CHANDRA
X-RAY OBSERVATORY CENTER

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SCIENCE FACT SHEET
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Chandra X-ray Observatory

Observing the High Energy Universe

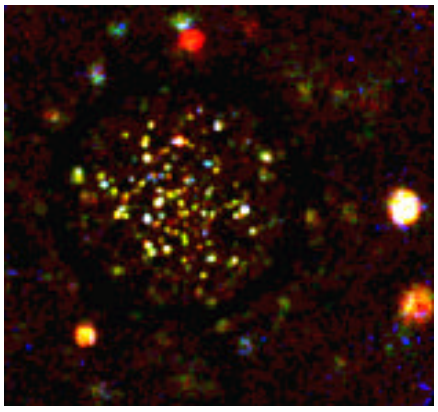
X-rays are a high energy, invisible form of light. They are produced in the cosmos when gas is heated to millions of degrees by violent and extreme conditions. Much of the matter in the universe is so hot that it can be observed only with X-ray telescopes. Flaring stars, exploding stars, black holes, and vast clouds of hot gas in galaxy clusters are among the fascinating objects that the Chandra X-ray Observatory is designed to study.

Images from Chandra will show fifty times more detail than any previous X-ray telescope. It is a revolutionary telescope that combines the ability to make sharp images while it measures precisely the energies of X-rays coming from cosmic sources.

Stars, Supernovae & Life

How will Chandra images of young stars help scientists better understand the evolution of life on Earth?

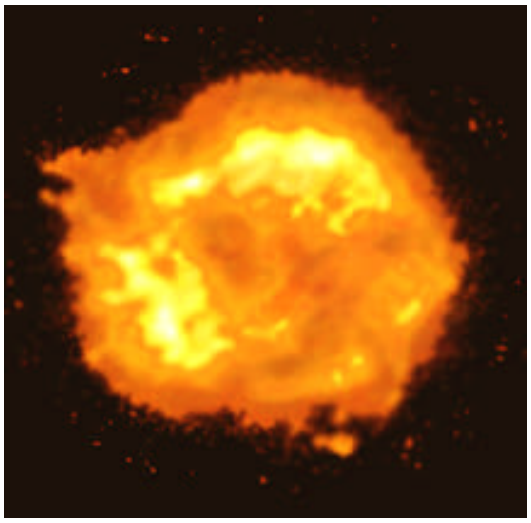
On occasion, a spectacular eruption occurs in the upper atmosphere of the sun. These eruptions, called solar flares, shower Earth's atmosphere with X-rays and high energy particles. The long term effects of solar flares on the climate and on life on Earth is not well understood. By observing X-rays from hundreds of other stars, especially young stars which flare much more often than the sun, astrophysicists hope to get a better idea of what conditions were like on Earth when the sun was young.



Rosat X-ray image of NGC 2516, a cluster of young stars. (NASA)

What can X-ray spectra reveal about the origin of heavy elements that are necessary for life?

Heavy elements such as carbon, nitrogen, oxygen and iron are made deep in the interior of massive stars. They are eventually spread throughout space when a massive star undergoes a catastrophic explosion called a supernova.



Rosat X-ray image of Cassiopeia A, a remnant of a star that exploded about 300 years ago. (NASA)

In our galaxy a supernova occurs about every fifty years. The shell of matter thrown off by the supernova creates a bubble of multimillion degree gas called a supernova remnant. This hot gas will expand and produce X-radiation for thousands of years. Chandra X-ray Observatory images will trace the dynamics of the expanding remnant. When heavy elements present in the hot gas are heated to high temperatures, they produce X-rays of specific energies. Chandra detectors will precisely measure the energies of these X-rays and tell how much of each element is present.

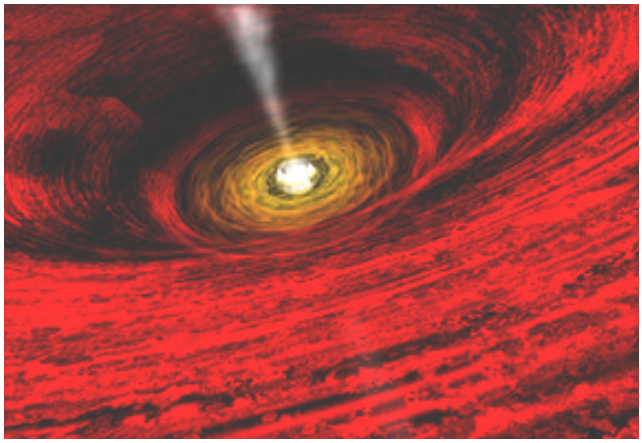
Black Holes & Quasars

How can an X-ray telescope provide new information about the warping of space around black holes?

Some of the most intense X-ray sources in the universe are caused by super-hot gas that is swirling toward a black hole. As the tremendous gravity of a black hole pulls gas and dust particles toward it, the particles speed up and form a rapidly rotating flattened disk. Friction caused by collisions between the particles heats them to extreme temperatures. Just before they pass beyond the event horizon of the black hole, the particles produce X-rays as their temperatures rise to many millions of degrees. By precisely determining the energy of individual X-rays, the Chandra X-ray Observatory can measure the motion of particles near black holes. This information will allow scientists to test theories about the gravity fields around black holes.

Can X-ray observations of quasars detect the spectral signatures of supermassive black holes?

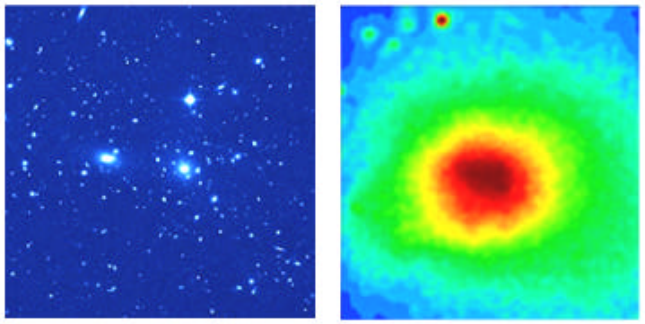
Astrophysicists have proposed that supermassive black holes may explain the mysterious and powerful objects called quasars. These objects radiate as much energy per second as a thousand normal galaxies from a region having a diameter less than a millionth of the size of one galaxy. Because the matter closest to the event horizon of a black hole radiates most of its energy as X-rays and gamma rays, the Chandra X-ray Observatory will present an unequaled view into the inner workings of these violent cosmic whirlpools.



Artist's rendition of the violent whirlpool of hot gas and high energy jets near a supermassive black hole. (SAO)

Clusters of Galaxies & Dark Matter

If much of the matter in the universe is so hot that it can be observed only with an X-ray telescope, where can large quantities of multimillion degree gas be found?



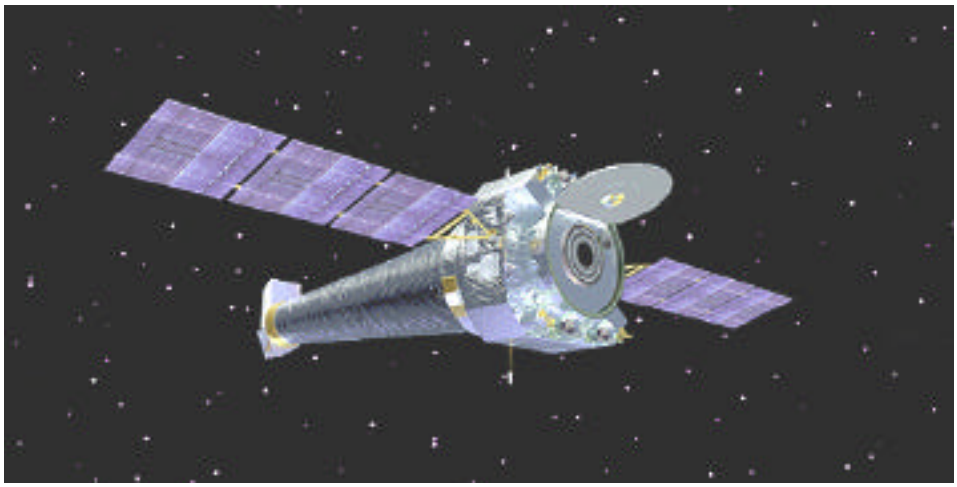
The UK Schmidt optical image (left) of the Coma cluster shows light from thousands of galaxies, whereas the Rosat X-ray image (right) reveals a massive cloud of 80 million degree gas.

More than half of all galaxies in the universe are members of groups of galaxies or larger collections of galaxies, called clusters. X-ray observations have shown that most clusters of galaxies are filled with vast clouds of multimillion degree gas. The mass of this gas is greater than all the stars in all the galaxies in a cluster of a thousand galaxies.

Can Chandra shed some light on the dark matter mystery?

The X-ray producing hot gas found in a typical cluster of galaxies also presents astronomers with a grand puzzle. Over time this extremely hot gas should escape the cluster since the galaxies and gas do not provide enough gravity to hold it in. Yet in clusters of all ages the gas remains. Scientists have concluded that some unobserved form of matter, called dark matter, is providing the extra gravity needed to hold the hot gas in the cluster. An enormous amount of dark matter is needed — about three to ten times as much matter as that observed in the gas and galaxies.

This means that most of the matter in the universe may be dark matter! The dark matter could be collapsed stars, planets or black holes. Or strange subatomic particles that produce no light, and can only be detected through their gravity. Detailed measurements of the size and temperature of the hot gas clouds in galaxy clusters by Chandra could help solve the dark matter mystery.



The Chandra X-ray Observatory Spacecraft (TRW, Inc.)

How will observations of hot gas in clusters help to determine which theories of the origin and evolution of the universe are correct?

The giant galaxy clusters have been assembled through the collision and merger of smaller groups and clusters over billions of years. The speed at which this process occurs differs greatly, depending on the theory that is adopted. Observations of the numbers and sizes of clusters at great distances, corresponding to early times in the evolution of the universe, should rule out some of the competing theories for the origin and evolution of the universe.

Operations

The Chandra X-ray Observatory Center (CXC) is operated by the Smithsonian Astrophysical Observatory in Cambridge, Mass. The CXC, with a staff of over one hundred fifty people will control science and flight operations of Chandra for NASA at two facilities. The operation and control facility in Kendall Square is electronically linked to the science support facility at the Harvard-Smithsonian Center for Astrophysics.

The CXC operations control group is responsible for directing the observatory's mission as it orbits Earth. The staff will interact with the observatory three times a day to acquire science and housekeeping information from its recorders. They will also send new instructions to the observatory as needed, and relay scientific information from the X-ray observatory to the CXC science support group.

The CXC science support group is an important resource for scientists and the public. They provide user support to researchers, including science data processing and a science data archive, and they work with NASA and the scientific community to inform the public of discoveries made by scientists using the observatory.

NASA and Partners

The Chandra X-ray Observatory program is managed by the Marshall Space Flight Center for the Office of Space Science, NASA Headquarters, Washington, D.C. TRW Space and Electronics Group of Redondo Beach, Calif., is the prime contractor and has assembled and tested the observatory for NASA. Using glass purchased from Schott Glaswerke, Mainz, Germany, the telescope's mirrors were built by Raytheon Optical Systems Inc., Danbury, Conn. The mirrors were coated by Optical Coating Laboratory, Inc., Santa Rosa, Calif., and assembled by Eastman Kodak Co., Rochester, N.Y.

The CCD Imaging Spectrometer was developed by Pennsylvania State University, University Park, Pa., and the Massachusetts Institute of Technology (MIT), Cambridge. The High Resolution Camera was built by the Smithsonian Astrophysical Observatory. One diffraction grating was developed by MIT, the other by the Space Research Organization Netherlands, Utrecht, Netherlands, in collaboration with the Max Planck Institute, Garching, Germany. The Ball Aerospace & Technologies Corporation of Boulder, Colo., developed the aspect camera and the Science Instrument Module.

Portrayal of Shuttle Columbia deploying Chandra. (TRW, Inc.)

Top Ten Amazing Facts About Chandra

 # 1 Chandra will fly 200 times higher than Hubble - more than 1/3 of the way to the moon!
 # 2 Chandra will be observing X-rays from clouds of gas so vast that it takes light five million years to go from one side to the other!
 # 3 During maneuvers from one target to the next, Chandra slews more slowly than the minute hand on a clock.
 # 4 At 45 feet long, Chandra is the largest satellite the shuttle has ever launched.
 # 5 If Colorado were as smooth as Chandra's mirrors, Pikes Peak would be less than one inch tall!
 # 6 Chandra's resolving power is equivalent to the ability to read a stop sign at a distance of twelve miles.
 # 7 The electrical power required to operate the Chandra spacecraft and instruments is 2 kilowatts, about the same power as a hair dryer.
 # 8 The light from some of the quasars observed by Chandra will have been traveling through space for ten billion years.
 # 9 STS-93, the space mission that will deploy Chandra, is the first NASA shuttle mission commanded by a woman.
 # 10 Chandra can observe x-rays from particles up to the last second before they fall into a black hole!!!

STS-93 Mission Patch (NASA)

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