conjugation (C) or Lepton Family number (LF) violating modes				
3γ	C	< 3.1 $\times 10^{-8}$	CL=90%	67
μ^+e^-	LF	< 3.8 $\times 10^{-10}$	CL=90%	26
μ^-e^+	LF	< 3.4 $\times 10^{-9}$	CL=90%	–
$\mu^+e^- + \mu^-e^+$	LF	< 1.72 $\times 10^{-8}$	CL=90%	26



week ending
4 JUNE 2004

→ $\omega Y(1S)$

E. Coan,[2] Y.S. Gao,[2] F. Liu,[2]
Dorjkhaidav,[3] R. Mountain,[3]
. Mahmood,[4] S. E. Csorna,[5]
pas,[7] A. Shapiro,[7] W. M. Sun,[7]

S 30 MARCH 1998

ISS

mendolia,[27] D. Amidei,[20] J. Antos,[33]
[8] M. Atac,[7] P. Azzi-Bacchetta,[25]

1 MARCH 1999

ıe Measurement
miokande

Itow,[1] T. Kajita,[1] J. Kameda,[1]

26 MAY 1975

e $\psi(3095)$†

ischer, D. Fryberger, G. Hanson,
, D. Lyon, C. C. Morehouse,
R. F. Schwitters,

ford, California 94305

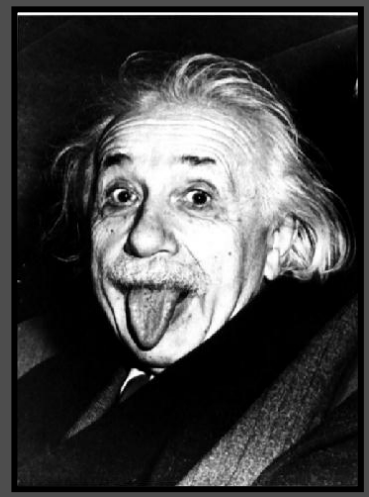
G. Goldhaber, J. A. Kadyk,
Trilling, J. S. Whitaker,

lifornia, Berkeley, California 94720

near 3095 MeV. The

What forces exist in nature?

What is a force?



How do they interact?

How do forces change with energy or temperature?

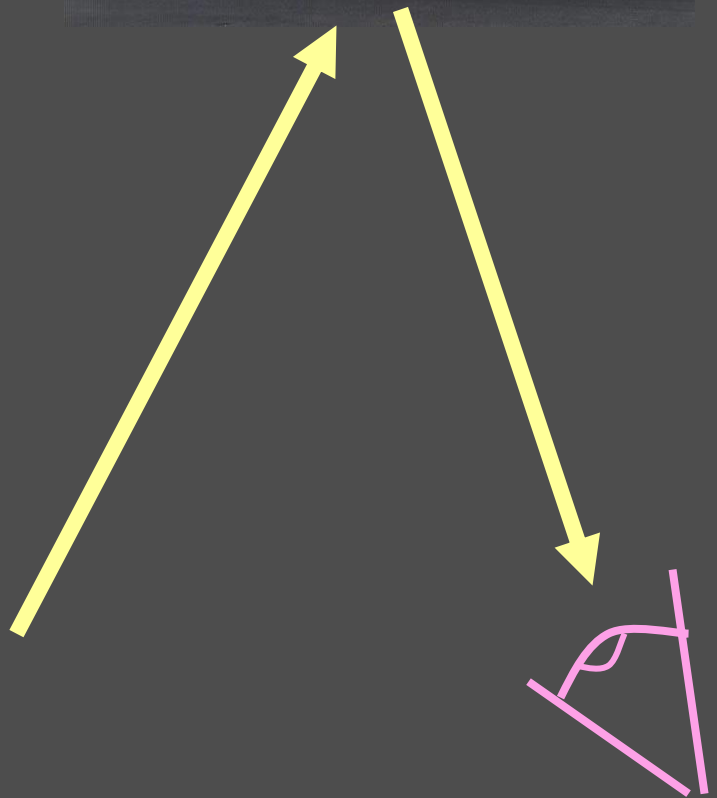
How has the universe evolved?

Mini-Ph.D. – Quantum Mechanics 101

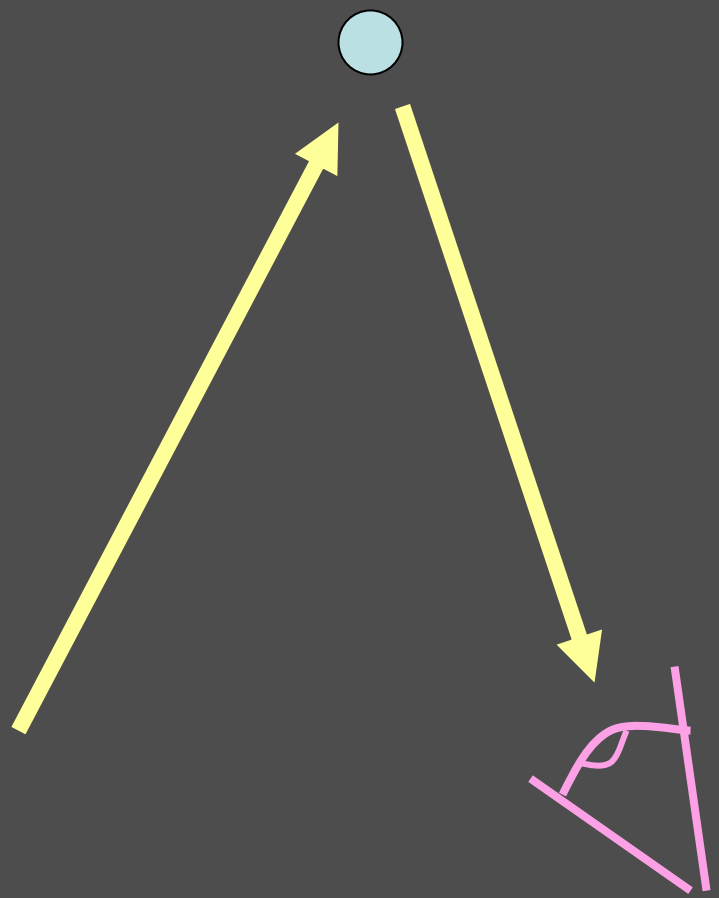
Lesson 1:

Size actually does matter.

Determine the postion and velocity of a car … no problem

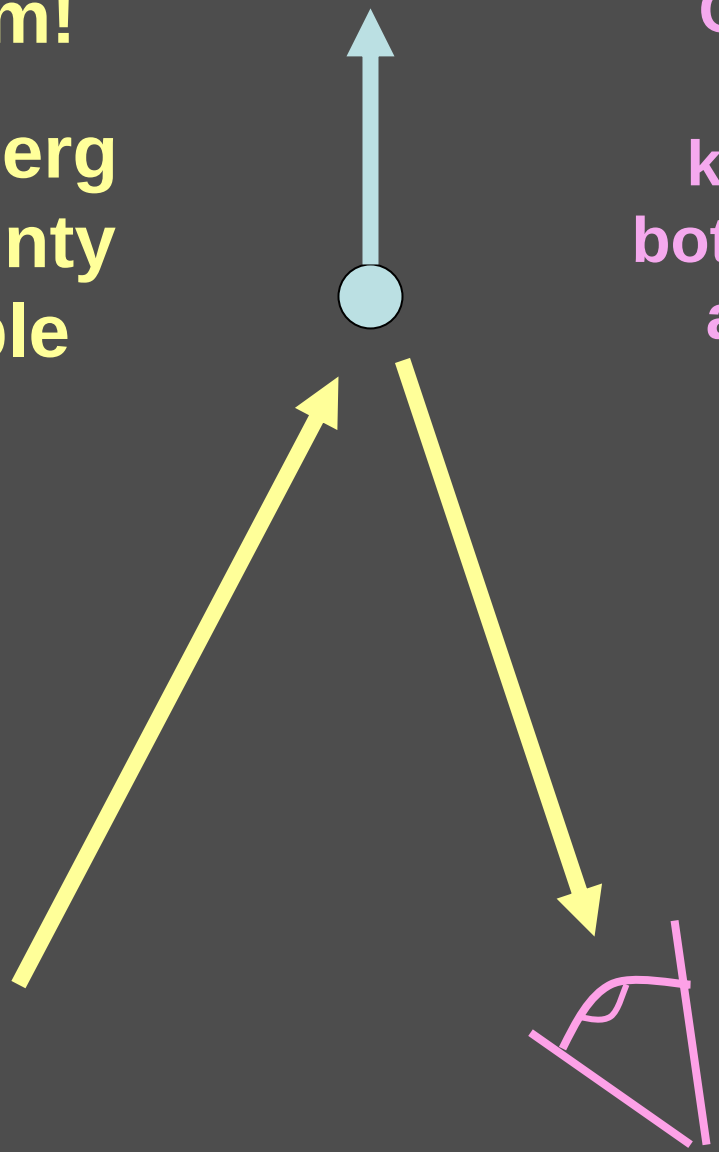


Determine the postion and velocity of a small particle … no problem



Problem!

Heisenberg uncertainty principle



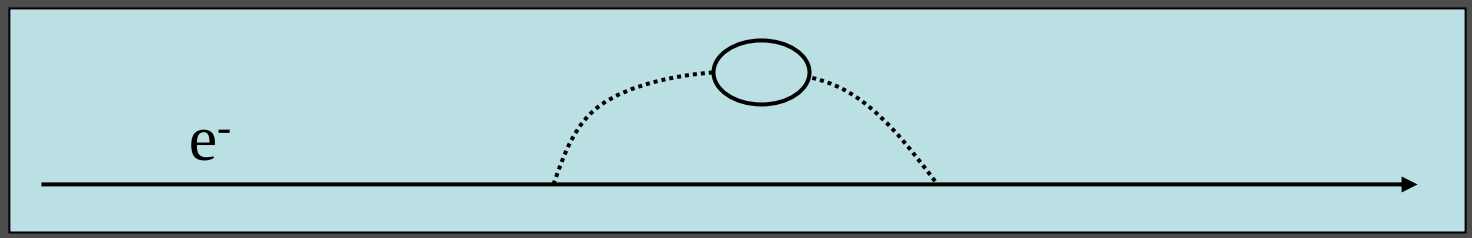
Cannot have perfect knowledge of both the position and velocity

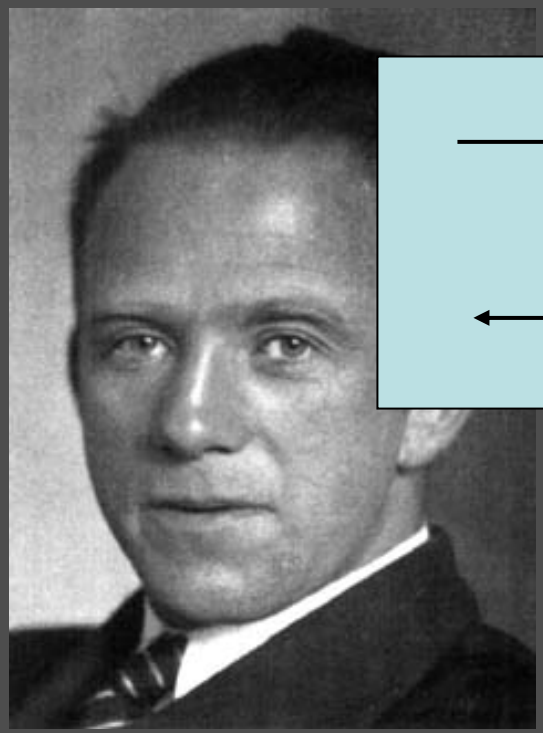
Heisenberg

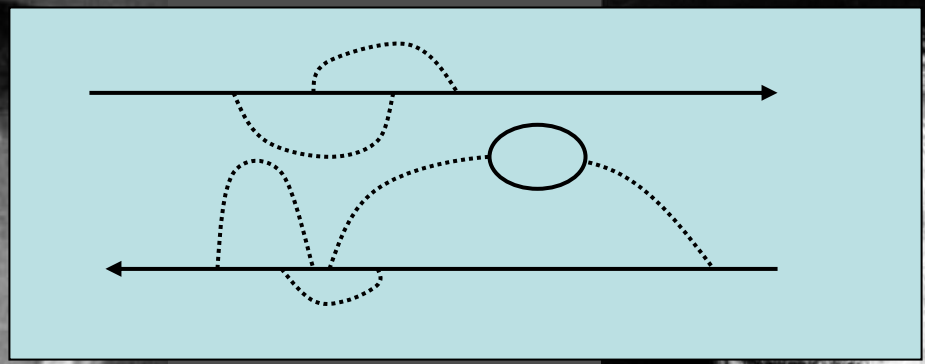
The fundamental nature of forces: virtual particles

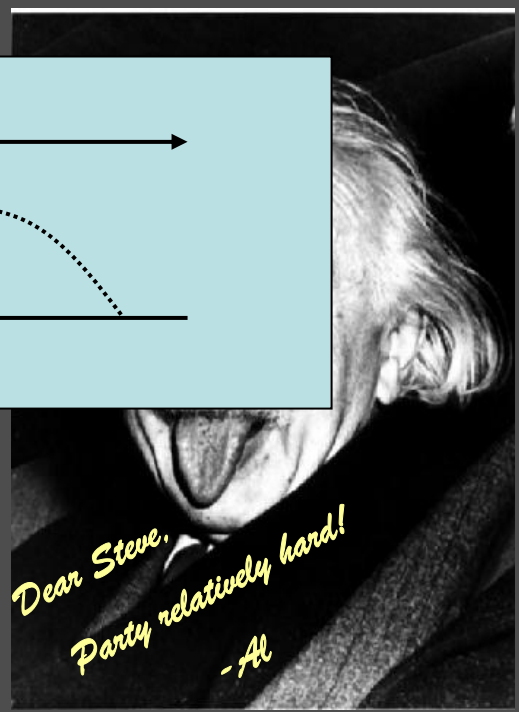
$\Delta E \Delta t \approx h$ Heisenberg

$E = mc^2$ Einstein



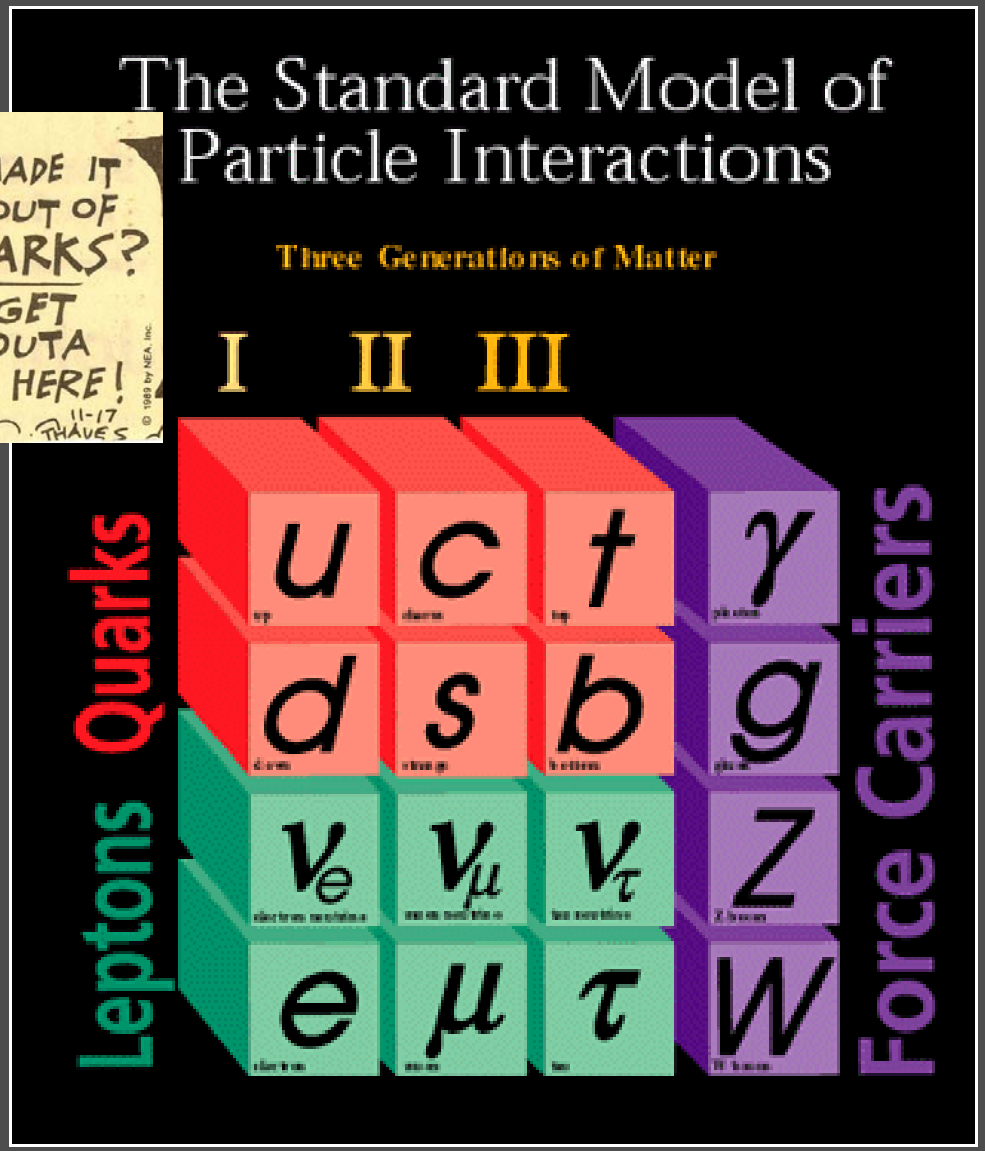






Force	*Source*	*Range*	*Strength*
Gravitation	mass	infinite	10^{-39}
Electromagnetism	Electric charge	infinite	10^{-2}
Strong nuclear	Color charge	10^{-15} m	1
Weak nuclear	Weak charge	10^{-18} m	10^{-5}


Frank and Ernest
YOU MADE IT ALL OUT OF QUARKS?
--GET OUTA HERE!
11-17
THAVES
© 1989 by NEA, Inc.


The Standard Model of Particle Interactions
Three Generations of Matter
I
II
III
Quarks
Leptons
Force Carriers
u
c
t
γ
d
s
b
g
ν_e
ν_μ
ν_τ
Z
e
μ
τ
W

quarks

u c t

d s b

leptons

e μ τ

ν_e ν_μ ν_τ

Gauge bosons

W, Z, g, γ, G

Strong interaction

Hadrons

Baryons qqq qq̄ mesons

p = uud

n = udd

K = us̄ or ūs

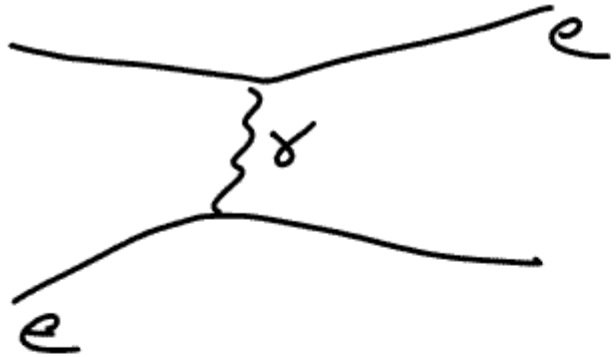
π = ud̄ or ūd

nuclei

Electromagnetic interaction

atoms

Quantum Field Theory → Exchange force



$\Delta E \Delta t \sim h$

big

small

massless $\gamma \longrightarrow$ large (infinite range)

Electromagnetism

Quantum electrodynamics

Weak nuclear interaction

Mass $W = 86$ GeV

1 GeV = 1000 MeV

Range $\sim 10^{-18}$ m