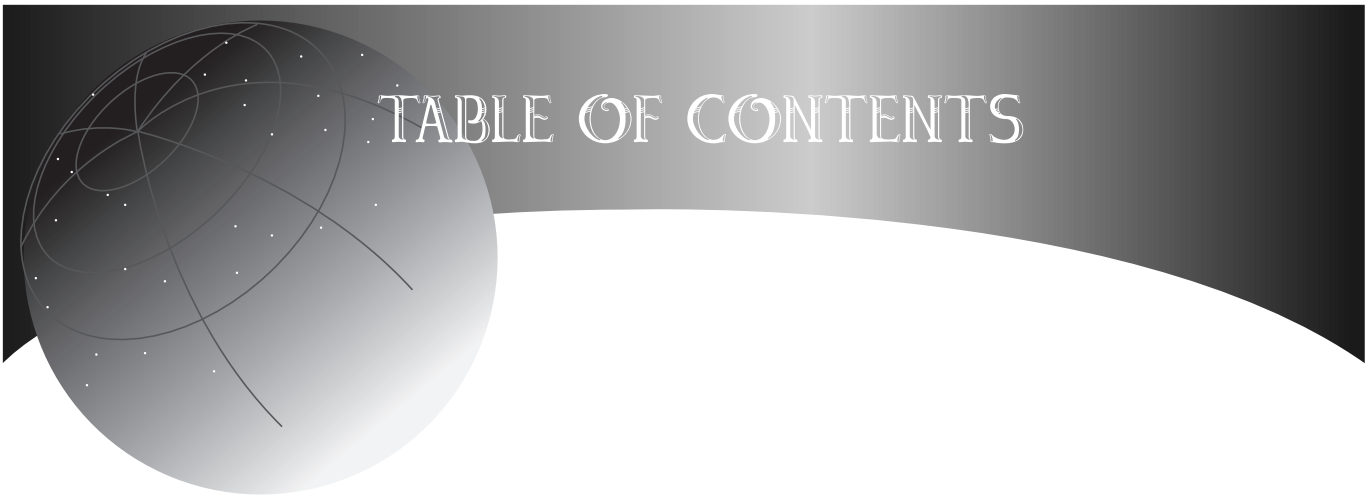

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SEEING AND EXPLORING THE UNIVERSE

Imagine that you are in your kitchen. You're thirsty, so you pour yourself a glass of water. Relaxing, you lean against the oven to take a drink.

Unfortunately, you have forgotten that you just turned off the stovetop a few minutes ago after cooking dinner, and it has not had time to cool. It doesn't look hot, because it isn't glowing red, but it's still hot enough to burn you. Ouch!

Too bad. The stovetop looks dark to your eye, but if you only had infrared vision, you'd see it as the brightest thing in the room. You would have paid better attention, and avoided a nasty burn. Unfortunately, the human eye is essentially blind to infrared, and you paid for that deficiency.

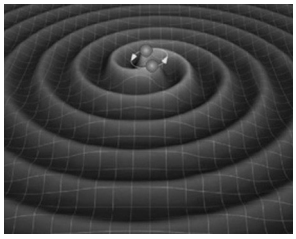


Image courtesy NASA JPL

Astronomers, too, have suffered in a similar way. They had to be content for centuries to view the Universe in visible light only, the type of electromagnetic radiation detectable by the human eye. It gave astronomers a beautiful vision of the Universe, but an extremely limited one. In visible light, the Universe is a fairly quiet, unchanging place. Stars shine with a relatively steady light, galaxies glow softly and space itself is vast and dark.

But the Universe has secrets it keeps from observers stranded in the visible range of light. To those who can see outside this limited range, the Universe isn't peaceful at all. It is a place of unimaginable violence, where distant objects explode in fury, pouring out more energy in a single second than our own Sun will emit over its entire lifetime. Giant black holes, a billion times the mass of the Sun, greedily eat surrounding gas. As the gas falls into this bottomless pit, jets of highly focused energy and matter are emitted which can stretch for hundreds of thousands of light years. The fires of the formation of the Universe even glow feebly all these billions of years later, and like the stove in our example above, that heat is invisible to us unless we stretch our vision to include microwaves.

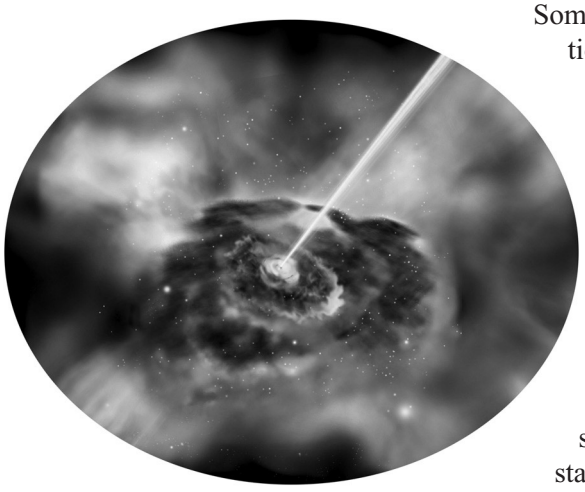


Image courtesy GLAST EPO

Sometimes cosmic events don't emit electromagnetic radiation; they announce their presence in ways more exotic. Smaller binary black holes dance to the tune of gravity, slowly drawing each other in. They finally merge in an event so sudden and dramatic it bends the fabric of space and time itself. These coalescing black holes send out ripples of gravity detectable only to the most finely tuned instruments. Giant stars which dwarf the Sun can explode, tearing themselves apart, accelerating subatomic particles to a hair's-breadth below the speed of light. These cosmic ray particles pack an enormous punch, and, even though they are sub-microscopic, they can reveal the life stories of giant stars and the Milky Way Galaxy.

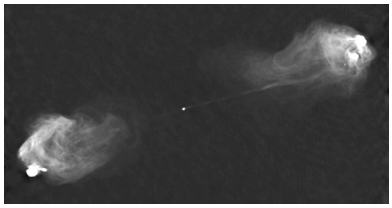


Image courtesy NRAO/AUI

NASA scientists have strived for decades to understand the nature of the Universe, and to broaden our senses enough to hear what the Universe is telling us. NASA, with the help of space agencies from several other nations, is assembling a fleet of spacecraft to expand our horizons. This fleet is a part of the NASA theme called "Structure and Evolution of the Universe", or SEU. The purpose of the SEU theme is to answer some of the broadest and most basic questions in astronomy, and perhaps all of science. What is the structure and ultimate fate of the Universe? How are the cycles of matter and energy powered? What happens at the ultimate limits of gravity and energy?

The telescopes in the fleet see and explore the Universe in different ways, each trying to tease out the answers to these questions. Most of these SEU missions are sensitive to different parts of the electromagnetic radiation, while other missions observe cosmic rays or gravitational waves. No matter what they detect, or how they detect it, scientists hope that these missions will ultimately give them insight into what makes the Universe tick.

One of NASA's most important directives is that each mission devotes time and funding to educating the public about science. To further this effort, the missions in the SEU theme have put together this kit of educational materials, which includes posters, CDs, lithographs of actual astronomical observations and more. This kit will introduce you to the basic science used in each mission, and will also help you see and explore the Universe in different ways on your own.

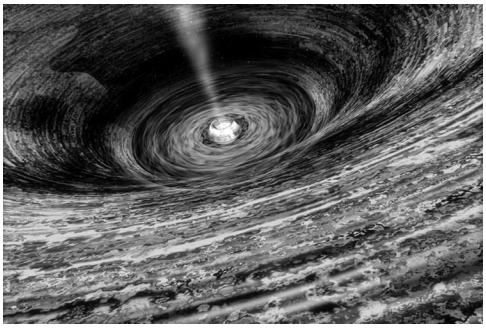


Image courtesy NASA/CXC/SAO

A clickable list of all the hyperlinks in this booklet can be found at:
http://universe.sonoma.edu/materials/2002/mission_links.html

SEU FORUM

http://cfa-www.harvard.edu/seuforum/

An introduction to NASA's Structure and Evolution of the Universe Education Forum

How did the Universe, galaxies, stars, and planets form and evolve, and what is their destiny? How can our exploration of the Universe revolutionize our understanding of physics, chemistry, and biology (and ourselves)? These are the fundamental questions of NASA's Space Science research program. This guide introduces an exciting series of NASA space science missions that will explore the essence of time, gravity, matter and energy in the Universe - the SEU missions. Over the next decade, these missions will use space-based observatories to study the Universe by observing the Earth, the Sun, the stars and beyond.

A key goal for NASA's space science program is Education and Public Outreach (EPO) to share the excitement and knowledge generated by scientific discovery and to help improve science education. Each of the SEU missions introduced in this booklet has its own EPO group, and these space scientists and science educators have worked together to create the Seeing and Exploring the Universe kit of materials. We hope that by literally putting the Universe in your hands through posters, flyers, informational essays and, of course, images, you will see the Universe in a new way, explore it in a different way, and ultimately comprehend more of it in your own way.

SEU missions coordinate their EPO efforts with the support of the SEU Education Forum, one of four Education Forums funded by NASA's Office of Space Science (the others include the Solar System Exploration Forum, the Sun-Earth Connection Forum, and the Astronomical Search for Origins Forum). The SEU Forum is headquartered at the Smithsonian Astrophysical Observatory, a member of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

Be on the lookout - SEU Science is coming to a science museum near you:

Beginning in September 2002, the major exhibition and education program "Cosmic Questions: Our Place in Space and Time" will begin a tour of science museums around the country. This project is funded by the National Science Foundation and NASA, developed at the Smithsonian Astrophysical Observatory, and supported by the SEU Forum and SEU mission EPO programs.

RESOURCES

Cosmic Journeys *http://universe.gsfc.nasa.gov/*
Cosmic Journeys is the main site for the NASA Structure and Evolution of the Universe theme. It has an overview of the SEU theme which includes descriptions of the missions, goals, and future plans as well as resources available for use. This should be your first stop for information about the SEU missions.

The Structure and Evolution of the Universe Education Forum *http://cfa-www.harvard.edu/seuforum/*
This site is the educational arm of NASA's Structure and Evolution of the Universe theme. The mission of the SEU Education Forum is to enhance public understanding of science and technology and to contribute to science education efforts nationally. It has resources and news for both educators and scientists, and links to many other NASA education efforts.

Universe at Sonoma State University *http://universe.sonoma.edu/*
This is a sister-site for the NASA SEU Forum website. It includes lesson plans for teachers, information from this kit, and downloadable informational fliers for many of the SEU missions. These fliers are full color, give background information on the mission, and also have a short activity based on the mission science that can be done in a classroom.

Imagine The Universe! *http://imagine.gsfc.nasa.gov/*
This site is intended for students age 14 and up, but can be used by anyone interested in learning about our Universe. Covering topics from the electromagnetic spectrum to black holes, this site features multimedia exhibits, a satellite showcase, "You Be the Astrophysicist" (an online series of pages where you solve an astrophysical problem), the latest space news, and much more.

StarChild *http://starchild.gsfc.nasa.gov/*
StarChild is an award-winning website for young astronomers, ages 4-14. The site offers information about the solar system, space travel, and the Universe, and includes interactive activities, puzzles and movies.

The Space Place *http://spaceplace.nasa.gov/* or *http://spaceplace.nasa.gov/espanol/*
At the SpacePlace, students can learn about a variety of astronomical objects by doing hands-on activities which include crossword puzzles, cookie-baking, building a rocket and even making a balloon-powered asteroid nanorover.

NASA Space Science Education *http://spacescience.nasa.gov/education/*
The Space Science Education website contains a wealth of information about NASA's space missions, including education resources, conference lists, newsletters and even a Frequently Asked Questions list.

ACE

http://www.srl.caltech.edu/ACE/

Launched:
August 25, 1997

Advanced Composition Explorer

Kit Item

Cosmic and Heliospheric Learning Center business cards

Mission

ACE is studying energetic particles coming from the Sun, interplanetary space, and the Galaxy, collecting data to help us understand the composition of the Universe and the chemical evolution of matter. The particles from the Galaxy are galactic cosmic rays (GCRs), one of the few direct samples of matter from outside our Solar System. GCRs flow into our Solar System at nearly the speed of light, and are primarily atomic nuclei from which all of the surrounding electrons have been stripped.

Education and Public Outreach Program

It is difficult to take pretty pictures of cosmic rays, but studying the quantity and type of these particles helps us to understand their origin and history. This science lends itself well to helping students and the public to better understand topics such as composition, acceleration, magnetic fields, and energy. The Cosmic and Heliospheric Learning Center web site covers these topics. It also includes a glossary, a history of cosmic ray studies, and answers to hundreds of questions from readers. ACE developed this website along with many educational briefs and investigations, a booklet, a poster, and a science fact sheet. The ACE team initiated the development of a traveling museum exhibit as well as a CD-ROM with information on several NASA/Goddard Space Flight Center missions. It has contributed to many teacher and student workshops, and one of the team scientists routinely speaks about ACE science in the classroom to students from elementary through high school.

❖*EPO site: http://helios.gsfc.nasa.gov/*

Seeing and Exploring the Universe

ACE is measuring the composition of GCRs, as well as the composition of energetic particles from the Sun and interplanetary space. By comparing the composition of these different samples of matter, ACE will further our understanding of the origin of the heavy elements in our Solar System and the Galaxy. GCRs are also an important component of the energetics of the Galaxy, but how they have obtained their high energies is not well understood. ACE has already shown that there is a long (>100,000 years) delay between the time of creation of the GCR elements and when they are accelerated up to high energy. Also, the composition of the heavy GCRs is surprisingly similar to that of the Solar System, which raises interesting questions about the chemical evolution of the Galaxy.

Cosmic rays are the nuclei of atoms such as hydrogen, helium, etc. ACE detects cosmic rays traveling at speeds up to 85% that of light.

Expected Launch:
February 2005

ASTRO-E2

http://lheawww.gsfc.nasa.gov/docs/xray/astroe/

Astro-E2

Mission

Astro-E2 is a joint Japanese-US mission devoted to observations of celestial X-ray objects. Astro-E2 is designed for broad-band, high-sensitivity, high-resolution spectroscopy. This means not only that its instruments are sensitive to both low and high energy X-rays, but they can distinguish very small differences in the energy of the X-ray photons that are being detected. Astro-E2's prime instrument is a revolutionary X-ray micro-calorimeter, which detects the energy of incoming X-rays with unprecedented accuracy.

Education and Public Outreach Program

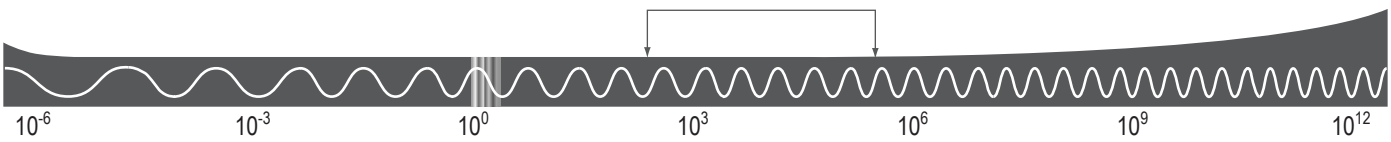
The Astro-E2 education program will give students and teachers the opportunity to participate in the mission and its discoveries. Through the planned educational video "The Story of Astro-E2," students will learn of the history of the mission and witness the challenges and successes of an international collaboration. Students will have an opportunity to share in the data from the mission through a student competition in the fall of 2004. The on-line Learning Center will provide background material and new graphics illustrating what we learn through spectroscopy.

❖EPO site: *http://astroe.gsfc.nasa.gov/docs/astroe_lc/*

Seeing and Exploring the Universe

X-ray astronomy studies very energetic objects and phenomena in the Universe. X-ray radiation, invisible to the human eye, is generated under the most extreme conditions of gravity, temperature and magnetic fields that exist in black holes, neutron stars, and active galaxies. Using its high resolution spectroscopy capabilities, Astro-E2 will explore how and where chemical elements are created, what happens to matter near a black hole, and how gas is heated to X-ray temperatures. Undoubtedly, Astro-E2 will reveal new objects and unanticipated phenomena, and possibly new fundamental physics.

ASTRO-E2 Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

CHANDRA

http://chandra.harvard.edu//

Launched:
July 23 1999

Chandra X-ray Observatory

Kit Items

Coloring and activity book, 2 lithos, and postcard

Mission

The Chandra X-ray Mission is designed to observe extremely energetic, turbulent regions of space where matter has temperatures of millions of degrees Celsius and radiates its light energy as X-rays. Although it is difficult to focus X-rays, Chandra has the sharpest X-ray focus of any satellite ever built. Chandra observes "hot" areas of the Universe such as the remnants of exploded stars, young stars in active star-forming regions, neutron star powerhouses, matter swirling toward black holes, the supermassive black holes at the centers of galaxies, and the dynamics of vast clouds of hot gas in clusters of galaxies.

Education and Public Outreach Program

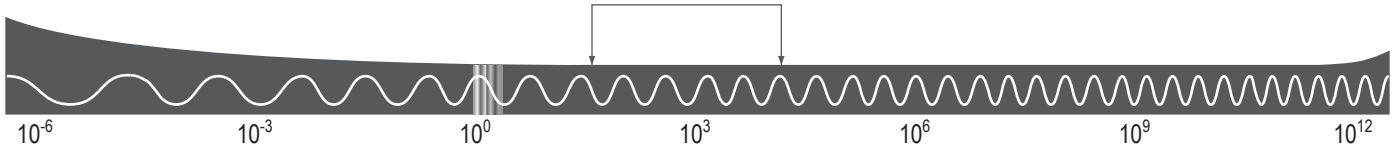
Our Education and Public Outreach program has been developed to share Chandra's exciting discoveries with broad segments of the general public, and to utilize those discoveries in materials and resources for both formal and informal learning. We maintain an extensive public web site that provides access to the latest Chandra images, extensive background materials, interactive and informal learning activities, and a section of formal, classroom ready activities. On-line request forms allow educators to order posters, bookmarks, CD-ROMs, and other Chandra materials. Links are provided to other resources for videos and slide sets. We also provide on-line information about Chandra-sponsored in-service and workshop opportunities.

❖EPO site: *http://chandra.harvard.edu/*

Seeing and Exploring the Universe

A major purpose of the Chandra mission is to take images and spectra of celestial X-rays with enough sharpness to distinguish previously unseen individual sources, as well as details of the X-ray sources that will give scientists information about their fundamental physical processes. In its first two years of operations, Chandra has discovered thousands of new X-ray sources, including classes of previously unknown black holes, and taken precise spectra that trace the distribution of elements flung out of exploded stars. Combined with data in different wavelengths from other space and ground-based missions, Chandra's discoveries are helping to give scientists their most complete picture yet of our Universe.

Chandra Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

Expected Launch:
Fall 2002

CHIPS

http://chips.ssl.berkeley.edu/

Cosmic Hot Interstellar Plasma Spectrometer

Kit Item
Local Bubble Boundary activity

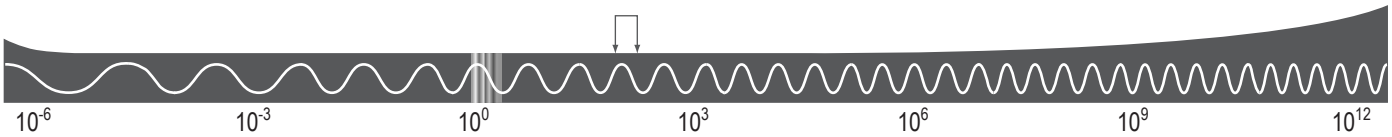
Mission
The Cosmic Hot Interstellar Plasma Spectrometer (CHIPS) will carry out all-sky spectroscopy of the diffuse sky background which glows in ultraviolet light. CHIPS data will help scientists determine the electron temperature, ionization conditions, and cooling mechanisms of the million-degree plasma believed to fill the local interstellar bubble. The majority of the luminosity from diffuse million-degree plasma is expected to emerge in the poorly-explored extreme ultraviolet band, making CHIPS data of relevance in a wide variety of Galactic and extragalactic astrophysical environments.

Education and Public Outreach Program
The idea of investigating our cosmic neighborhood, its past and future, is a very interesting topic that engages the curiosity of students, educators and the general public, going beyond the details of measuring particular physical parameters in the interstellar medium. The CHIPS Education and Public Outreach Program has been developed for middle and high school grades to promote the inquiry-based exploration of matter, with concepts such as density, temperature and heat. It also contributes to science education research in student's conceptual understanding of the particulate nature of matter.

❖EPO site: *http://cse.ssl.berkeley.edu/chips_epo/*

Seeing and Exploring the Universe
Our Solar System is located in an unusual region of space called the Local Bubble (LB). The LB is a bubble of hot gas about 300 light years in radius, surrounded by colder, denser gas in our Galaxy. The CHIPS Mission is dedicated to understanding how hot, million-degree gas in the Sun's local neighborhood (the local interstellar medium) cools. Astronomers believe that our bubble may have been created by a supernova explosion ten million years ago: the explosion blew most of the gas and dust from the interstellar medium outward. It is the extremely hot, diffuse gas inside the Local Bubble that the CHIPS mission will be studying. Studying how this gas cools will lead to a greater understanding of the nature of hot gas in our own and other galaxies.

CHIPS Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

CON-X

http://constellation.gsfc.nasa.gov/

Expected Launch: 2008

Constellation -X

Mission

Constellation-X will not be a single telescope but a team of four orbiting telescopes all linked together electronically. They will work together to be over 100 times as sensitive to X-ray light than any other previous X-ray telescope. The telescopes will act as a high-resolution spectrometer, able to determine the energy of each X-ray photon that they detect, allowing them to measure the velocity, temperature and magnetic field strength of objects they observe. The increase in sensitivity over previous missions will allow Constellation-X to peer more clearly into the matter falling into black holes, tracing it down to its last gasp before oblivion. Constellation-X will also be able to trace dark matter, invisible to optical telescopes, but which affects the matter around it with its gravity. Hot gas falling under the influence of dark matter will emit X-rays, betraying its presence. Constellation-X has the potential to help solve the decades-long mystery of the makeup of dark matter.

Education and Public Outreach Program

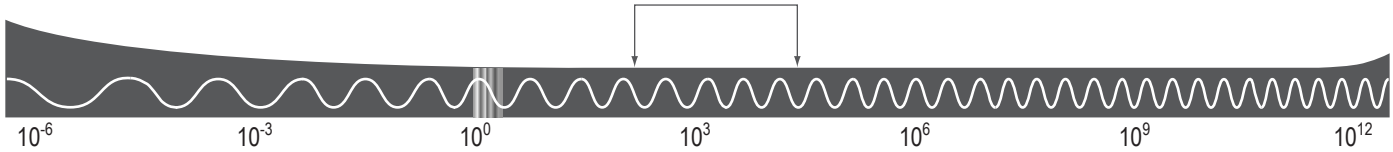
The Constellation-X website contains mission profiles, illustrations of the satellites, videos and animations of the mission. As time progresses and the satellites are built, the website will be upgraded with lesson plans for teachers, hands-on activities for students and more images and information for the general public.

❖EPO site: *http://constellation.gsfc.nasa.gov/*

Seeing and Exploring the Universe

Constellation-X will detect X-rays which come from energetic phenomena such as black holes, ultra-hot gas and supernovae. The unique contribution of Constellation-X will be its unprecedented sensitivity to X-rays, allowing astronomers to peer more deeply into the high-energy Universe than ever before. Astronomers have learned that the deeper you can see, the more surprises await. Constellation-X will no doubt provide scientists with many unexpected discoveries during its mission.

Constellation-X Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

Expected Launch:
July 2002

GALEX

http://www.srl.caltech.edu/galex/

Galaxy Evolution Explorer

Mission

GALEX, the Galaxy Evolution Explorer, is an ultraviolet imaging and spectroscopic survey mission designed to map the global history and probe the causes of star formation from the current era back to a time when the Universe was roughly one-fifth its present age. During this time period, galaxies and the gas they contain have changed dramatically, forming most of the structures we see today. Data from GALEX will help astronomers understand what galaxy-wide factors drive star formation and the evolution of galaxies.

Education and Public Outreach Program

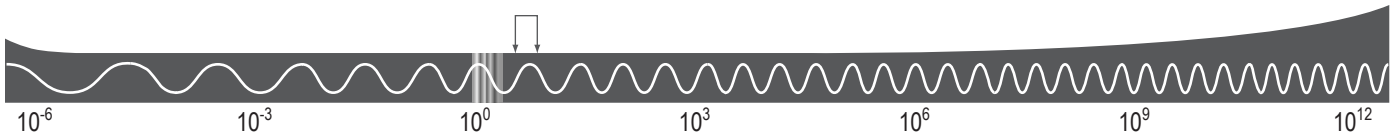
A multifaceted outreach program is underway for GALEX. It will provide timely and engaging information about GALEX accomplishments and discoveries to the public, the media, and the educational and scientific communities. It includes outreach activities by GALEX team members and easy public access to GALEX information. It also describes the structure and origin of galaxies and why these phenomena are relevant to the public. The GALEX Education and Public Outreach Program will use proven NASA outreach programs, including The Space Place to make information accessible to all audiences. One GALEX activity already online at The Space Place is "Make a Galactic Mobile" at: *http://spaceplace.nasa.gov/galex_make1.htm*

❖EPO sites*: http://spaceplace.nasa.gov/* and *http://spaceplace.nasa.gov/espanol/*

Seeing and Exploring the Universe

When massive stars are created from their cocoons of gas and dust in galaxies, they shine brightly at ultraviolet energies, heating up and fluorescing the gas the around them. Ultraviolet observations can directly determine the rate that stars form in galaxies. By observing tens of thousands of galaxies, we can deduce what happens over time as the galaxies live and die. Stars and gas are the basic building blocks of galaxies, from our own Milky Way to the most distant galaxies ever seen. The cores of stars are factories for converting hydrogen and helium into ever-heavier elements, so we owe our very existence to massive stars. Studying them gives us vital clues into how we came to exist.

GALEX Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

GLAST

http://glast.gsfc.nasa.gov/

Expected Launch: 2006

Gamma-ray Large Area Space Telescope

Kit Item

Active Galaxies poster

Mission

GLAST is designed to image celestial gamma-ray sources in the energy band extending from 10 keV to more than 300 GeV, utilizing two detectors: the LAT (Large Area Telescope) and the GBM(Gamma-ray Burst Monitor). GLAST is the next major mission planned by the Structure and Evolution of the Universe theme area in the NASA Office of Space Science, and is an international collaboration between NASA, the U.S. Department of Energy and agencies in France, Germany, Italy, Japan and Sweden.

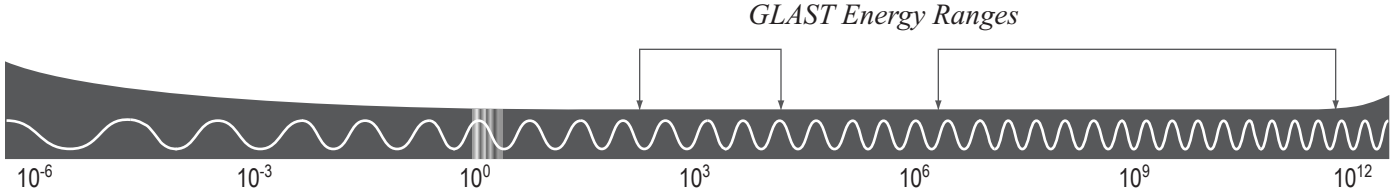
Education and Public Outreach Program

The goal of the GLAST Education and Public Outreach (EPO) program is to use the observations and scientific discoveries of the GLAST mission to improve the understanding and utilization of physical science and mathematics concepts for grades 9-12. Future EPO projects will include additional printed materials such as learning modules from TOPS Science, Inc., web-based adventures called Space Mysteries, a PBS television special on high-energy astronomy and much more. We have also selected a team of top educators, called GLAST Ambassadors, to help us develop and distribute educational materials; five more Ambassadors will be chosen in 2003.

❖EPO site: *http://glast.sonoma.edu/*

Seeing and Exploring the Universe

Gamma-ray astronomy studies the most energetic objects and phenomena in the Universe. Gamma radiation, invisible to the human eye, is generated under the most extreme conditions. The mission of GLAST is to study these powerful objects and violent events in order to understand Nature at its ultimate limits. Exploring the limits often reveals new things and unanticipated phenomena, particularly in fundamental physics. This knowledge may eventually find application in current technologies, or create technologies that are entirely new.



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

Expected Launch:
October 2002

GP-B

http://einstein.stanford.edu/

Gravity Probe B

Kit Item
Informational brochure

Mission
Gravity Probe B is a relativity gyroscope experiment being developed to measure the local spacetime curvature caused by the Earth's mass and the local spacetime "frame-dragging" caused by the rotation of the Earth. Four spinning gyroscopes will be placed in Earth orbit for one to two years. As they travel around the Earth, the orientation of each spin axis should be slightly changed by the curvature and "twist" of local spacetime. These two effects are extremely small- a predicted 6.6 arcseconds of spacetime curvature, and a predicted 42 milliarcseconds of twist, or "frame-dragging" (there are 3600 arcseconds in one degree). Several cutting-edge technologies have been developed by GP-B to distinguish these miniscule angles and "see" our invisible intangible spacetime.

Education and Public Outreach Program
At the heart of Gravity Probe B are questions about spacetime and gravity - questions that both experienced physicists and young students ponder. The goal of the GP-B EPO program is to make these questions understandable and meaningful to high school physics students and anyone else who wants to learn about these phenomena. The program concentrates on communicating the scientific and technical concepts that make up the GP-B mission, as well as introducing students to the ideas of spacetime and connecting those ideas to previously-formed notions of gravity. To this end, we are producing a teacher's guide, wallsheet, and lithograph set, and assisting with the production of a CD-ROM and video, as well as visiting local classrooms and national conferences to present the material.

❖EPO site: *http://einstein.stanford.edu/*

Seeing and Exploring the Universe
In 1916, Einstein published the General Theory of Relativity, which gave us a new understanding of the structure of the Universe itself. Gravity Probe B will be making the most precise examination of Einstein's theory ever conducted, and should provide us with a clearer view of the physics underlying our Universe. With the results of this mission, scientists can further understand all sorts of physical phenomena and ideas, from seeing where inertia comes from, to understanding the powerful bursts emerging from black holes, to understanding the nature of motion in the Universe.

GPB measures a unique gravitational effect and does not measure the EM spectrum.

HETE-2

http://space.mit.edu/HETE/

Launched:
October 9, 2000

High Energy Transient Explorer 2

Mission

The High Energy Transient Explorer-2 is designed to detect and localize gamma-ray bursts (GRBs), which are thought to originate billions of light-years away: each burst releases as much energy as a billion billion Suns, but lasts only for a few seconds. HETE-2 can quickly determine the celestial coordinates of GRBs and distribute these coordinates to other instruments, both on the ground and in orbit, which can make detailed observations of the GRB before it fades away. HETE-2 is equipped with gamma-ray and X-ray detectors which can make simultaneous observations of the GRB and calculate its position on the sky.

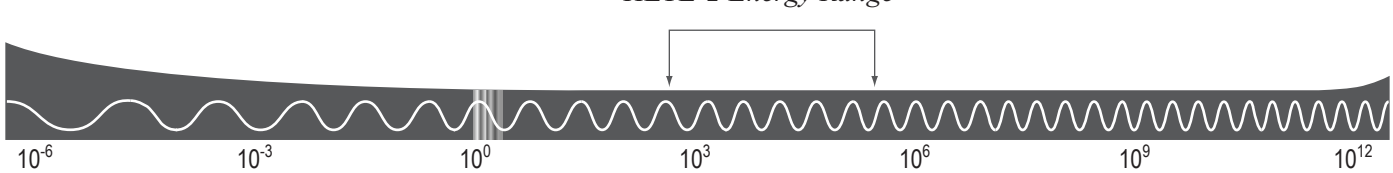
Education and Public Outreach Program

Coordinated by the Education and Public Outreach Office of MIT's Center for Space Research, scientists of the HETE-2 team take visitors on a tour of the HETE-2 Command and Control Center. Here scientists and engineers direct the flight, execute the observing plan, and receive the data from HETE-2. During the tour the visitors learn about gamma-ray astronomy and become acquainted with some of the concepts and operational procedures of low-Earth-orbit satellites. The HETE-2 team is also an active contributor to workshops for middle and high school science teachers organized by the Center for Space Research EPO Office. These workshops present the teachers with the content, materials, and methods to introduce their students to space science through the exciting discoveries made by the HETE-2 and other space missions.

❖EPO site: *http://space.mit.edu/CSR/outreach/*

Seeing and Exploring the Universe

Gamma-ray bursts are the most energetic events since the Big Bang, yet one occurs about once a day somewhere in the sky. The unique power of HETE-2 is that it can calculate the precise position of a GRB within seconds of the start of the burst and then immediately transmit the position to ground-based receivers located around the Equator. The data are transmitted to the MIT Control Center and then relayed to ground-based optical, infrared, and radio observers who search for GRB counterparts and afterglows. The opportunity to see the afterglow in other wavelengths provides crucial information about what is triggering these mysterious bursts, which scientists speculate to be the explosion of massive stars, the merging of neutron stars and black holes, or possibly both.



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

Expected Launch:
October 2002

INTEGRAL

http://astro.estec.esa.nl/SA-general/Projects/Integral/

International Gamma-Ray Astrophysics Laboratory

Mission

INTEGRAL is an international collaboration headed by the European Space Agency and includes NASA's participation. It is designed to study celestial gamma-ray sources in the energy range from 10 keV to 10 MeV. X-ray and optical instruments will further aid in the identification and characterization of the objects seen in gamma rays by the primary instruments. One of INTEGRAL's primary objectives is the study of the origin and evolution of chemical elements in our Galaxy and the Universe. In carrying out this mission, INTEGRAL will perform studies of a variety of phenomena, such as novae and supernovae and their radioactive debris, black holes, active galaxies, gamma-ray bursts, and the center of our own Galaxy.

Education and Public Outreach Program

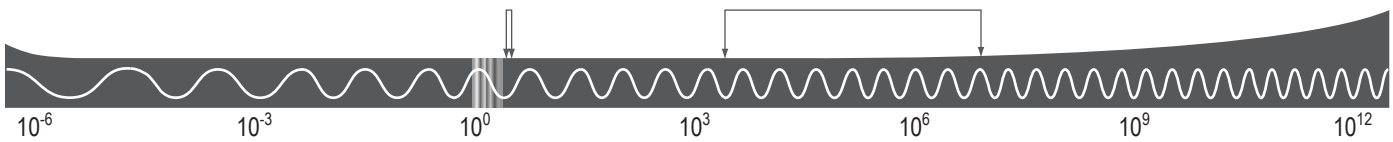
The NASA Education Program for INTEGRAL includes the publication of a poster and information booklet which illustrate and discuss the life cycle of matter in the Universe. The booklet will include classroom activities illustrating key concepts. The program also plans to publish a comic book describing gamma-ray astronomy and INTEGRAL's role in making new discoveries. The INTEGRAL Science Data Centre in Europe hosts public outreach pages describing the mission and science.

❖EPO site: *http://obswww.unige.ch/isdc/Outreach/*

Seeing and Exploring the Universe

INTEGRAL will study how the different chemical elements in the Universe are made. Elements heavier than helium, which are familiar to us in our everyday lives, are made in energetic events such as violent supernova explosions or built up through collisions between subatomic constituents. INTEGRAL will explore where and when this element building takes place, and in doing so, provide further insight into the underlying physical processes. Using gamma-ray, X-ray, and optical detectors, INTEGRAL will examine the sites of these events in its study of the creation of elements.

INTEGRAL Energy Ranges



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

LISA

http://lisa.nasa.gov/

Expected Launch: 2008

Laser Interferometer Space Antenna

Mission

The Laser Interferometer Space Antenna (LISA) is planned as a joint NASA/ESA mission. LISA will fly three spacecraft in the formation of an equilateral triangle, five million kilometers apart. It will measure the distortion of space caused by passing gravitational waves that come from the violent motion of large, dense masses in the Universe. LISA will detect binary star systems in our Galaxy and other galaxies, observe and measure the rate of massive black hole mergers, observe compact stellar objects spiraling into massive black holes, and observe gravitational waves from the early Universe.

Education and Public Outreach Program

LISA's Education and Public Outreach Program has been developed to promote an understanding of the use of gravitational waves to study the origin and structure of the Universe. The LISA EPO team will develop curriculum supplements, posters, and lithographs. It will also participate in NASA public events and in educator and professional conferences. The LISA Education and Public Outreach Program will use proven NASA outreach programs, including The Space Place to make information accessible to all audiences. Be sure to visit The Space Place LISA interactive crossword puzzle at: *http://spaceplace.nasa.gov/lisaxword/lisaxword.htm*

❖EPO site: *http://spaceplace.nasa.gov/* and *http://spaceplace.nasa.gov/espanol/*

Seeing and Exploring the Universe

As the first space observatory for gravitational wave science, LISA will capture a new vision of the Universe. Although gravitational waves have not yet been directly detected there is strong indirect evidence that they exist. Albert Einstein proposed the idea that mass curves space, and that rapidly moving masses create ripples in space. These ripples are called gravitational waves. As in our oceans on Earth, very large disturbances cause very large waves. Large cosmic events in space cause large gravitational waves. But even the biggest of these waves can be very weak by the time they reach us here on Earth, making them very hard to detect. Although gravitational waves get weaker as they travel across space, they aren't changed when they pass through matter. Therefore, the signals they carry will be unchanged across time and space and through them we may even be able to learn how the Universe began.

LISA will not observe the EM spectrum; it will detect gravitational waves in the frequency range of 0.0001 to 1 Hz.

Launched:
June 30, 2001

MAP

http://map.gsfc.nasa.gov/

Microwave Anisotropy Probe

Kit Items
Fact sheet and business card

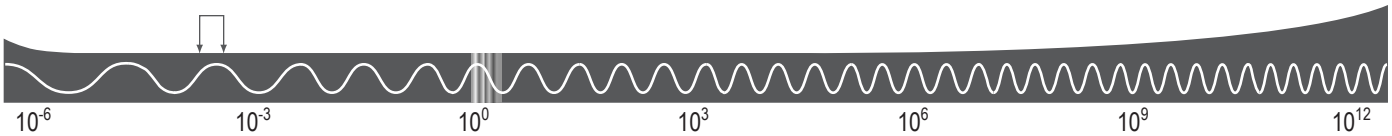
Mission
MAP is a NASA explorer mission that is measuring the temperature of the cosmic microwave background radiation over the full sky with unprecedented accuracy. This map of the remnant heat from the Big Bang will provide answers to fundamental questions about the origin and fate of our Universe.

Education and Public Outreach Program
The MAP mission will result in an incredible baby picture of the Universe by collecting light from the Big Bang. By examining this baby picture, the MAP team hopes to be able to address many key questions such as: Will the Universe expand forever, or will it recollapse? Is the Universe dominated by exotic dark matter? What is the shape of the Universe? How and when did the first galaxies form? How rapidly is the Universe expanding? The MAP mission has supported an educational web site called "A Teacher's Guide to the Universe", designed to help high school teachers explain the exciting results of this mission to their students while also addressing national science standards.

❖EPO site: *http://map.gsfc.nasa.gov/m_or.html*

Seeing and Exploring the Universe
MAP collects microwaves from all over the sky and uses them to create a very detailed all-sky temperature map. This map is a record of the temperature of the Universe 400,000 years after the Big Bang. COBE, a previous NASA mission, showed that the Universe was relatively uniform with only tiny variations in temperature. The MAP team will make a high resolution map of these variations. These hot and cold spots are the seeds for the large scale structure of galaxies and voids that we observe in the Universe today.

MAP Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

RXTE

http://rxte.gsfc.nasa.gov/

Launched:
December 30, 1995

Rossi X-ray Timing Explorer

Kit Item

RXTE Learning Center - Contained on "Exploring the Extreme Universe" CD-ROM

Mission

The Rossi X-ray Timing Explorer probes the physics of cosmic X-ray sources by making sensitive measurements of their variability over time scales ranging from milliseconds to years. How these sources behave over time is a source of important information about processes and structures in white dwarf stars, X-ray binaries, neutron stars, pulsars, and black holes. With instruments sensitive to a wide range of X-ray energies, RXTE studies not only known sources, but has discovered many transient and new X-ray sources.

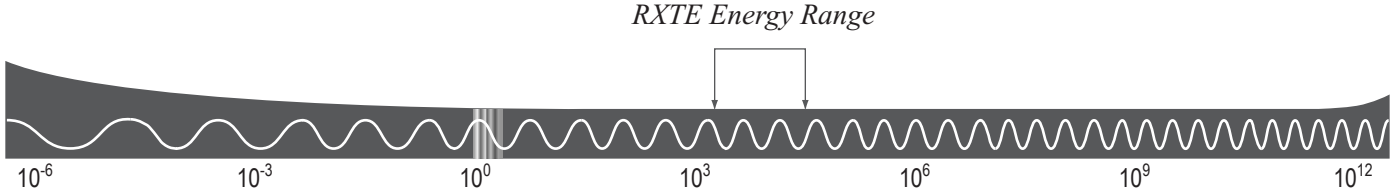
Education and Public Outreach Program

The RXTE Learning Center web site provides a wealth of information about the mission, X-ray astronomy, and discoveries made by RXTE. In addition, the web site includes lesson plans, a model of the satellite, a tour of the X-ray sky, and current RXTE data from over 100 X-ray sources. Our on-line booklet, "Shedding a New Light on the Universe," explores the electromagnetic spectrum and multiwave-length astronomy, focusing on X-ray astronomy.

❖EPO site: *http://rxte.gsfc.nasa.gov/docs/xte/learning_center/*

Seeing and Exploring the Universe

X-ray astronomy studies very energetic objects and phenomena in the Universe. X-ray radiation, invisible to the human eye, is generated under the most extreme conditions of gravity, temperature, and magnetic fields. RXTE is exploring the limits of matter and space-time at the very edge of black holes, and investigating neutron stars that emit X-rays that pulse over 1,000 times a second.



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

Launched:
December 2, 1998

SWAS

http://sunland.gsfc.nasa.gov/smex/swas/

Submillimeter Wave Astronomy Satellite

Mission

The Submillimeter Wave Astronomy Satellite (SWAS) is the first space-based radio satellite sensitive to electromagnetic radiation at submillimeter wavelengths. The overall goal of the mission is to gain a greater understanding of star formation by determining the composition of interstellar clouds and establishing the means by which these clouds cool as they collapse to form stars and planets. SWAS observes these clouds in the radio region of the electromagnetic spectrum, where the atoms and molecules within these clouds strongly emit radiation.

Education and Public Outreach

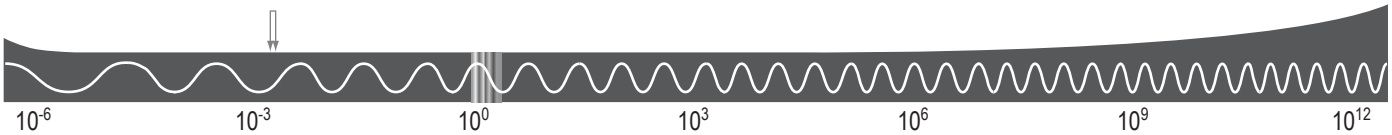
Over a three year period, the SWAS EPO program collaborated with the Cooperative Satellite Learning Project to teach high school students the basics of radio astronomy, star formation and independent scientific research. SWAS EPO also had a successful partnership with the Keystone Oaks High School in Pittsburgh, PA. SWAS data were given directly to the students, which resulted in numerous awards and two scientific publications. Self-contained high school level classroom materials related to SWAS have been created by scientists and are available at the SWAS EPO website.

❖EPO site: *http://cfa-www.harvard.edu/swas/*

Seeing and Exploring the Universe

Stars form when a giant cloud of dust and gas collapses. As it shrinks, the interior heats up. That heat escapes the cloud as infrared, submillimeter and radio waves, and as it cools it can collapse further to form stars. By observing these star-forming clouds in radio wavelengths, SWAS can determine the chemical content of the clouds and the detailed mechanisms by which they cool. As a complete radio observatory in space, SWAS has a front-row seat to phenomena invisible from the ground.

SWAS Energy Range



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

SWIFT

http://swift.gsfc.nasa.gov/

Expected Launch:
September 2003

Swift

Kit Item

Spin-A-Spectrum teacher's guide

Mission

Swift will detect and accurately position gamma-ray bursts -- the most energetic events seen in today's Universe. The satellite will carry a complement of three co-aligned detectors that will enable scientists to detect and get accurate positions for these mysterious gamma-ray bursts, which disappear within seconds, never to appear in the same spot again. A "swift" response is therefore the only way to track down these elusive bursts, hundreds of which will be observed. When a burst is not being monitored, Swift will conduct the most sensitive gamma-ray survey of the sky ever made, leading to the expected discovery of hundreds of super-massive black holes at the cores of distant galaxies. Swift is an international collaboration between NASA and space agencies in the U.K., Italy and France.

Education and Public Outreach Program

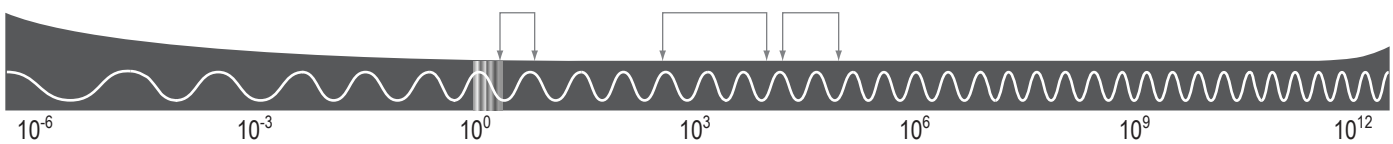
The goal of the Swift EPO program is to use the observations and scientific discoveries of the Swift mission to improve the understanding and utilization of science and mathematics concepts for grades 7-12. There are four major components within the Swift EPO program which combine synergistically: web-based materials, printed curriculum materials - a GEMS guide and more, "What's In The News?" public television broadcasts, and educator training, including Swift workshops and conferences.

❖EPO site: *http://swift.gsfc.nasa.gov/epo/*

Seeing and Exploring the Universe

Every day there is a bright flash of gamma rays from a random point on the sky that can last from a few milliseconds to a few minutes, and then is never seen again. These events are among the most puzzling and intriguing astronomical phenomena found in modern times. Only recently have we begun to understand in some small part the true nature of these incredibly energetic events. The time has come for us to fully reveal their nature, and to use them as a unique probe into our Universe and into the physics of matter and energy. Swift is a mission dedicated to unraveling the mystery of cosmic gamma-ray bursts.

Swift Energy Ranges



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

Launched:
December 10, 1999

XMM-NEWTON

http://xmm.vilspa.esa.es/

X-ray Multi-Mirror-Newton Mission

Kit Item
Bookmark with multi-wavelength views of the Universe

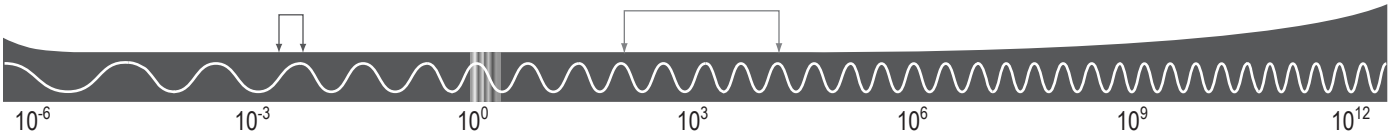
Mission
The XMM-Newton satellite - named for both its X-ray Multi-Mirror design and after Isaac Newton - investigates the violent processes of the Universe. It takes images and spectrographic measurements of very hot celestial objects. The resulting elemental makeup of these objects provides information about the processes that stars and galaxies go through during their lifetimes. XMM-Newton is an European Space Agency mission with NASA instrumentation and support.

Education and Public Outreach Program
Our program is designed to inform the public and the education community about XMM-Newton and resulting discoveries. Elements include: educational materials aimed at secondary science classrooms, extended educator workshops held during the summer, educator workshops at regional and national science teacher meetings, a web site aimed at the non-scientist and educator, (which contains information about the mission, X-ray astronomy, and discoveries resulting from XMM-Newton data), and classroom visits from XMM-Newton team members.

❖EPO sites: *http://heasarc.gsfc.nasa.gov/docs/xmm_lc/index.html* and *http://outreach.ucsb.edu/xmm/*

Seeing and Exploring the Universe
XMM-Newton observes a multi-wavelength Universe with instruments including optical, ultraviolet, and X-ray telescopes, and is now returning impressive scientific results. XMM-Newton has observed the farthest quasar ever detected, uncovered mysteries in the vicinity of massive black holes, and revealed the details of supernova remnant X-ray emission.

XMM-Newton Energy Ranges



Electromagnetic energy spectrum in units of electron-Volts (logarithmic scale)

CREDITS AND ACKNOWLEDGMENTS

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Seeing & Exploring the Universe Educator Resources Kit

EDUCATOR REPLY CARD

To achieve America's goals in educational excellence, it is NASA's mission to develop supplementary instructional materials and curricula in science, mathematics and technology. NASA seeks to involve the educational community in the development and improvement of these materials. Your evaluation and suggestions are vital to continually improving NASA educational materials.

Please take a moment to respond to the statements and questions below. You can submit your responses through the Internet or mail. Send your reply to the following Internet address:

http://mo-www.harvard.edu/Forum/seukitfeedback.html

You will then be asked to enter your data at the appropriate prompt.

Otherwise, please return the card by mail. Thank you.

1. With what grades did you use the Seeing/Exploring the Universe kit?
Number of Teachers/Faculty:
_____ K-4 _____ 5-8 _____ 9-12 _____ Community College
College/University- _____ Undergraduate _____ Graduate

Number of Students:
_____ K-4 _____ 5-8 _____ 9-12 _____ Community College
College/University- _____ Undergraduate _____ Graduate

Number of Others:
___ Administrators/Staff ___ Parents ___ Professional Groups
___ General Public ___ Civic Groups ___ Other

2. What is your home 5- or 9-digit zip code? __ __ __ __ __ - __ __ __ __

3. This is a valuable resource for educators.

❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

4. I expect to apply what I learned in this Seeing/Exploring the Universe kit.

❑ Strongly Agree ❑ Agree ❑ Neutral ❑ Disagree ❑ Strongly Disagree

5. What kind of recommendation would you make to someone who asks about the Seeing/Exploring the Universe (SEU) kit?

❑ Excellent ❑ Good ❑ Average ❑ Poor ❑ Very Poor

6. How did you use this SEU kit?

❑ Background Information
❑ Demonstrate NASA Materials
❑ Group Discussions
❑ Integration Into Existing Curricula
❑ Lecture
❑ Team Activities
❑ Critical Thinking Tasks
❑ Demonstration
❑ Hands-On Activities
❑ Interdisciplinary Activity
❑ Science and Mathematics
❑ Standards Integration
Other: Please specify:_____

7. Rate the following items from the SEU kit according to their educati usefulness-H(igh) M(edium) or L(ow) (leave blank if you did not use):

____ Seeing and Exploring the Universe resource guide booklet
____ Anatomy of a Black Hole poster with information and activity booklet
____ Imagine the Universe! CD
____ Exploring the Extreme Universe CD
____ Chandra CD and other Chandra materials
____ CHIPS Local Bubble activity
____ GLAST Active Galaxies poster
____ Gravity Probe B brochure
____ MAP fact sheet
____ Multi-wavelength Milky Way poster
____ Swift Spin-a-Spectrum teacher's guide
____ XMM-Newton bookmark
____ Other: Please specify:

8. What features of this educator kit did you find particularly helpful?
_____
_____

9. How can we make this educator kit more effective for you?
_____
_____

10. Additional comments:
_____
_____

Today's Date:_____

SEU Kit Feedback
Universe! Education Forum
Harvard-Smithsonian Center for Astrophysics
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Cambridge, MA 02138

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