The Big Bang and The Expanding Universe

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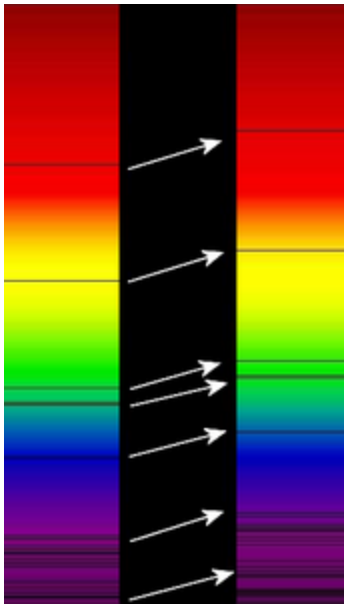
Hubble's "Red Shift"

- In the 1920s, Edwin Hubble discovered that spectral lines from galaxies were always shifted toward the "red" end of the spectrum
- This meant that **everything is moving away from us**

- The image shows how light from a supercluster (right) compares with normal light



http://en.wikipedia.org/wiki/Redshift

Hubble's Law

- Galaxies with the greatest shift are farthest away
- Also, the farther away they are, the faster they are moving away
- It doesn't matter where the observer is—from anywhere, the red shift would be detected
- From this evidence, astronomers conclude **we are part of an ever-expanding universe**

What Might This Mean about the Origin of the Universe?

THE "BIG BANG THEORY"

- Mentally "re-winding" this expansion, astronomers have developed the theory that the ENTIRE UNIVERSE WAS ALL TOGETHER IN A SUPERMASSIVE, SUPERDENSE, SUPERHOT "BALL"
- A violent explosion sent everything outward

HST – Hubble Space Telescope

- One of the most important instruments for studying “Deep Space/Time” has been the Hubble Space Telescope http://www.hubblesite.org/
- HST’s First Decade 1990 – 2000
- 20 Years of Discovery
- Discovering Planets Beyond Pluto
- Looking Back Almost to the Beginning

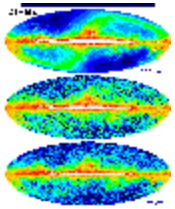
Radio Static and the Big Bang

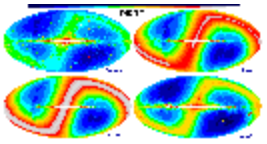
- In 1963, Arno Penzias and Robert Wilson of Bell Labs (AT&T's research center) discovered that the static in their radio antenna came from outer space
- They realized that it was "background radiation," a remnant of the Big Bang: energy at about 2.7 K

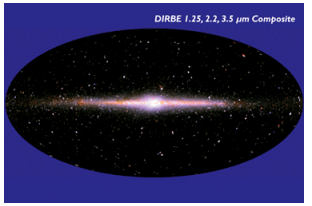
http://www.bell-labs.com/project/feature/archives/cosmology/

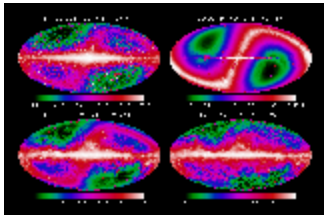
COBE – Cosmic Background Explorer

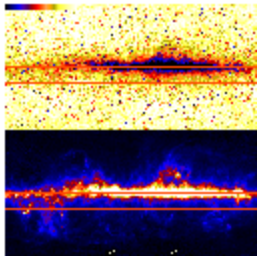
- More recently, NASA launched a satellite devoted to investigating cosmic bacground radiation
- http://lambda.gsfc.nasa.gov/product/cobe/





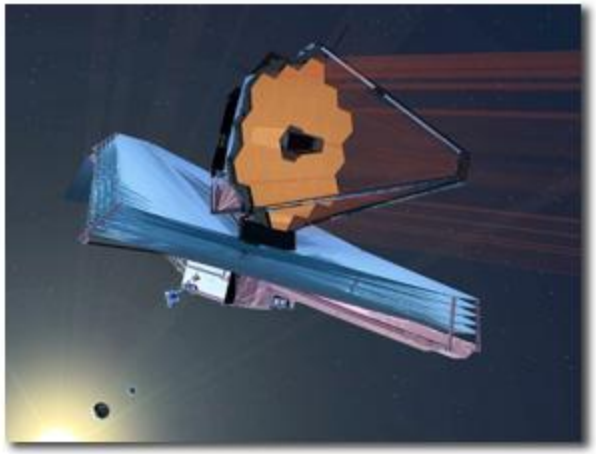






Coming in the Future: Webb Telescope

- The James Webb Space Telescope (JWST) will be a large infrared telescope with a 6.5-meter primary mirror. Launch is planned for 2014.



http://www.jwst.nasa.gov/about.html

- JWST will be the premier observatory of the next decade, serving thousands of astronomers worldwide. It will study every phase in the history of our Universe, ranging from the first luminous glows after the Big Bang, to the formation of solar systems capable of supporting life on planets like Earth, to the evolution of our own Solar System.

Alternate Theories

- The “Big Bang” is the most popular theory, because it best explains current evidence
- But because certain assumptions (called “paradigms”) must be made, these are open to challenge
- Several astrophysicists have proposed other theories which they claim better explain observed facts
- http://www.big-bang-theory.com/

So how old is the Universe

- 30 – 40 years ago, the “accepted” age was between 15 – 20 billion years
- But evidence from the HST has considerably reduced and narrowed this
- The current estimate is **13.7 billion years**
- The earliest stars and galaxies may have formed some 200 million years after this
- Our solar system, including Earth, formed 4.5 bya