Extra! Extra!
Read All About the Universe!

Barb Mattson (USRA/GSFC)
JHU Space Grant
July 8, 2013
You will receive the Cosmic Times posters at the end of this workshop.
Gallery Walk

Take a tour of the Cosmic Times posters
Gallery Walk

•' Start at one Cosmic Times poster station
  ➢ Cosmic Times poster
  ➢ 3 versions of the newsletter: early edition (7-8 grade), home edition (9-10 grade), late edition (11-12 grade, same readings as on posters)

•' At each poster, use the chart paper to record the answers to the following two questions, as they relate to that issue of Cosmic Times
  ➢ What big questions are facing scientists?
  ➢ What answers have scientists just found?

•' You will have 4 minutes at the first poster, and 2 minutes at each subsequent poster

•' Return to first poster and prepare a 1-minute summary of all the responses (write it down!)
The year is 1919...

- What’s going on?
- What’s going on in science?
- What is your view of the Universe?
  - Infinite
  - Unchanging/static
  - Ageless
1919 – Einstein’s Gravity

• ' What is Gravity?

• ' Gravity is curved space-time.
  ➢ Gravity bends light.
  ➢ Amount of deflection ' differs from Newton’s prediction.'

➔ 1919 Solar Eclipse verified Einstein’s prediction.
1919 – Einstein’s Gravity

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## Einstein’s Gravity Bends Starlight
### Einstein’s Theory Triumphs

One of the greatest—perhaps the greatest—accomplishments in the history of human thought was what Albert Einstein, President of the Royal Society of London, called the Albert Einstein’s prediction, which was apparently verified during the total eclipse of the Sun on May 29.

Einstein when he was 85 years old.

The prediction

According to the gravitational principles, proposed by Sir Isaac Newton in his classic work Optics, some two centuries ago, a ray of light from a distant star just passing the edge of a massive object should be bent by an amount that depends on the object’s mass and its gravitational field. Newton’s theory of gravity is a force that pulls things toward its center.

The amount of deflection (the bending of the Sun’s gravitational field) differs from Newton’s prediction.

1919 Solar Eclipse verified Einstein’s prediction.

### WHY A TOTAL SOLAR ECLIPSE?

According to predictions by both Sir Isaac Newton and Dr. Albert Einstein, the Sun’s shadow from a star enters the earthly atmosphere at a certain angle. The deflection would make the star slightly farther away from the Sun and thus visible to us.

Dr. Einstein’s theory of relativity, however, predicts that the amount of deflection should be double that predicted by Newtonian mechanics.

The maximum shift for a star whose ray of light just grazes the edge of the Earth’s atmosphere is about 1.75 arcseconds.

Fundamental science concepts: motions of the Earth, Moon & Sun, solar eclipse, gravity, curved space-time
1929 - Expanding Universe

- Vesto Slipher showed the “nebulae” were redshifted.
  - I.e. moving very fast away from us.
- Hubble put together the redshifts with their distances.
  - Universe is expanding!
1929 - Expanding Universe

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  ➢ i.e. moving very fast away from us.
- Hubble put together the redshifts with their distances.

Fundamental science concepts: redshift, distance to galaxies, Cepheid variables (patterns in data)
1955 – Origin of the Universe

- Scientists debate: 'Is Universe …'
  - ageless and infinite?
  - finite, with hot "bang" beginning?
Steady State vs. Big Bang

**Steady State theory**

- Fred Hoyle, Hermann Bondi and Thomas Gold see the movie *The Dead of Night*, in which the end of the story circles back to its beginning.
- Unchanging situations need not be static.
- New matter can be created spontaneously as the universe expands (a few hundred atoms per year per galaxy).
- Expansion of universe and creation of new matter balanced via a negative energy.
- The universe is constant in its overall density.

**Evolutionary theory**

- Starting from earlier work, George Gamow & Ralph Alpher worked out the conditions in the early universe.
- Universe is expanding from a state of high density and pressure.
- Hydrogen and helium were formed as universe cooled.
- There should be left over a background radiation with a temperature of ~ 5 Kelvin.
- Hoyle scoffed at this theory and coined the term “Big Bang.”
1955 – Origin of the Universe

- Scientists debate: Is Universe …
  - ageless and infinite?
  - finite, with hot “bang” beginning?
- Both theories account for observations
- Deadlock!

Fundamental science concepts: nature of science, origin of the Universe

Origin of Everything: Hot Bang or Ageless Universe?

It’s difficult to imagine a deeper mystery than the one being addressed recently at the meeting of the National Academy of Sciences in Pasadena, California: Is the universe eternal or does it have a beginning, middle, and an end? The case for an ageless, steady-state universe which forever looks much as it does today was presented at the conference by astrophysicists Jesse L. Greenstein and physicist William A. Fowler of the California Institute of Technology. The steady state theory rivals the “evolutionary” theory of the universe which calls on an initial brew of hot particles exploding at the dawn of time and making all the universe’s hydrogen and perhaps helium on one fell swoop.

Both theories explain – in entirely different ways – the inescapable fact that the universe is expanding. This cosmic expansion was first detected in 1914, when American astronomer Vesto Melvin Slipher surveyed some galaxies and noticed the light from most of them was “red-shifted.” This is essentially the broadening and reddening of the visible light waves caused by the retreat of the galaxies. It’s the electromagnetic equivalent of how the wall of a retreating locomotive drops in tone as it passes by a train watcher’s ear.

In the steady-state theory the expansion comes from the continuous bubbling up of the most basic element, hydrogen, from empty space at a rate of one particle every cubic meter every 300,000 years or so. This hydrogen eventually gathers and condenses into stars which, through again in an gigantic collapse that rebounds and starts the universe all over – the endlessly exploding and collapsing universe described by the late Caltech physicist Richard Tolman. Which theory will prevail? Only more research with bigger and better telescopes will tell.

Fred Hoyle and William Fowler in Fowler’s office in the W. K. Kellogg Lab at Caltech.

Hoyle Scoffs at “Big Bang” Universe Theory

The steady-state theory has thrown a shadow over where the real universe was thought to be a rival theory, championed by Ukrainian-born American physicist George Gamow. Labeling it
1965 - Breaking the Stalemate

• 'A hot “bang” should leave left-over heat
• 'Data and theory came together in 1965
  ➢ Penzias and Wilson found 'a mysterious 3 K residual noise while making radio observations of the Milky Way.'
  ➢ Peebles and Dicke (Princeton) had just calculated an estimate for 'the temperature of the residual background in the microwave region.'
1965 - Breaking the Stalemate

- A hot “bang” should leave left-over heat.
- Data and theory came together in 1965
  - Penzias and Wilson found a mysterious 3 K residual noise while making radio observations of the Milky Way.
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Fundamental science concepts: spectra, electromagnetic spectrum, origin of the Universe

Murmur of a Bang

Robert Wilson (left) and Arno Penzias stand in front of their horn reflector antennas in Holmdel, New Jersey. They discovered a radiation signal that matches that expected by theorists who proposed that the universe began with a hot explosion called the “big bang”. This discovery was made by accident as they tried to track down the source of unwanted noise in their receiver.
1993 - Cosmology’s End?

• By the mid-90s, cosmologists thought that they had only to “fill in the details”

• Remaining questions:
  - Will the expansion continue forever, or will Universe eventually collapse back on itself?
  - What is the mass-density of the Universe (which would answer the above)?
1993 - Cosmology’s End?

- By the mid-90s, cosmologists thought that they had only to “fill in the details”
  - Remaining questions:
    - Will the expansion of the Universe eventually stop?
    - What is the mass-density of the Universe (which would answer the above question)?

Fundamental science concepts: origin of the Universe
Cosmology’s End?

- Things may not be what they seem.
- When we see odd behavior, we look 'more carefully at what’s going on.'
2006 – Cosmologists are busy

• 'In 1997, cosmologists were surprised (to say the least)
  ➢ Gravity is the longest-reaching force according to physics '
  ➢ SO, the expansion of the Universe should be slowing down… '
  ➢ By observing supernovae in distant galaxies, researchers determine that the expansion is **speeding up** '

• 'Now, dark energy is well-established, having been detected in many ways

• 'Still, the nature of dark energy is largely a mystery

• 'Stay tuned to this continuing science story…

Cosmologists get very excited!'
History of the Universe’s Expansion'

Video clip from DVD Beyond the Solar System: Expanding the Universe in the Classroom, produced for NASA by the Harvard-Smithsonian Center for Astrophysics. © Smithsonian Institution
2006 – Cosmologists are busy

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- Still, the nature of dark energy is largely a mystery
- Stay tuned to this continuing science story...

Fundamental science concepts: expanding universe, distances in the universe, supernovae, gravity
The year is 2013…'

- What’s going on?
- What’s going on in science?
- What is your view of the Universe?
  - Finite
  - Changing
  - 13.7 Billion Years Old
Cosmic Times'

2019 Cosmic Times

• In our “capstone” lesson plan, students are asked to look to the future

• Students speculate what we will know on the 100th anniversary of the Cosmic Times, what technology we will have, and what questions are still unanswered

• We’re inviting submissions for a possible “student gallery” of 2019 Cosmic Times creations

• See the website for more
Universe Mash-up'

New project-based lesson plan and materials where students create a media mash-up related to Cosmic Times themes.
Universe Mash-up'

Sample mash-up created by our summer intern, Faith Tucker'
Century Timeline

Compare the Cosmic Times timeline with events in:

★ Other Science
★ Arts/Entertainment/Culture
★ World History/Politics

Opportunities for cross-disciplinary collaboration
Cosmic Times Timeline

- 1912 - Henrietta Leavitt determines Cepheid Period-Luminosity relationship
- 1916 - Einstein’s Theory of Gravity
- 1929 - Hubble’s Law
- 1934 - “Super-nova” identified by Baade & Zwicky
- 1949 - Alpher & Gamow discuss nucleosynthesis
- 1952 - Baade recalibrates Cepheid P-L relationship
- 1965 - Penzias & Wilson discover CMB
- 1970 - Vera Rubin makes case for Dark Matter
- 1981 - Guth proposes Cosmic Inflation
- 1993 - COBE measures anisotropies in CMB
- 1998 - Dark Energy discovered
- 2003 - WMAP refines anisotropies in CMB
Andromeda Nebula Lies Outside Milky Way Galaxy...
Teacher Resources

Cosmic Times Teacher Resources

Cosmic Times is a series of curriculum support materials that trace the history of our understanding of the universe during the past 100 years, from Einstein’s formulation of gravity to the discovery of dark energy. It consists of 6 posters, each resembling the front page of a newspaper from a particular time in this history, with articles describing the discoveries. The language of the articles mimics that of a newspaper from its respective era.

In this Teacher Resource area of the Cosmic Times website, you will find materials to help you use Cosmic Times in your classroom. We have divided the Teacher Resources into three areas (also accessible from the navigation bar above):

- Guide to the Cosmic Times Articles
  Here you will find information on each of the articles in the Cosmic Times series. The Guide is organized by Cosmic Times issue, so that each poster, or “year”, has its own set of pages. Each issue you will find notes on each article.

- Cosmic Times posters are available through the Imagine the Universe! Request Form

- Keep up with our latest news by subscribing to our Cosmic Times news service

- Follow us on Twitter @NASA Cosmic Times
Guide to the Articles

1929 Cosmic Times

This poster is the second edition of the Cosmic Times, with the publication date chosen to coincide with the announcement of Hubble’s results which found that the Universe was expanding. These results were contrary to Einstein’s assumption of a static Universe. In addition, in order to show that the galaxies were all moving away from us, Hubble first showed that there were other galaxies outside the Milky Way.

- Download 1929 poster, newsletters, and glossary
- Teacher’s Guide to the 1929 articles
- 1929 Lessons

Order your set of Cosmic Times posters through the Imagine the Universe Request Form

1929 Article Overview
Keyword Clouds

Below is a keyword cloud for all of the Cosmic Times articles and lessons. A keyword cloud is a visualization of keywords associated with the Cosmic Times articles and lesson plans. The size of each tag in the cloud is related to the number of lessons and/or articles associated with that keyword. Clicking a keyword will bring you to a list of articles and lesson plans that are related to that keyword.

We have Other Keyword Clouds, including those based on key scientists and event dates.
Master Download Page

Below are all of the downloads of materials for the Cosmic Times suite of materials.

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