Physics 100 - April 13, 2009

Group	topic	15-Apr-09	20-Apr-09	27-Apr-09	29-Apr-09
A	Nuclear physics and society	3	1	✓ 2	4
B	String theory	3	2	✓ 1	4
C	Global Positioning System				✓ 1
D	Search for extra-terrestrial life	✓ 1	2	3	4
E	Music	3	4	1	✓ 2
F	Life and times of a great physicist	3	✓ 1	2	4
G	Radiation - dangers and uses	4	✓ 1	2	3

- Presentations begin this Wednesday
- Exam 2 one week from Wednesday
  plan to schedule a Q+A session

This is your life ... starting at the very beginning

- In the beginning there was ...

- Space-time foam
  - NOT empty space
  - quantum fluctuations
  - Very small $\sim 10^{-33}$ cm possibly

what was there and what exactly caused inflation NOT established yet ... models exist

- Fluctuation occurs w/ property that include
  - Tremendous repulsive pressure

inflation

inflaton Field

- AT $\sim 10^{-43}$ s $\rightarrow 10^{-35}$ s exponential expansion

- How big did inflation make universe by 10^{-35} s ?

Much bigger than observable universe

at the time

$(10^{-35}\,s)(3\times10^{8}\,m/s)$

or

Bigger than now

Maybe factor of $10^{10^{12}}$

- What was curved $\longrightarrow$ Now flat

geometry of Universe flat

- What was small $\longrightarrow$ Now big

quantum fluctuations become large density/energy fluctuations

ACTS as nucleus for large-scale structure formation

- As "inflaton field" properties change during inflation, inflation ends

- Energy Driving inflation Dumped into Matter and radiation in early universe

- $10^{-35} - 10^{-5}$ sec

  universe is primordial soup of quark-gluon plasma

  Subatomic particles quarks, Z, W, γ, gluons ...

- 10^{-5} sec quarks bound into

  Baryons $\rightsquigarrow$ Protons, neutrons

  Mesons

- t = 3 minutes — light nuclei form

  Big Bang Nucleosynthesis

- t = 400,000 years — neutral atoms form

  Universe becomes TRANSPARENT

  light we see from this time called

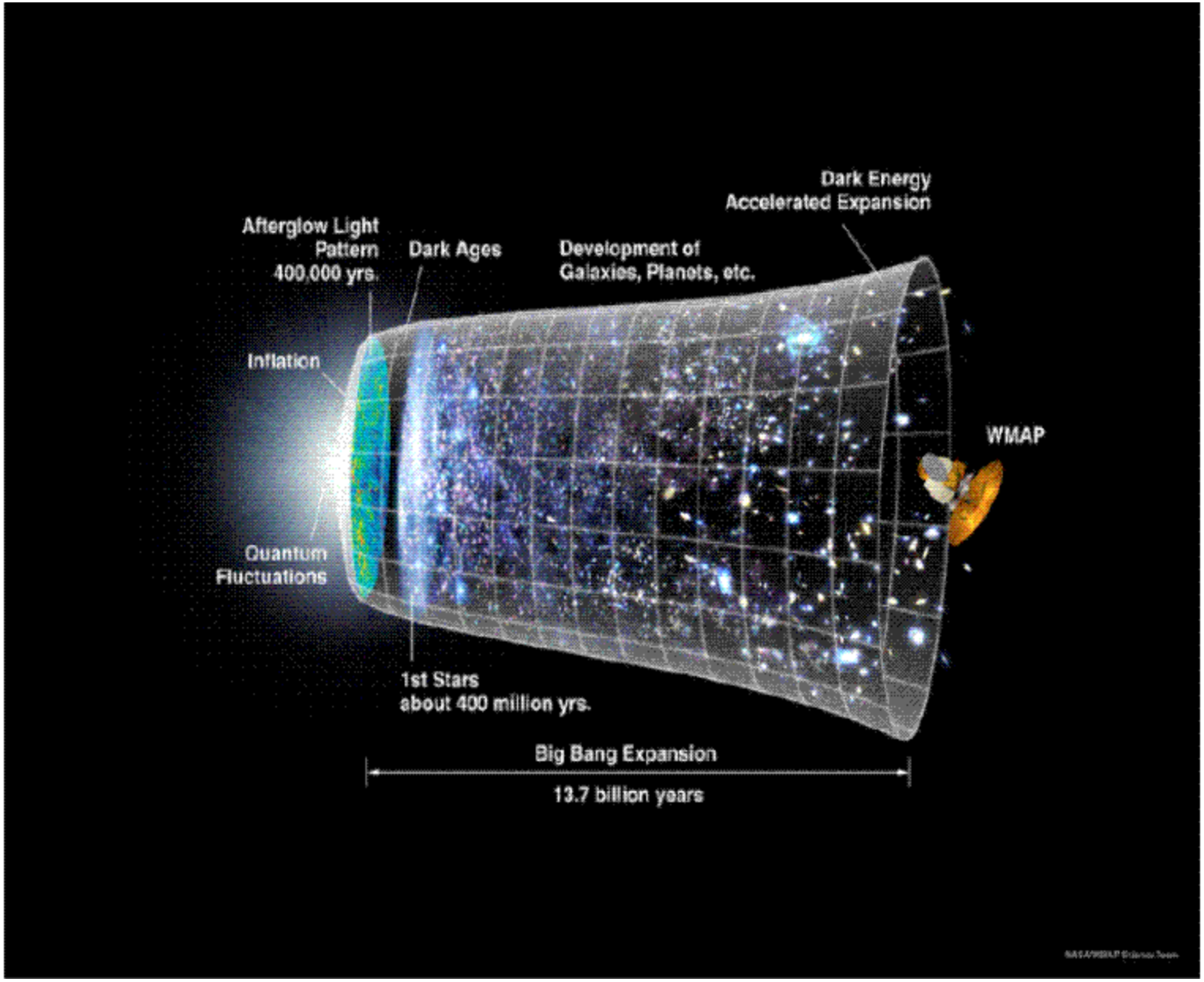
  Cosmic Microwave Background

- t = 400 Million years — First STARS

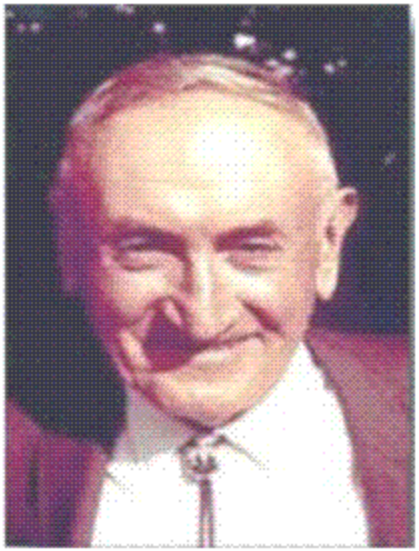
- t = 13.7 billion years — ~~Buffalo wins Superbowl~~

  Now

- Expansion is accelerating


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
WMAP
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years

DARK MATTER



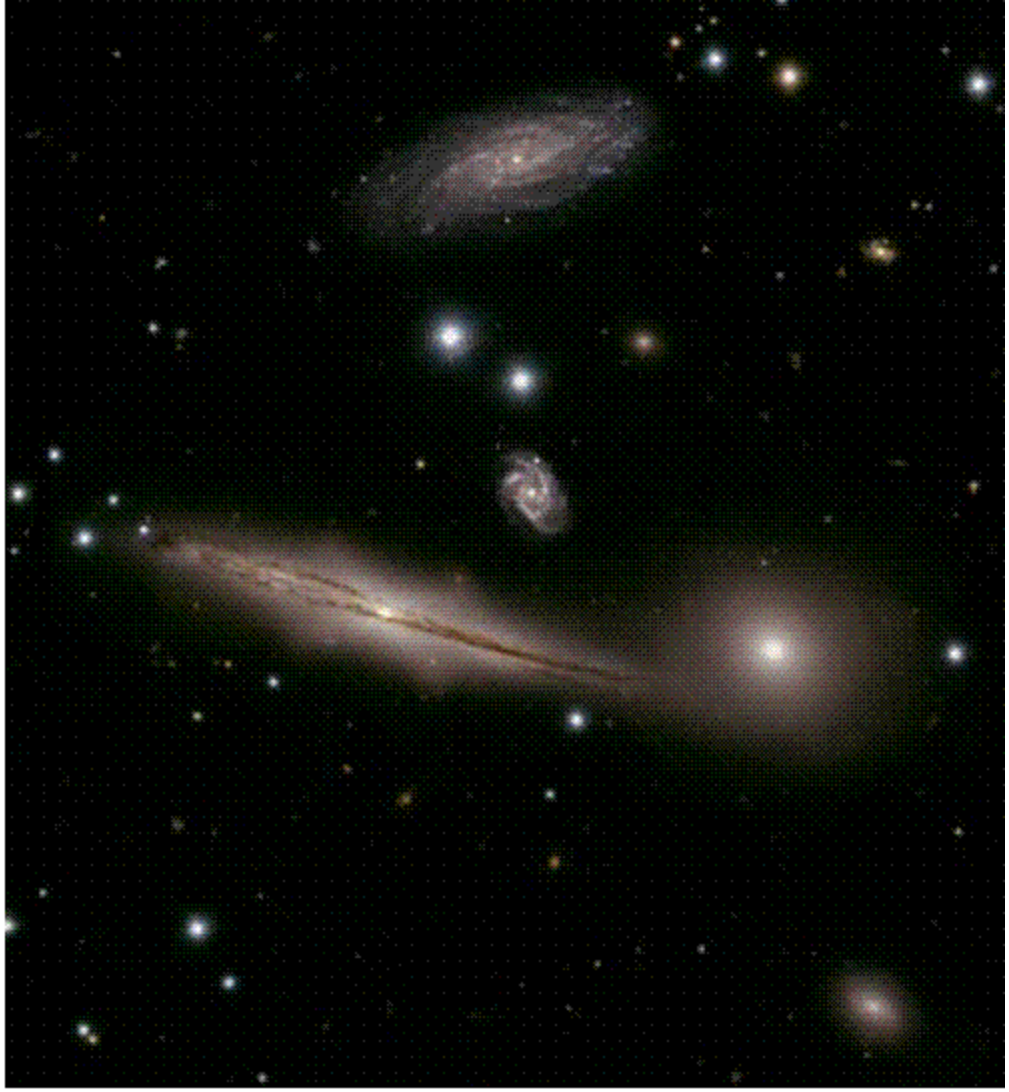
Fritz Zwicky (1898-1974)
CalTech astrophysicist

- jet engines
- "Spherical bastard"
- Suggested galaxies could act as gravitational lenses
- Dark Matter

Zwicky compared mass of galactic cluster using two methods

① number + brightness of galaxies in cluster

② motion of galaxies at edge of cluster



galactic cluster

$$\text{Mass}\Big|_{\text{method 2}} >> \text{Mass}\Big|_{\text{method 1}} \rightarrow \text{DARK Matter}$$

Dark Matter

Orbits $F = \frac{mv^2}{R}$ $F = \frac{GMm}{R^2}$

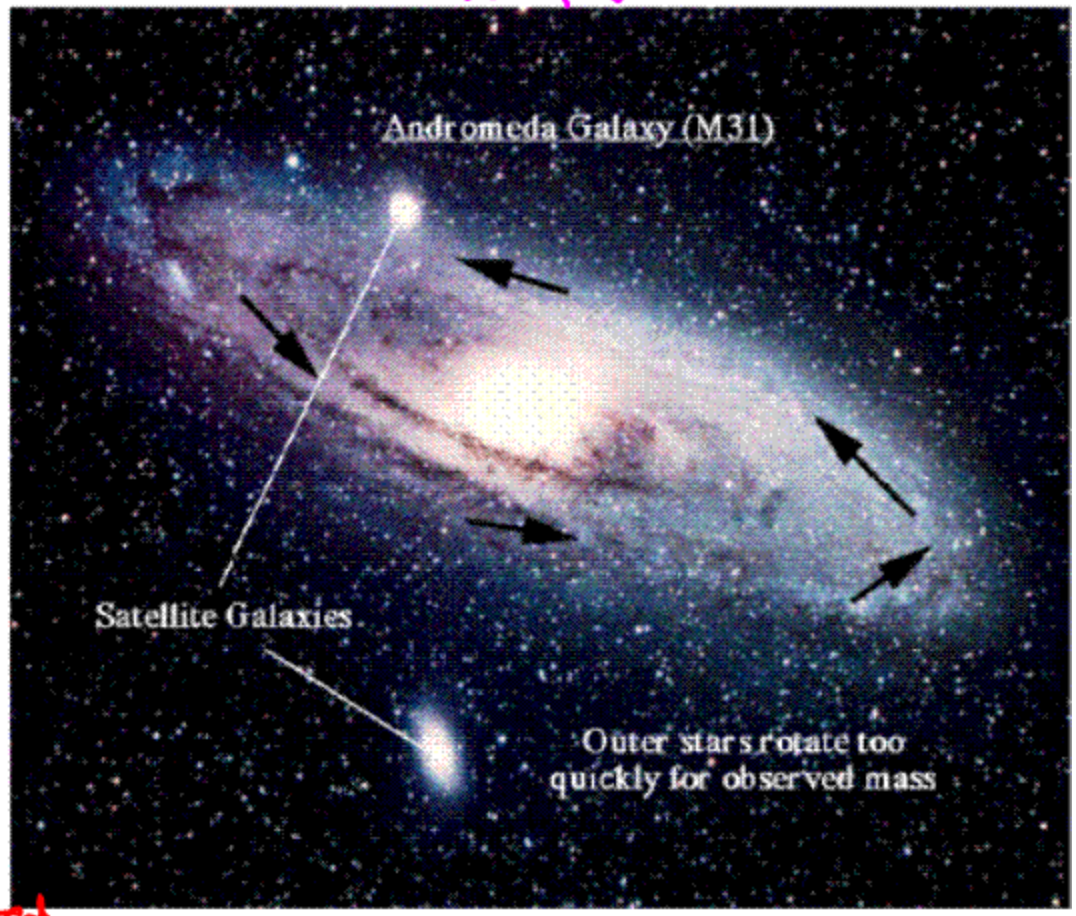
Circular Motion

$$\frac{mv^2}{R} = \frac{GMm}{R^2}$$

Can relate velocity radius and force in orbits.

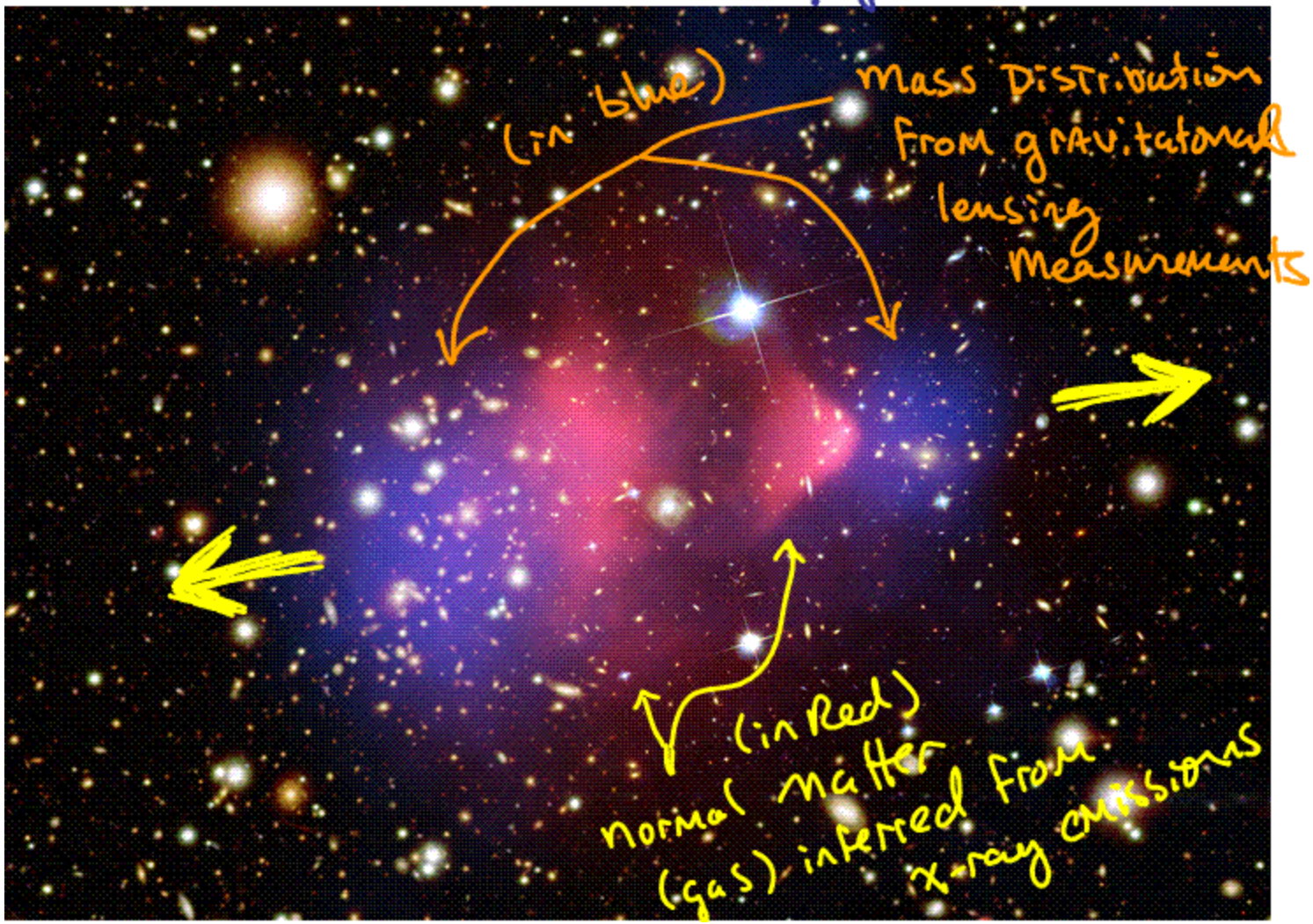
1975 - Kent Ford, Vera Rubin

Have seen that orbits in stars and galactic clusters Require Stronger Gravitational force than can be explained by conventional Observable "visible" matter



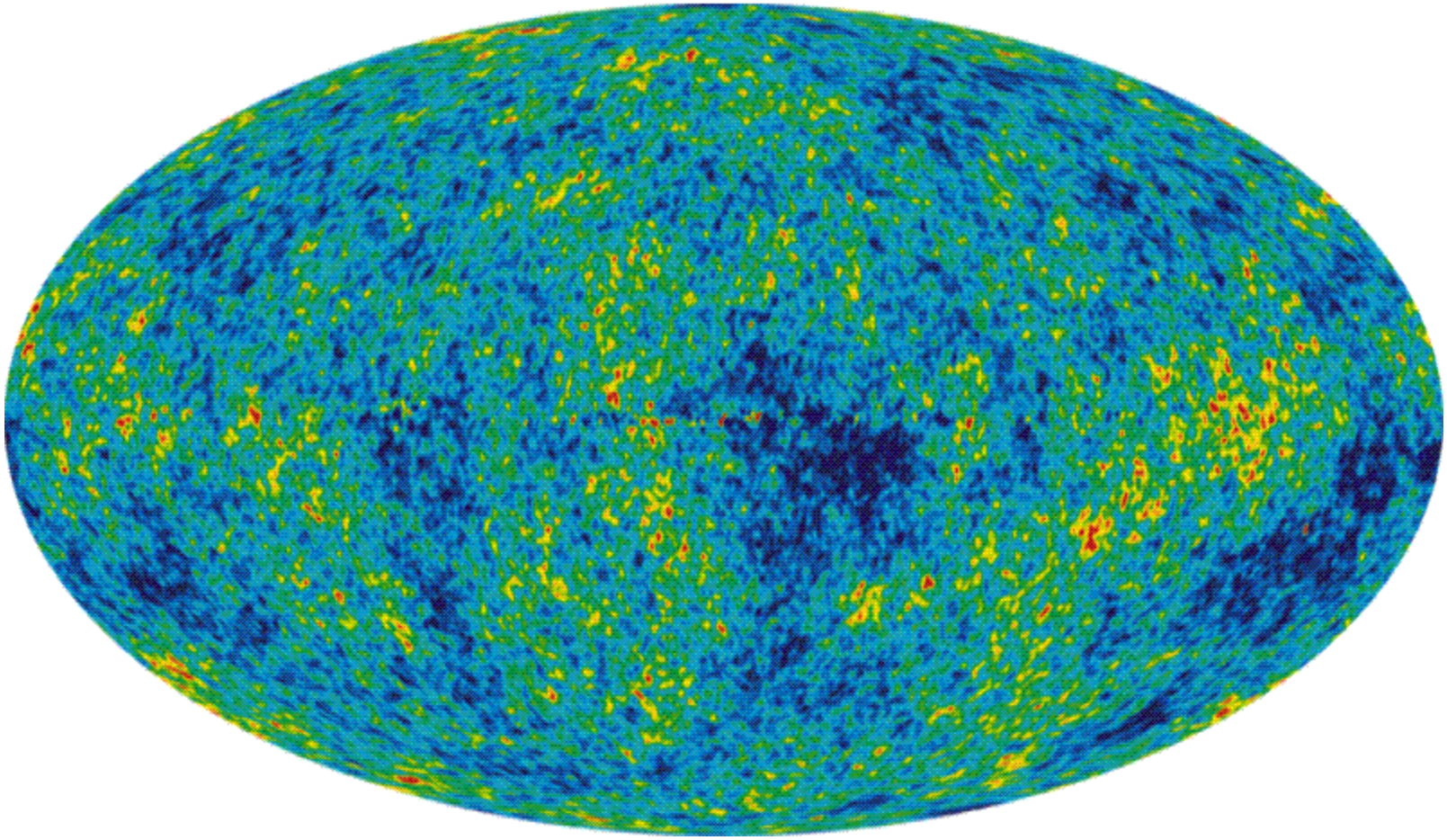
-P. Cushman

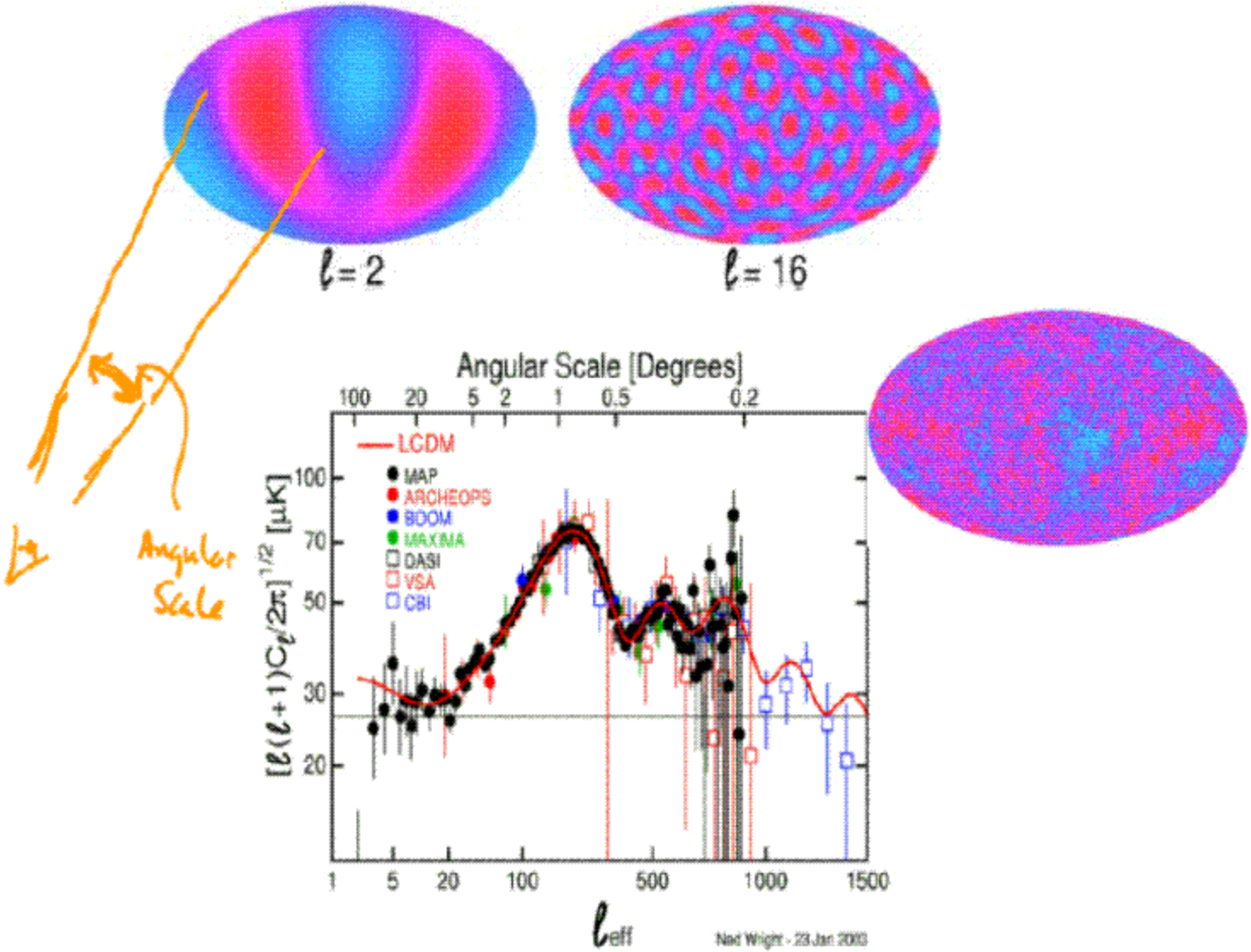
Bullet Cluster - colliding galactic clusters



The universe at $t = 400{,}000$ years

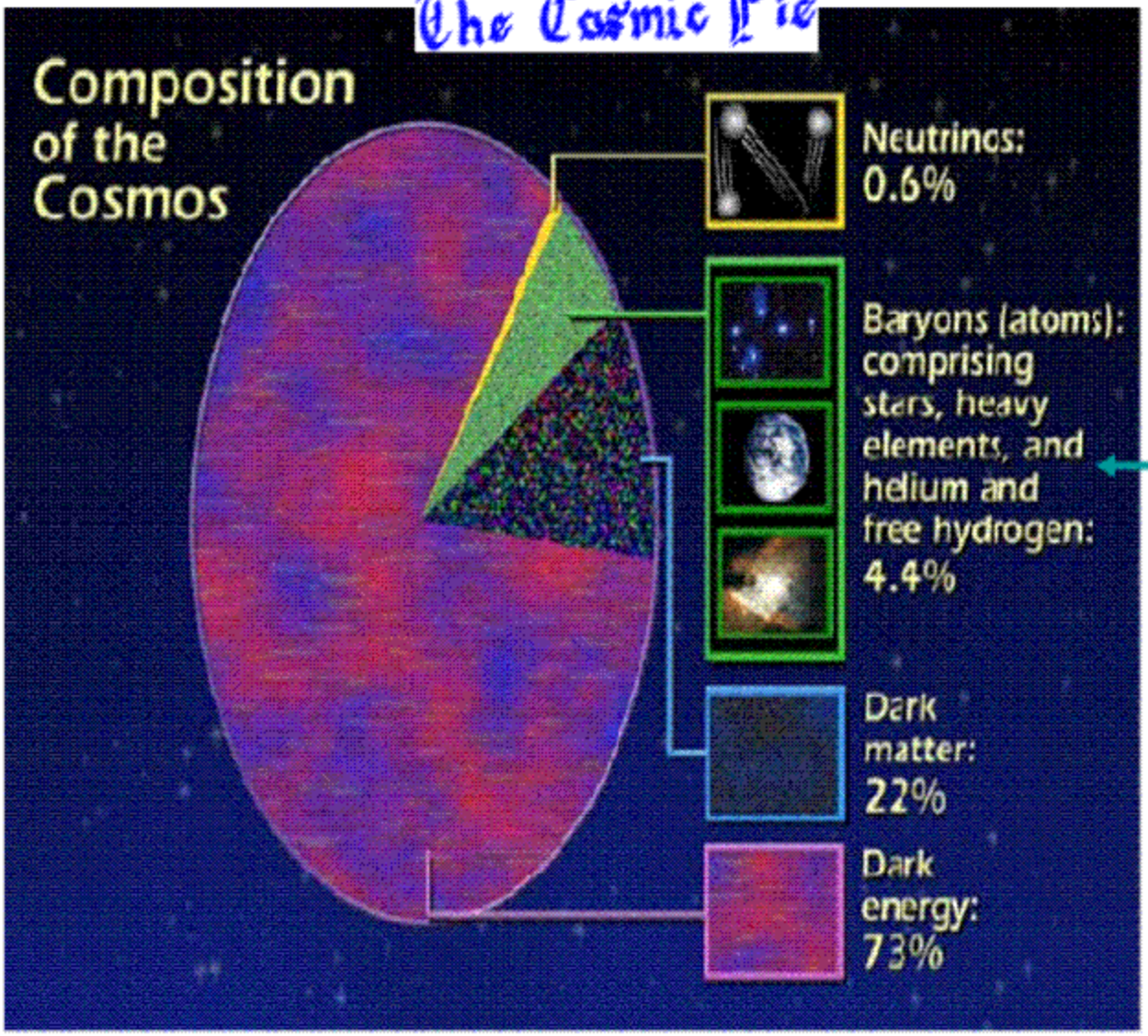
CMB
from WMAP





"Power spectrum" (size) of temperature fluctuations sensitive to different matter/energy components of the universe

The Cosmic Pie

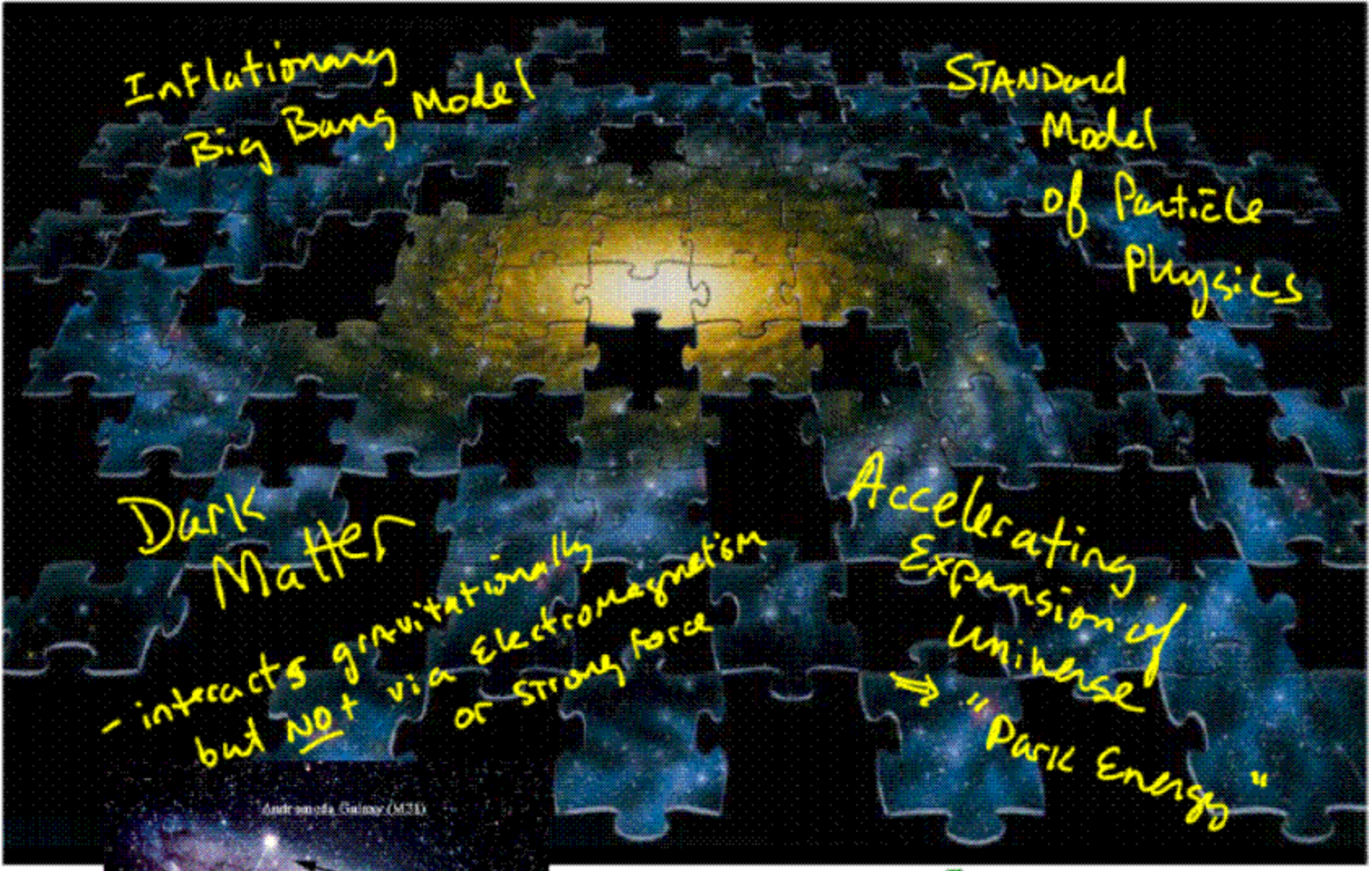


Us

STScI

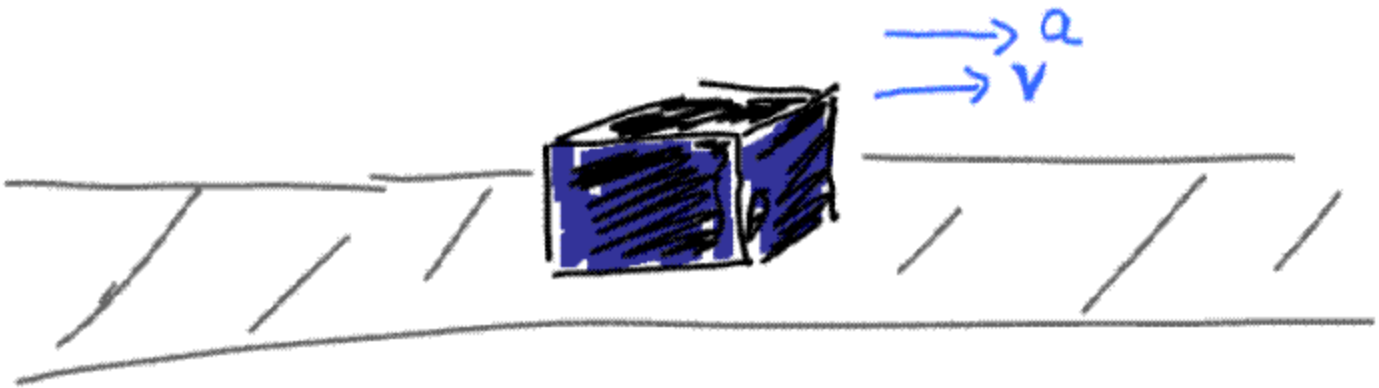
95% of the universe is unknown!

figure from E. Linder LBL



dark energy — sort of an inflation-like pressure (slower) on space expansion — Exact source unknown as yet.

Dark Energy Analogy



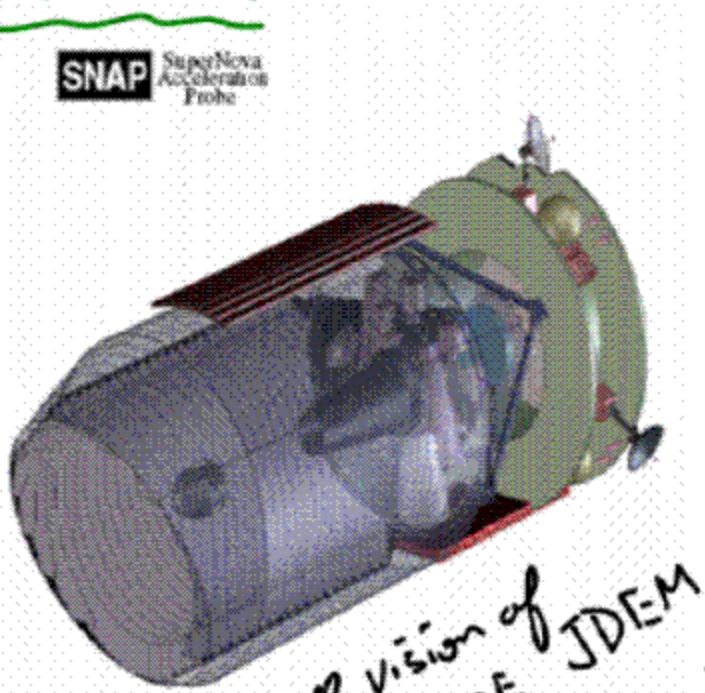
See box accelerating down sidewalk

We Know there is a force + source of energy.

(F)(dist) = work = Energy

We have ideas ... but we don't know for sure the nature of the force / energy

Where do we go from here?



one vision of NASA DOE JDEM Joint Dark Energy Mission

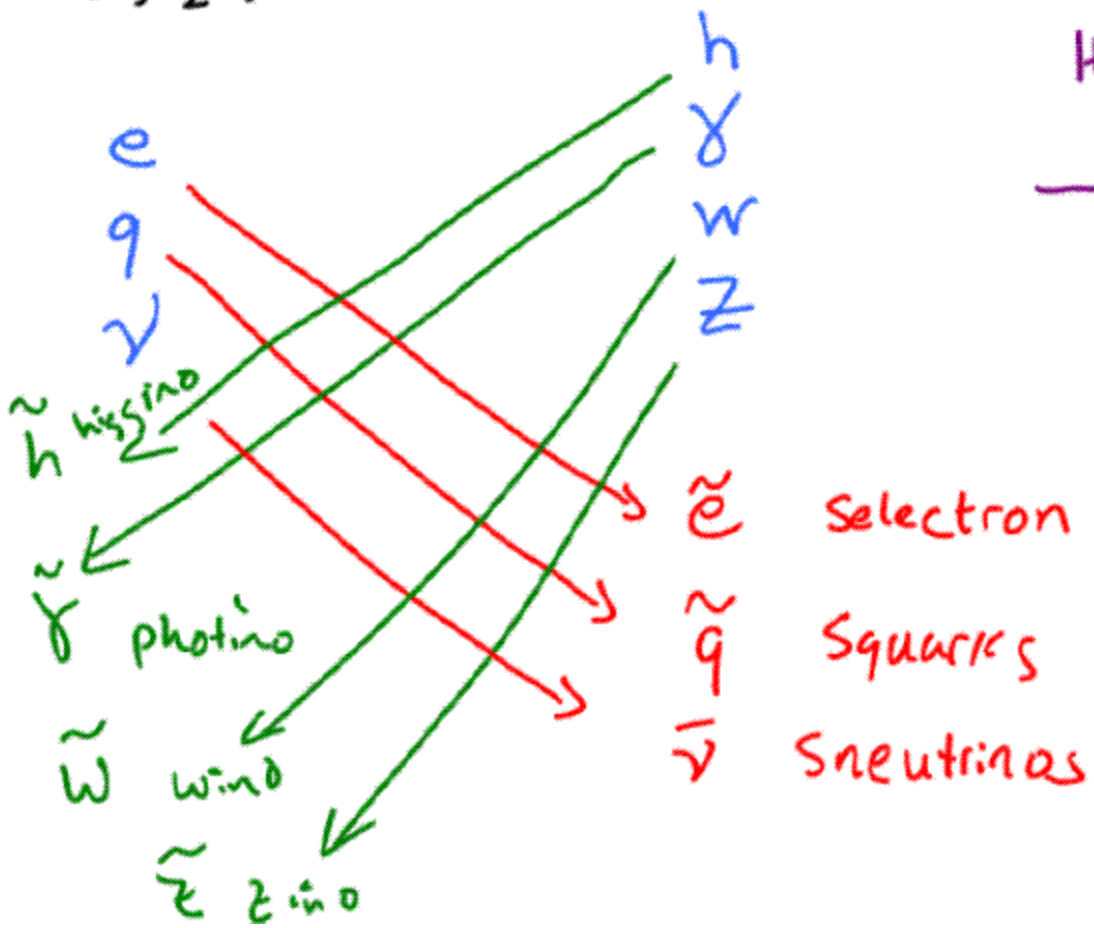
Large Hadron Collider (LHC)

Supersymmetry

Intro to particle spect
R parity
LSP
Gauge heirarchy
Coupling Unification
Dark energy?

fermion $\longleftrightarrow$ boson

$\frac{1}{2}, \frac{3}{2}, \ldots$ $\qquad$ $0, 1, \ldots$



Higgs

$\Delta E \Delta t > \hbar$

Standard Model

Minimal Supersymmetric Model