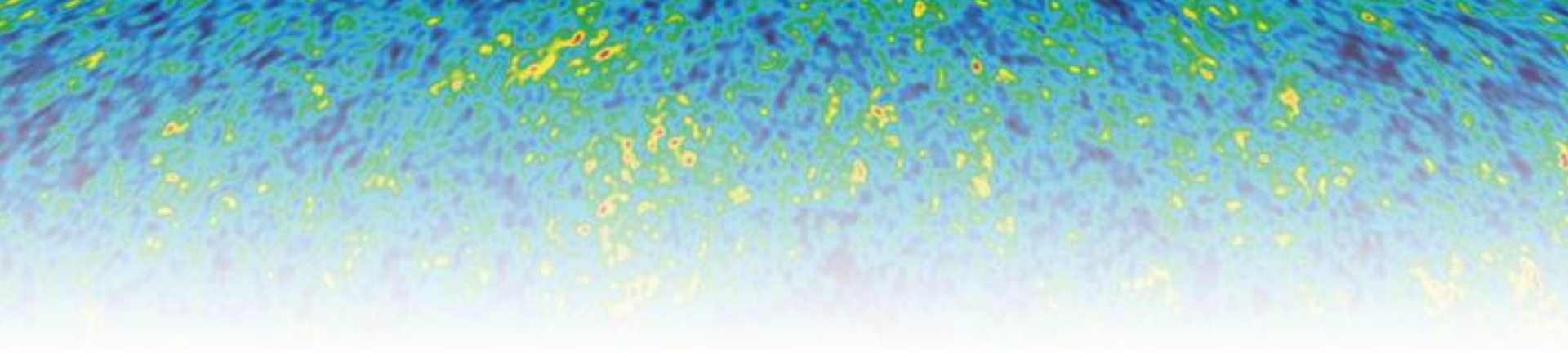
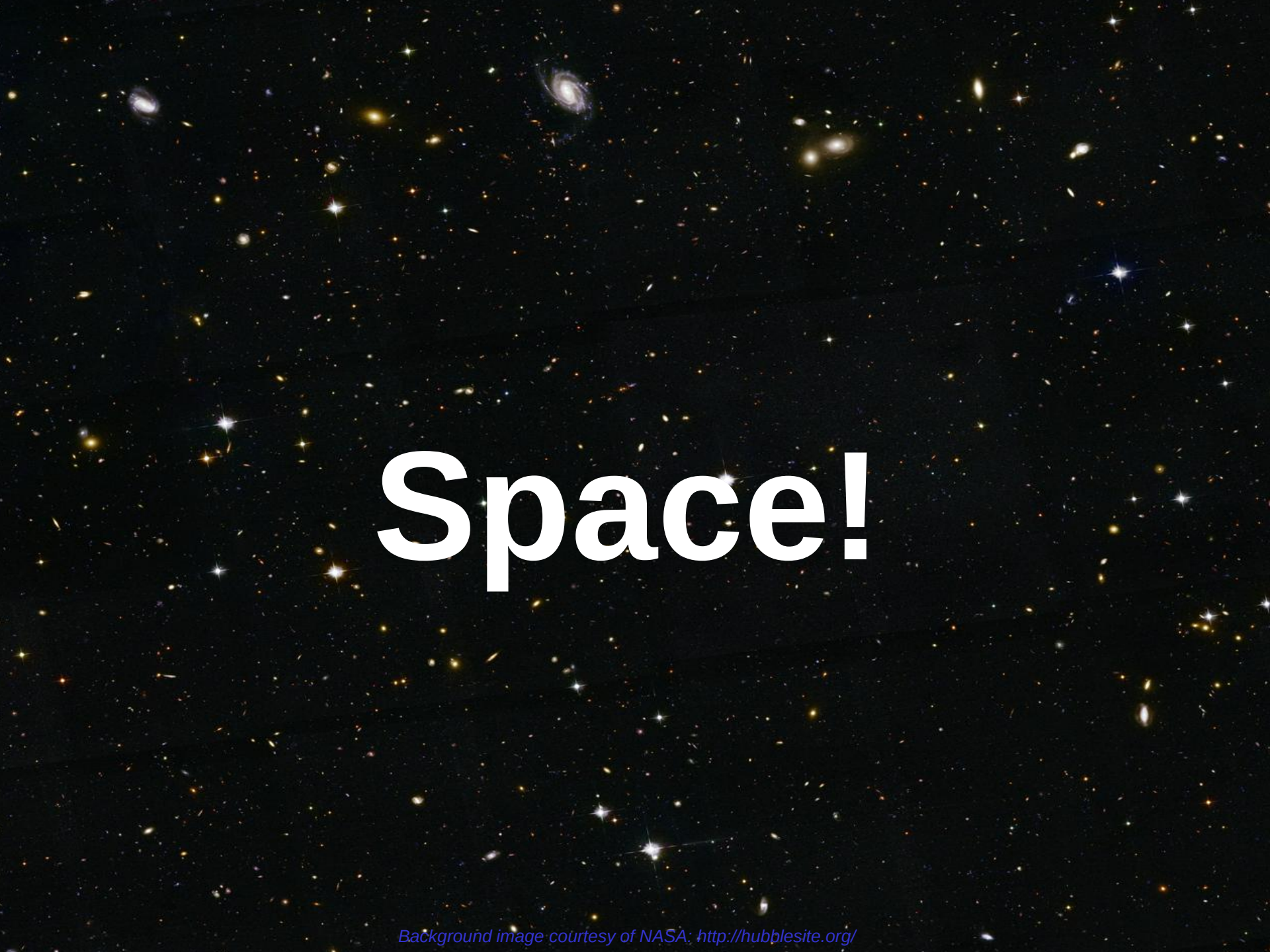


Solving the Universe

Mr. Wickman
University of Delaware

Background image courtesy of NASA: http://map.gsfc.nasa.gov/media/080997/index.html


BIGGEST?



Background image courtesy of NASA: http://hubblesite.org/


smallest?

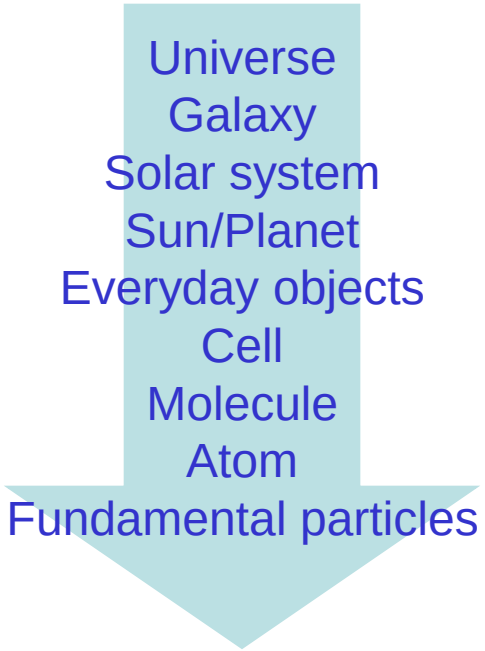
Subatomic particles!

Atoms are so small we can’t see them --
these particles are even smaller than that!

Opposite Extremes of Size

- Objects in the universe cover a very wide range of sizes

- So-called “fundamental particles” can’t be broken down into smaller pieces
  - Examples include electrons, quarks, and photons, but not protons or neutrons



Why Particle Physics?

- Big Bang: very hot, very dense
- Early universe: only fundamental particles existed
- Higher energy = smaller distances

Looking Back In Time

- Light travels at a fixed speed: 3×10^8 m/s
  - This means the starlight we observe was emitted a long time ago
- Higher energy = looking further back in time
  - We can look all the way back to early stages of the universe – about 380,000 years[1] after the Big Bang!

[1] WMAP Collaboration press release, http://www.nasa.gov/topics/universe/features/wmap_five.html (2008)

Effects of Particle Interactions

- Expansion of the universe
- Formation of atoms
- Formation of galaxies and other structures
- Many other effects, including:
  - Dominance of matter over antimatter
  - Unification of forces
  - Creation/decay of exotic, never-before-seen particles

Cosmic Microwave Background

- CMB radiation
  - Doppler shifted from the visible/near infrared range[2]
  - Strong evidence for the Big Bang
- Some properties:
  - Very uniform throughout the universe
  - Small variations

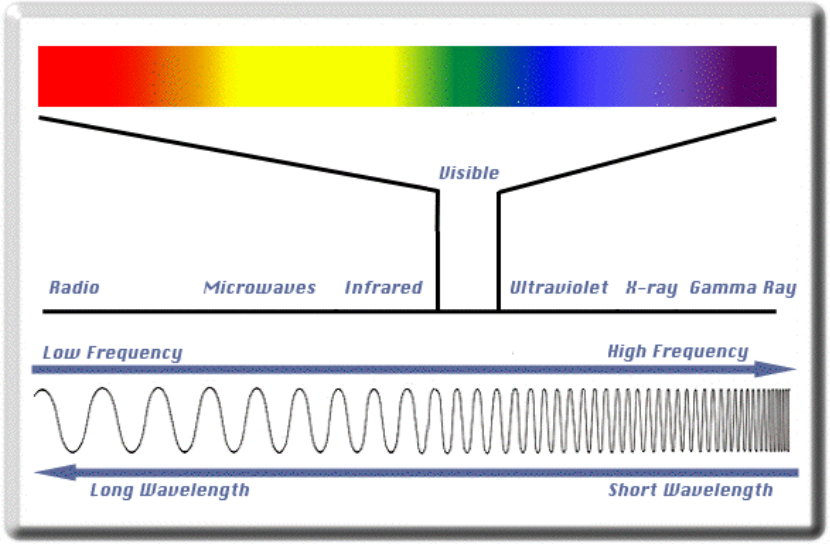


Image courtesy of the University of Minnesota: http://www.lcse.umn.edu/specs/labs/glossary_items/em_spectrum.html

[2] Ryden, B. *Introduction to Cosmology.* Addison Wesley (2003).

CMB Experiments

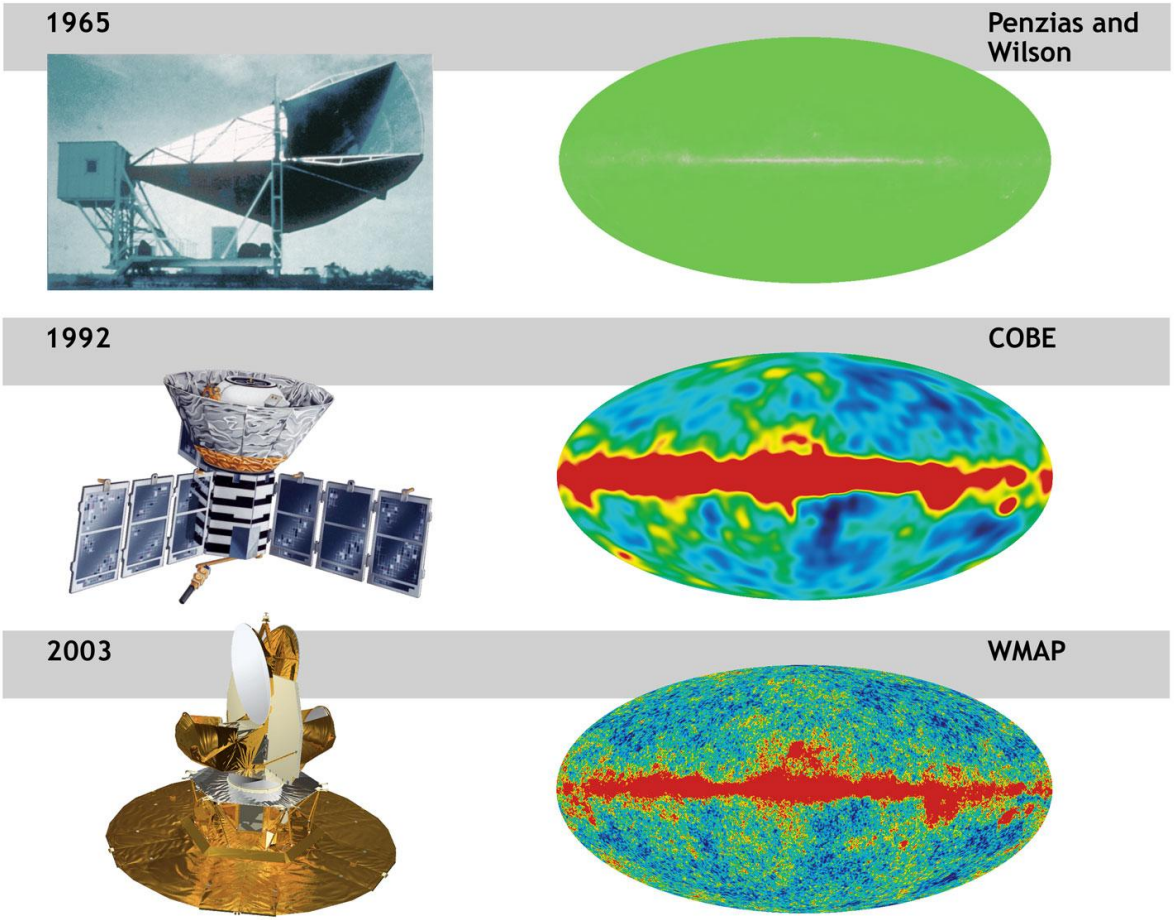


Image courtesy of NASA:
http://map.gsfc.nasa.gov/media/081031/index.html

Cosmic Inflation

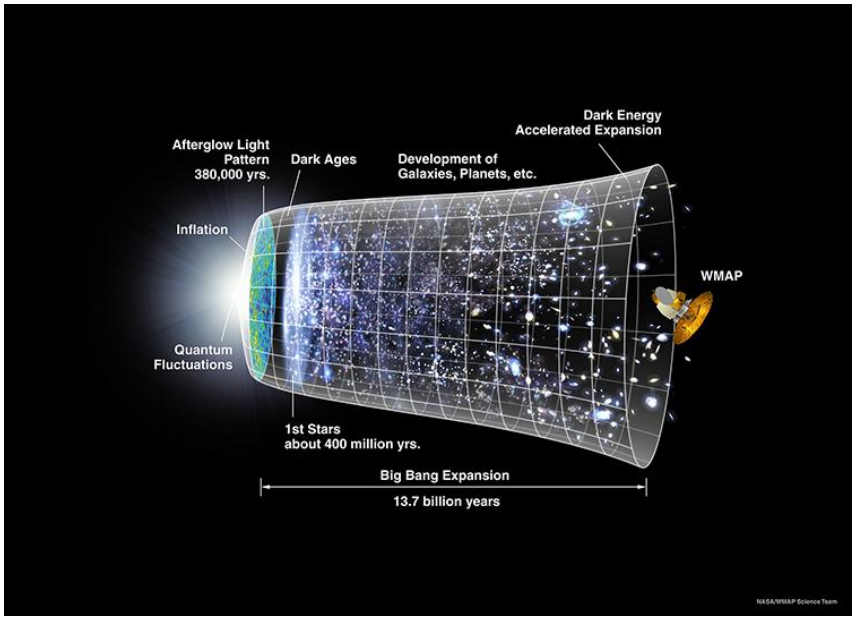


Image courtesy of NASA:
http://map.gsfc.nasa.gov/media/060915/index.html

- Explains why the CMB looks so uniform
- Allows for small variations
- Fixes some of the gaps in the Big Bang theory

- Theories of inflation rely heavily on particle physics

Bringing Inflation into Focus

- So far, experimental evidence allows for a wide range of theories
  - In order to understand how inflation works, we need to narrow this range

- In the end, only experimental measurements can eliminate theories

Just What Is It That I Do?

- Develop and/or modify inflationary models that fit experimental data better
- In order to do this, I:
  - Think of a model that solves the problem in question
  - Perform calculations to obtain estimates of quantities that can be measured by experiments
  - Make predictions of what should happen if the model is true

Questions