



**HEASARC**  
High Energy Astrophysics  
Science Archive Research Center

# E/PO Activities in the HEASARC

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*CRESST USRA*  
*HEASARC E/PO Lead*

Oct 15-16, 2007  
HEASARC Users Group

James Lochner



# What We Do

- Publish Imagine the Universe! web site
  - Teacher and Student Resources for grades 7-14
- Host StarChild web site (grades K-8)
- Develop curriculum support materials
- Develop and give teacher workshops
- Work within a growing ASD Division E/PO effort
  - Also work with GSFC Education Office, Origins/Universe E/PO Forum, and other Universe E/PO teams on projects of mutual interest.



# Why We Do It

- Our work fulfills a need for education resources.
- NASA's Higher Ed. and Pipeline education goals require qualified high school and interested middle school students.
- We further our position in the E/PO community as a respected member and resource.



## Who Does It

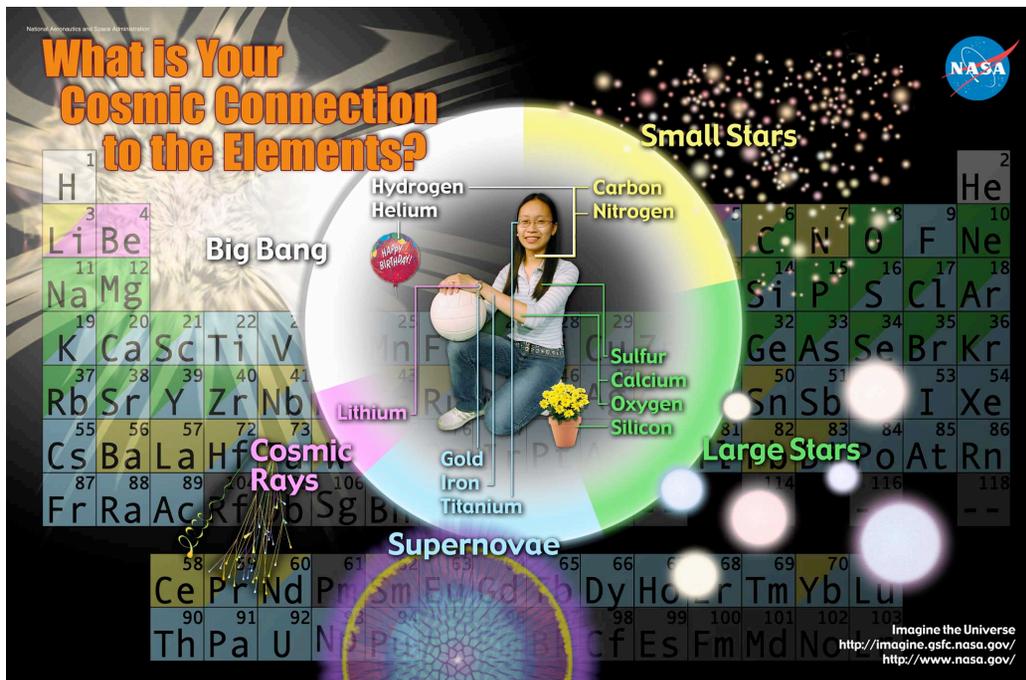
- Scientist Lead, web programmer, distribution assistant, with support from Division E/PO specialists, graphic artist, and volunteer scientists.
  - Some of the staffing now also doing ASD E/PO tasks.
- Educator Ambassador
  - Cheryl Niemela (WA) has been trained on our materials and gives local/regional workshops.
  - We now sponsor her directly rather than through Sonoma State Univ.



# Example of Our Influence

“Cosmic Elements” is one of our most successful projects

- Included on NASA portal for distribution via OfficeMax.
- Will be included in ASP Night Sky Network toolkit on Supernovae and GRBs for amateur astronomy clubs.
- Included in Beyond Einstein Explorers’ Program.
- Distributed at Mayor Daley’s “Celebration of Science” in Chicago.



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# Our Alignment with NRC Astrophysics Data Centers Review

## Best Practices for E/PO:

- Involve staff scientists in E/PO activities
  - 14 Division scientists volunteer for Ask an Astrophysicist
  - Scientists routinely provide input and review
- Coordinate smaller mission E/PO efforts with efforts of data centers
  - RXTE and INTEGRAL leveraged with HEASARC resources
  - Imagine! materials provided basis for Beyond Einstein Explorers' Program



## Alignment with NRC ADC Review

Develop Classroom Materials that:

- Are designed iteratively with classroom testing.
  - part of our standard development cycle (e.g. see Cosmic Times)
- Include hands-on activities
  - Our foundational philosophy
- Supports Standards-based curricula
  - Ditto



## Alignment with NRC ADC Review

- Include protocols for measuring learning effectiveness
  - Classroom activities include assessment guidelines
- Are accessible and cross-linked
  - Materials available via Imagine! site, NASA's SSERD, and NASA CORE
- Include Teacher Support
  - All materials come with teacher guides
  - Present ~18 workshops/year, with workshop materials available on Imagine!



## Milestones & Short-term Plans

- Published 11th editions of Imagine CD
  - with StarChild, APOD & Cosmicopia
  - Includes 2006 APOD, and APOD pages linked from those.
    - Developed topical index of APOD images.
- Next edition will include ASD Podcasts
- Undertaking the updating of science pages on Imagine site.
- Developing “Space Forensics” workshop on supernovae.



# Student Hera

- We're extending Student Hera to include a spectroscopy module.
  - Use Suzaku data for 4U1630 (transient black hole) and Cygnus Loop.
  - Tim Kallman provided data, science background, and analysis procedure.
  - Teacher working through XSPEC and will write associated web pages for the module.
  - High Schools in Anne Arundel Co. will test the new module.



# Cosmic Times

Trace the understanding of the nature of the universe during last 100 years.

- Start in 1919 with confirmation of Einstein's theory of gravity (and its implications for the nature of the universe).
- Continue through to discovery of Dark Energy, our current state of knowledge, and stepping stones to future.
- Six Posters resembling front page of newspapers, with related lessons.



# Scientific Themes in “Cosmic Times”

- Our changing understanding of the Expansion of the Universe
- Nature of Supernovae
- The size and scale of the Universe

A number of other themes will also appear.

- Role of Women in early astronomy.
- Impact of improved technology.



# Cosmic Times Status

Team consists of a freelance writer, teachers developing lessons, and teachers evaluating lessons.

- 1919 is complete with articles, poster layout, and reviewed lessons.
  - Our reviewer was on PBS' NewsHour, complete with a shot of our poster.
- 1929 articles being completed. Lessons have been completed and reviewed.



# Cosmic Times Status

- 1955 articles complete, with lessons in reviewer's hands.
- 1965 articles complete, with teachers brainstorming lesson ideas.

We're presenting workshops on this material at NSTA meetings.

Target Completion: Fall 2008.



# HEASARC

## High Energy Astrophysics

# COSMIC TIME

1919

### SUN'S GRAVITY BENDS STARLIGHT Einstein's Theory Triumphs

"One of the greatest—perhaps the greatest—of achievements in the history of human thought" was what Sir Joseph Thomson, President of the Royal Society of London, called a prediction of Dr. Albert Einstein that was experimentally verified during the total eclipse of the sun May 29 last.

Sir Joseph made his pronouncement during a discussion of the results from the solar eclipse at a joint meeting of both the Royal Society along with the Royal Astronomical Society in London on Thursday evening, November 6, before a large attendance of astronomers and physicists. The excitement in the air was almost palpable as a general consensus accepted that the observations were conclusive in verifying the prediction of Dr. Einstein, Professor of Physics at the University of Berlin and Director of the Kaiser Wilhelm Physical Institute.

led an expedition to the island of Principe in the Gulf of Guinea close to the coast of West Africa near the end of the path of visibility (see map). He also convinced the Astronomer Royal—Sir Frank Dyson, Director of the Royal Observatory, Greenwich—to send another expedition to minimize the chances of cloud interference with the observations. Led by Dr. Andrew Crommelin from the Royal Observatory, it set up instruments at Sobral in northern Brazil, near the beginning of the path of

total eclipse to stay several more months to take check photographs of the star field. Sir Frank explained in detail the apparatus both expeditions had employed, the way the photographic plates were measured back at the Greenwich Observatory, the corrections that had to be made for various disturbing factors, and the methods by which comparison between theoretical and observed positions of the Sun can be made.

He concluded the meeting that the results were definite and conclusive, and that deflection did take place. He also asserted that the measurements showed that the extent of the deflection was in close accord with the theoretical degree predicted by Dr. Einstein, as opposed to half of that degree the amount that would follow if the principles of Newton were correct.

"After a careful study of the plates I am prepared to say that there can be no doubt that they confirm Einstein's prediction," Sir Frank declared. "A very definite result has been obtained that light is deflected in accordance with Einstein's law of gravitation."

"For the full effect that has been obtained, we must assume that gravity obeys the law proposed by Einstein," added Prof. Eddington. "This is one of the most crucial tests between Newton's law and the proposed new law."

The most massive object in the vicinity of the Earth is the Sun. So according to Newtonian principles, a light ray from a distant star grazing the edge of the Sun should be attracted or bent by the Sun's gravity for an amount equal to 0.87 second of arc. To be sure, that angle is very small, about equivalent to a human hair 75 feet, but it is actually measured in the astronomical photographic plates if adequate care is taken.

Newton thought of gravity as a force that pulls things toward an object the bigger the object, the stronger the pull. Dr. Einstein's general theory of relativity, however, conceives of gravitation as arising from a curvature in the "force" of space itself, bending from one down to a star, or even as the "force" of time when pulled forward in an automobile when the driver brakes.

According to Dr. Einstein, gravity, like inertia, doesn't pull. Instead, a mass warps space and time around it, and it is this warping that causes the deflection of the object. The amount of curvature is proportional to the amount of mass. And the curvature of space causes the paths taken by rays of light.

Dr. Einstein's theory, which is highly mathematical, predicts that the curvature of space around the Sun should bend starlight by twice as much as Newton predicts, 1.75 seconds of arc. Thus, Dr. Einstein had predicted that a ray of light from a distant star, grazing the edge of the Sun on its way to the earth, would suffer twice the deflection predicted by Newtonian principles.

The amount by which starlight is deflected by the Sun is thus regarded by astronomers and physicists as one of the crucial tests in determining the validity of Dr. Einstein's theory of relativity versus Newtonian physics.

**May's solar eclipse**  
Dr. Einstein had made his prediction in a paper published in 1916. In the middle of the late Great War between England and Germany, but a neutral Dutch astronomer smuggled a copy of Dr. Einstein's published paper though war was then raging in England. Then it was sent by Arthur Stanley Eddington, Plumian Professor of Astronomy and Experimental Philosophy at Cambridge University—the same scholar and university where Newton presented his great theory of gravity.

Although astronomers who had read earlier unpublished drafts of Einstein's paper tried to test his prediction during the total solar eclipses of 1912 and 1914, the observations were not conclusive. They were folded by clouds by the start of the Great War. But a study of the conditions of the 1919 solar eclipse, however, showed that the Sun would be very favorably placed among a group of bright stars. Moreover, the Sun's light would be easily blocked away by the Moon for five minutes, obscuring "why a total solar eclipse?"

Following both the Sun and the stars to be photographed at the same time.

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### Age of the Universe: 2 Billion Years

# COSMIC TIME

1919

### Andromeda Farther Away Than Originally Thought Spiral nebulae are indeed "island universes"

But Dr. Hubble's galactic astronomer according to Hubble, the Sun can be seen in its center. In other words, the spiral nebulae are indeed "island universes" as Hubble has shown.

In 1912, Dr. Shapley became the first to measure the distance to the spiral nebulae. He found that the distance to the spiral nebulae was much greater than originally thought. This discovery led to the realization that spiral nebulae are indeed "island universes" and that the universe is much larger than previously believed.

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### Age of the Universe: 6 Billion Years

# COSMIC TIME

1929

### Universe "Red Shift" is Proof

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### "Yardsticks" in Neighbor Galaxy Double Universe's Size

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### 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, in a lecture series on the origin of the universe. The question is whether the universe had a beginning, middle and end.

The case for an ageless, steady-state universe which forever looks much as it does today was presented at the conference by astrophysicist Arno Penzias and physicist William A. Fowler of the California Institute of Technology. The steady state theory treats the "workable" theory of the universe which calls on an inflow of low velocity particles equal to the loss of time and making all the earth on an island and perhaps being on the fall asleep.

Both theories explain—in entirely different ways—the measurable fact that the universe is expanding. This cosmic expansion was first discovered in 1919 when American astronomer Vesto Slipher measured the red shift of galaxies and noticed the light from all of them was "red-shifted." This is essentially the reddening and reddening of the visible light waves caused by the retreat of the galaxies. It's the electromagnetic equivalent of how the wail of a retreating locomotive drops to an inaudible wail 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 elements, hydrogen, from empty space. The rate of expansion is called matter every 300,000 years or so. This hydrogen eventually gathers and condenses into stars which, through nuclear fusion in their cores, manufacture all the heavier elements. As stars age and die, they deposit the heavier elements around by the gas being used to form new stars with rocky planets around them—like our own Solar System. An evidence of that process, Penzias and Fowler referred to the heavy-element dust grains which can be seen today in our Galaxy.

An important aspect of the steady-state is that anything that exists, in the expansion of the theory, thinks it is stationary. It has to be, for the universe to be stationary. It has to be, for the universe to be stationary. It has to be, for the universe to be stationary.

Then, on the other hand, there is the somewhat less "evolutionary" theory of the universe. This theory is based on the work of the American physicist George Gamow and his colleagues Ralph Alpher and Hans Bethe. These scientists call the expansion and decay of a half of matter as the origin of the universe to create all the elements and some helium. These elements form out as the stars expand and cool. The first stars were made of only these original elements and shed their most heavy, heavier elements. These, they are dispersed through the galaxy as the first stars die, and led to the later generations of elements seen in stars now.

This evolutionary theory also accounts for the expanding galaxies. They are still in flight from the power of the initial blast. They may be other direct evidence of the heat of a hot bang, but the evidence is not as clear as the steady-state theory. Gamow has speculated that some form of residual heat from that "explosion" may still be glowing dimly in the form of stretched-out light waves called "microwaves" or "cosmic background radiation." As yet, however, no one has devised a way to detect this theoretical remnant heat.

More accessible evidence for the evolutionary universe comes from Edwin Hubble's 1929 measurements of the velocities of galaxies beyond our own, which built on Slipher's earlier discoveries. Hubble found that the more distant a space galaxy is, and therefore the closer it is to the original explosion, the faster they appear to be moving away. This is exactly what would be expected if there was an ancient blast that started it all and things have been slowing down ever since.

The demands to an evolutionary universe, of course, that it doesn't happen. There's no limitation most of the origin in the steady-state theory. The universe has been expanding since the beginning. It has been expanding since the beginning. It has been expanding since the beginning.

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### Size of the Universe: 2 Billion Light Years

# COSMIC TIME

1929

### Death of a Genius: Albert Einstein 1879 - 1955

Albert Einstein in 1930

The world has just lost its greatest scientific mind. Albert Einstein died on April 18th from complications of a lingering gall bladder infection. He was 76. There is no doubt that this remarkable, white-haired, pipe-smoking professor passed deeper into the history of the universe than any other man. In death he joins a select few—such as Newton, Copernicus, Archimedes and Pythagoras—in a great list of scientific geniuses who changed the course of history.

The immediate outpouring of tributes to the German-born scientist begins to correct his place in history. President Eisenhower said, "No other man contributed so much to the vast expansion of 20th century knowledge." Mode-Strasser, the Prime Minister of Israel observed, "The world has lost its greatest genius." There were even eulogies behind the Iron Curtain. Preside described him as "A great transformation of natural science."

The true nature of Einstein's scientific achievements are better known to his colleagues and scientific progress, who still labor to understand, but not apply his theories. There is no revolutionary thinking of light as just not just but particles. There is no theory of special relativity, which set speed limit with the universe at that of light. Or his most famous equation, E=mc<sup>2</sup>, which dissolved the wall between matter and energy. Finally, we have his space-time bending theory of gravitation. Taken together, Einstein's ideas are the basis of all modern physics.

For the non-physicist, however, Einstein's genius is a great, but largely a mystery. The man on the street knows that such things as television and the hydrogen bomb are the results of his work, but he scarcely grasps how it is so. As it is, across, rather like the man of Einstein's deathbed, who failed to grasp the great man's final words, uttered in German. He did not speak German. Most of all, he did not speak English. And he did not speak Hebrew. Instead, we sense the importance of the man indirectly and gain the glimpse of a genius, in his life and his genius pieces before us.

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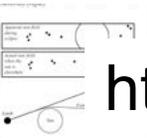
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## HEASARC Users Group

# "Newsletter version" for individual student use

## http://cosmictimes.gsfc.nasa.gov/



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of the Milky Way. Dr. Hubble estimates the Andromeda Nebula is as large and holds as much matter as our own galaxy, the Milky Way.

The first clue that there were super-novae lurking among the stars came 35 years ago by the recently deceased astronomer Edwin Hubble. Using his revolutionary method for measuring stellar distances, he calculated that a nova observed in 1915 in the Andromeda Galaxy actually may have been about one hundred times more luminous than any nova recently observed in our own Milky Way Galaxy.

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