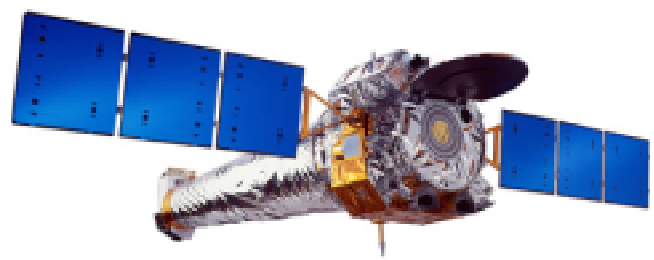
CXC Deep Field Press Kit

CHANDRA X-RAY OBSERVATORY



The Chandra X-ray Observatory is the third in NASA's family of Great Observatories that includes the Hubble Space Telescope and the Compton Gamma Ray Observatory. NASA's Marshall Space Flight Center manages the Chandra program. TRW is the prime contractor for the spacecraft. Key subcontractors include Ball Aerospace & Technologies, Inc., Eastman Kodak Company, and Raytheon Optical Systems, Inc. The scientific instruments were built by teams from MIT, Pennsylvania State University, the Smithsonian Astrophysical Observatory, the Laboratory for Space Research in the Netherlands, and the Max Planck Institute in Germany. The Smithsonian's Chandra X-ray Center controls science and flight operations from Cambridge, MA

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Deepest X-Rays Ever Reveal Universe Teeming With Black Holes

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For the first time, astronomers believe they have proof black holes of all sizes once ruled the universe. NASA's Chandra X-ray Observatory provided the deepest X-ray images ever recorded, and those pictures deliver a novel look at the past 12 billion years of black holes.

Two independent teams of astronomers today presented images that contain the faintest X-ray sources ever detected, which include an abundance of active super-massive black holes.

"The Chandra data show us that giant black holes were much more active in the past than at present," said Riccardo Giacconi, of Johns Hopkins University and Associated Universities, Inc., Washington, DC. The exposure is known as "Chandra Deep Field South" since it is located in the Southern Hemisphere constellation of Fornax. "In this million-second image, we also detect relatively faint X-ray emission from galaxies, groups, and clusters of galaxies".

The images, known as Chandra Deep Fields, were obtained during many long exposures over the course of more than a year. Data from the Chandra Deep Field South will be placed in a public archive for scientists beginning today.

"For the first time, we are able to use X-rays to look back to a time when normal galaxies were several billion years younger," said Ann Hornschemeier, Pennsylvania State University, University Park. The group's 500,000-second exposure included the Hubble Deep Field North, allowing scientists the opportunity to combine the power of Chandra and the Hubble Space Telescope, two of NASA's Great Observatories. The Penn State team recently acquired an additional 500,000 seconds of data, creating another one-million-second Chandra Deep Field, located in the constellation of Ursa Major.

The images are called Chandra Deep Fields because they are comparable to the famous Hubble Deep Field in being able to see further and fainter objects than any image of the universe taken at X-ray wavelengths. Both Chandra Deep Fields are comparable in observation time to the Hubble Deep Fields, but cover a much larger area of the sky.

"In essence, it is like seeing galaxies similar to our own Milky Way at much earlier times in their lives," Hornschemeier added. "These data will help scientists better understand star formation and how stellar-sized black holes evolve." Combining infrared and X-ray observations, the Penn State team also found veils of dust and gas are common around young black holes.

Another discovery to emerge from the Chandra Deep Field South is the detection of an extremely distant X-ray quasar, shrouded in gas and dust. "The discovery of this object, some 12 billion light years away, is key to understanding how dense clouds of gas form galaxies, with massive black holes at their centers," said Colin Norman of Johns Hopkins University.

The Chandra Deep Field South results were complemented by the extensive use of deep optical observations supplied by the Very Large Telescope of the European Southern Observatory in Garching, Germany. The Penn State team obtained optical spectroscopy and imaging using the Hobby-Eberly Telescope in Ft. Davis, TX, and the Keck Observatory atop Mauna Kea, HI.

Chandra's Advanced CCD Imaging Spectrometer was developed for NASA by Penn State and Massachusetts Institute of Technology under the leadership of Penn State Professor Gordon Garmire. NASA's Marshall Space Flight Center, Huntsville, AL, manages the Chandra program for the Office of Space Science, Washington, DC. The Smithsonian's Chandra X-ray Center controls science and flight operations from Cambridge, MA. More information is available on the Internet at:

http://chandra.harvard.edu

AND

http://chandra.nasa.gov

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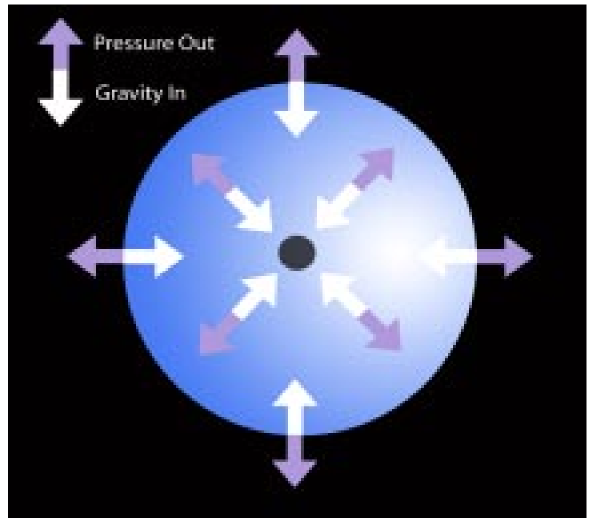
MORE ABOUT BLACK HOLES

When a star runs out of nuclear fuel, it will collapse. If the core, or central region of the star, has a mass that is greater than three suns, no known nuclear forces can prevent the core from forming a black hole. Anything that comes within a certain distance of the black hole, called the event horizon, cannot escape, not even light. The radius of the event horizon (proportional to the mass) is very small, only 30 kilometers for a non-spinning black hole with the mass of ten suns.



Since a black hole cannot be directly observed, astronomers must use circumstantial evidence to prove its existence. The bottom line is that the observations must imply that a sufficiently large amount of matter is compressed into a sufficiently small region of space so that no other explanation is possible.

How can black holes be located? X-ray observations are extremely useful for finding black holes. The extreme gravity around black holes will produce X-rays when infalling gas is heated to millions of degrees. The best places to look for black holes are regions where large supplies of gas are available, such as double star systems, star forming regions, or the centers of galaxies.

Have different types of black holes been discovered? There is strong evidence for two types of black holes: stellar black holes with masses of a dozen or so suns, and supermassive black holes with masses of many millions of suns. Stellar black holes are formed as a natural consequence of the evolution of massive stars (see 1st paragraph). The origin of supermassive black holes is a mystery. They are found only in the centers of galaxies. It is not known whether they formed in the initial collapse of the gas cloud that formed the galaxy, or from the gradual growth of a stellar mass black hole, or from the merger of a centrally located cluster of black holes, or by some other mechanism.

How do astronomers determine the mass of black holes? The mass of a stellar black hole can be deduced by observing the orbital acceleration of a star as it orbits its unseen companion. Likewise, the mass of a supermassive black hole can be determined by using the orbital acceleration of gas clouds swirling around the central black hole. When orbital acceleration cannot be used to establish the mass of a black hole, astronomers can place a lower limit on its mass by measuring the X-ray luminosity due to matter falling into a black hole. The radiation pressure of the X-rays must be less than the pull of the black hole's gravity. In the case of the black hole discovered in M82, this limits its mass to greater than 500 suns. The M82 black hole is much larger than known stellar black holes, and much smaller than supermassive black holes, thus it is called a "mid-mass" black hole.

What is the significance of a third type of black hole? Astrophysicists had come to believe that galactic centers were the only places where conditions were right for the formation and growth of large or very large black holes. The discovery of a large, mid-mass black hole away from the galaxy's center shows that somehow -- and it is not an easy task theoretically – black holes much more massive than ordinary stellar black holes can form in dense star clusters. Current possible explanations for the formation of mid-mass black holes includes such exotica as black hole mergers or the collapse of a hyperstar. An intriguing implication is that mid-mass black holes could prove to be a common feature in star forming regions of galaxies.

Dr. Alan Bunner
Science Program Director, NASA

Dr. Alan Bunner is currently the Science Program Director (Structure & Evolution of the Universe) at NASA Headquarters in Washington, DC. As a member of the Office of Space Science (OSS) Board of Directors, he has responsibility for the science discipline areas of high energy astrophysics, extreme ultraviolet astronomy, submillimeter and radio astronomy, relativistic astrophysics, and general relativity.

Dr. Bunner received his B.A. in Mathematics and Physics from the University of Toronto in 1960 and his Ph.D. in Physics from Cornell University in 1967.

Dr. Riccardo Giacconi
President of Associated Universities, Inc. and Research Professor at Johns Hopkins University

Riccardo Giacconi is an astronomer with a long history and expertise in deep surveys. Giacconi was the principal investigator (PI) of the program which discovered the first X-ray stars and the X-ray background in the 1960s and conceived of and led the implementation of the Uhuru and Einstein X-ray Observatories in the 1970s. He is the PI for the ultradeep survey with Chandra -- the "Chandra Deep Field South" -- that has already obtained the deepest X-ray exposures to date with a million-second observation. He is also participating in the follow-up optical work in this field with HST and VLT. He is an expert in the analysis and interpretation of astronomical data.

Dr. Giaconni has held chairs at Harvard University, Milano University, and Johns Hopkins University. He has held positions as Associate Director for High Energy Astrophysics at the Harvard-Smithsonian Center for Astrophysics, first Director of the Space Telescope Science Institute, and Director General of the European Southern Observatory. He is currently President of Associated Universities, Inc., and a Research Professor at Johns Hopkins University.

Ann Hornschemeier
Ph.D. student in Astronomy and Astrophysics at Penn State

Ann Hornschemeier is a 4th year Ph.D. student in Astronomy and Astrophysics at Penn State. She completed her Master's degree in 1999, the topic of which was a 1998 sounding rocket mission to observe Scorpius X-1, the brightest extrasolar X-ray source in the sky. For the past two years, she has been working with Gordon Garmire (PI for ACIS, one of the major instruments on the Chandra X-ray Observatory) and Niel Brandt of Penn State on a very deep Chandra X-ray observation of the Hubble Deep Field-North (HDF-N), one of the most intensively studied patches of sky at all wavelengths.

Ann is a NASA GSRP graduate fellow and a NASA Pennsylvania Space Grant fellow. Ann's main research focus is X-ray astronomy, but she also observes in the optical band. Her current research relies heavily on optical spectroscopy done with the Keck and Hobby-Eberly telescopes. She is also currently working on exciting new prospects for studying "normal" galaxies in the X-ray band at much larger distances than was possible before Chandra.

Dr. Colin Norman
Physics and Astronomy at The Johns Hopkins University and Astronomer at the Space Telescope Science Institute

Colin Norman is Professor of Physics and Astronomy at The Johns Hopkins University and Astronomer at the Space Telescope Science Institute. He works on both theoretical and observational astrophysics in areas including: the formation, structure, and evolution of galaxies; the physics of active galaxies, quasars, and starburst galaxies; the structure of the intergalactic medium and the interstellar medium; and, star formation.

He was an undergraduate at the University of Melbourne, Australia, a graduate student in Theoretical Physics at Oxford as a Rhodes Scholar, and then elected as a Fellow of Magdalen College, Oxford. After his postdoctoral work at UC Berkeley as a Miller Fellow, Dr. Norman joined the faculty at Leiden University as an Assistant Professor in 1978. In the next 6 years he held, in addition, appointments at the Institute of Astronomy, Cambridge, the University of Paris and the European Southern Observatory. In 1984, he moved to his current post in Baltimore. From 1988 through 1994 he was Head of the Academic Affairs Division at the Space Telescope Science Institute. He frequently visits the European Southern Observatory where the optical work for this project was done using the 8-meter telescope at the VLT. He is currently proposing to create a new Astrophysics Institute at the Johns Hopkins University.

Dr. Bruce Margon
Professor of Astronomy, and Adjunct Professor of Physics, at the University of Washington

Bruce Margon is Professor of Astronomy, and Adjunct Professor of Physics, at the University of Washington, and previously served as Chairman of the UW Astronomy Department for 11 years. He received his undergraduate degree in astrophysics at Columbia University, and M.A. and Ph.D. degrees in astronomy from University of California, Berkeley. He held positions at the University of California, Berkeley, and Los Angeles, prior to joining the University of Washington faculty in 1980. Dr. Margon has been the recipient of the Newton Lacy Pierce Prize of the American Astronomical Society as well as being elected as a Fellow of the American Association for the Advancement of Science and of the American Physical Society. Dr. Margon's research interests include X-ray and ultraviolet astronomy, the late stages of stellar evolution, and quasi-stellar objects.

Dr. Margon is a Co-Investigator on the Hubble Space Telescope project, serving as a member of a team that designed and built one of the telescope's light sensing instruments, the Faint Object Spectrograph. He has chaired the Board of Directors of the Association of Universities for Research in Astronomy, Inc. (AURA) and the Astrophysical Research Consortium, Inc. (ARC) as well as serving as the Scientific Director of the Sloan Digital Sky Survey. Professor Margon is the author of more than one hundred seventy research papers in professional journals, and also a frequent contributor on astronomical topics to the popular press, including Scientific American and Sky and Telescope.

CHANDRA DEEP FIELD NORTH

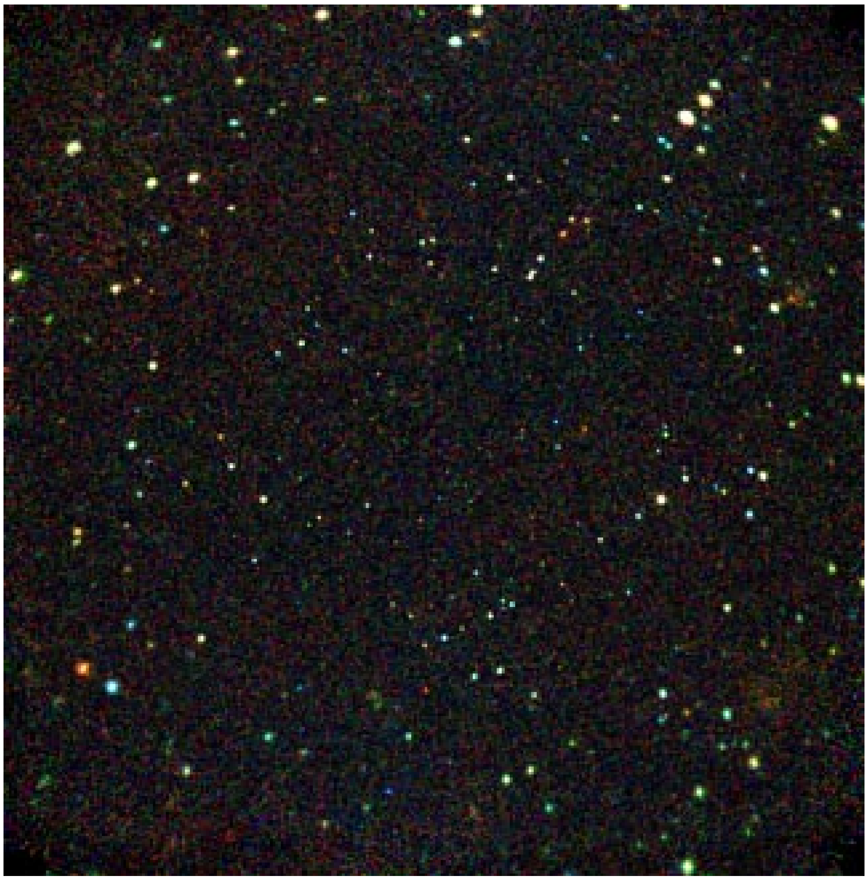
Chandra Deep Field North: A 500,000 second image of an area in the sky known as the Hubble Deep Field North.
(Credit: NASA/PSU/G.Garmire, N.Brandt et al.)

Caption: Chandra's extremely deep image provides a crucial view of one of the most intensively studied patches of the night sky – the Hubble Deep Field North. This area has been examined at all wavelengths, from radio through optical and now X-ray. About half the X-ray sources in this image are due to matter falling into supermassive black holes in the centers of active galaxies and quasars. Other sources include galaxies that are much like our own Milky Way galaxy, but several billion years younger. The X-rays are color coded with shades of red representing lower energies and blue representing the highest energies.

Scale: Images are 2.5 arcmin on a side.

Chandra X-Ray Observatory ACIS Image

CHANDRA DEEP FIELD SOUTH



Chandra Deep Field South: A one-million second image located in the constellation Fornax.
(Credit: NASA/JHU/AUI/R.Giacconi et al.)

Caption: This Chandra image shows that gigantic black holes were much more active in the past than the present. In this deepest X-ray exposure ever made, some of the sources are 12 billion light years away. Most of the objects are active galaxies and quasars powered by supermassive black holes, while other objects are galaxies, and groups and clusters of galaxies. Information from this image will help astronomers understand how dense clouds of gas form galaxies with massive black holes at their centers. The energy bands of the X-rays are color coded, with red representing lower energies, yellow intermediate, and blue the highest energies.

Scale: Image is 16 arcmin on a side.

Chandra X-Ray Observatory ACIS Image