Through the Eyes of Chandra

Chandra X-ray image of the innermost 10 light years at the center of our galaxy. The image has been smoothed to bring out the X-ray emission from an extended cloud of hot gas surrounding the supermassive black hole candidate Sagittarius A* (white dot at the center of the image). This gas glows in X-ray light because it has been heated to a temperature of millions of degrees by shock waves produced by supernova explosions and perhaps by colliding winds from young massive stars. The images were captured by the Chandra Observatory (above).

Dark Energy, Black Holes and Exploding Stars: NASA's Chandra Observatory Continues to Achieve Scientific Firsts

In August 1999, NASA's Chandra X-ray Observatory opened for business. More than six years later, one of the Tennessee Valley's greatest engineering marvels continues to achieve scientific firsts.

"When Chandra opened its sunshade doors for the first time, it opened the possibility of studying the X-ray emission of the universe with unprecedented clarity," says Chandra project scientist Dr. Martin Weisskopf of NASA's Marshall Space Flight Center in Huntsville.

Already surpassing its goal of a five-year life, says Weisskopf, "today Chandra continues to rewrite textbooks with discoveries about our own solar system and images of celestial objects as far as billions of light years away."

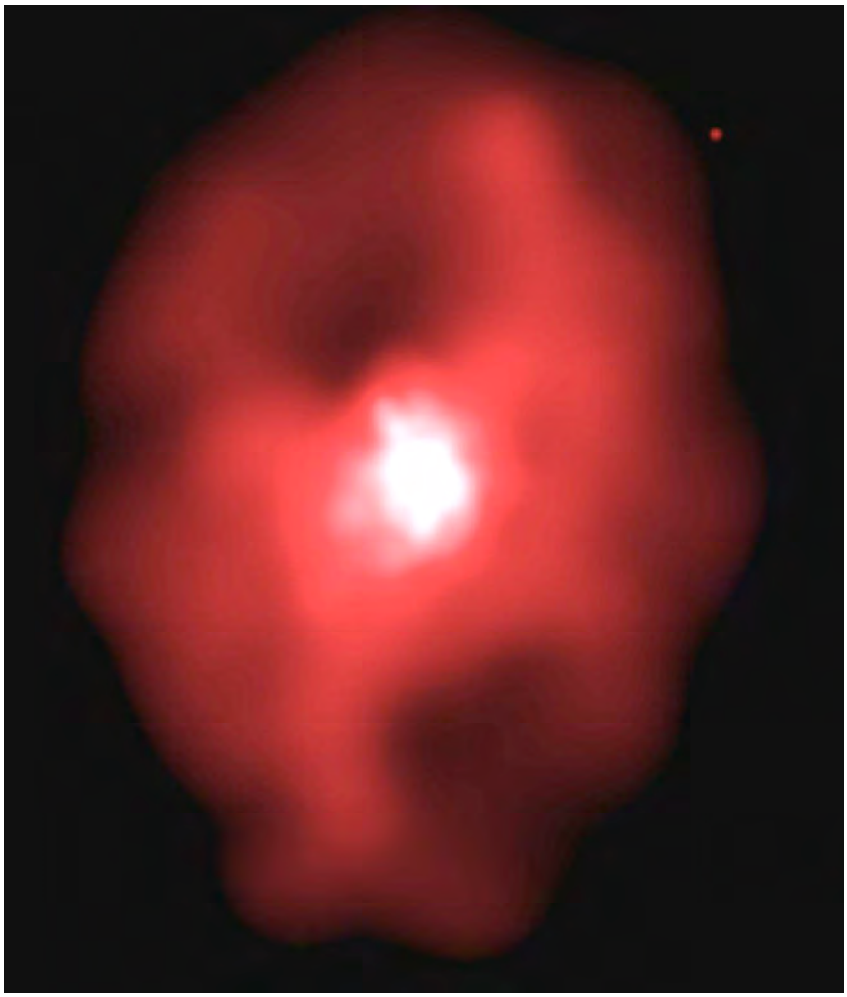
In the shadows of the Appalachian foothills, the Marshall Space Flight Center has

developed, integrated and operated some of the world's most complex scientific space systems, building on its initial claim to fame — developing the massive Saturn V rocket that in the 1960s sent the first humans to the moon.

Other accomplishments include developing NASA's Hubble Space Telescope and contributing to the construction of the International Space Station. And, as the developer of the Chandra Observatory, Marshall continues to use its expertise and capabilities to create spacecraft and instruments to operate in the harsh environment of space. Such capabilities, developed during decades of engineering and scientific research, are key to supporting the Vision for Space Exploration, which calls for human and robotic missions to the moon, Mars and beyond.

"Humans cannot see X-rays, but Chandra can," says Weisskopf. "And what the observatory has revealed has been nothing short of amazing. Thanks to Chandra, we've gleaned new information on dark energy, black holes, exploding stars and all other categories of astronomical objects, leading to a better understanding of the composition and evolution of the universe."

Based on the Chandra observatory's outstanding results, NASA Headquarters in Washington decided in 2001 to extend Chandra's mission from its original five years. During the observatory's sixth year of operation, aurorae from Jupiter, X-rays from Saturn, and the early days of our solar system were the focus of Chandra discoveries close to home — discoveries with the potential to better understand the dynamics of life on Earth.

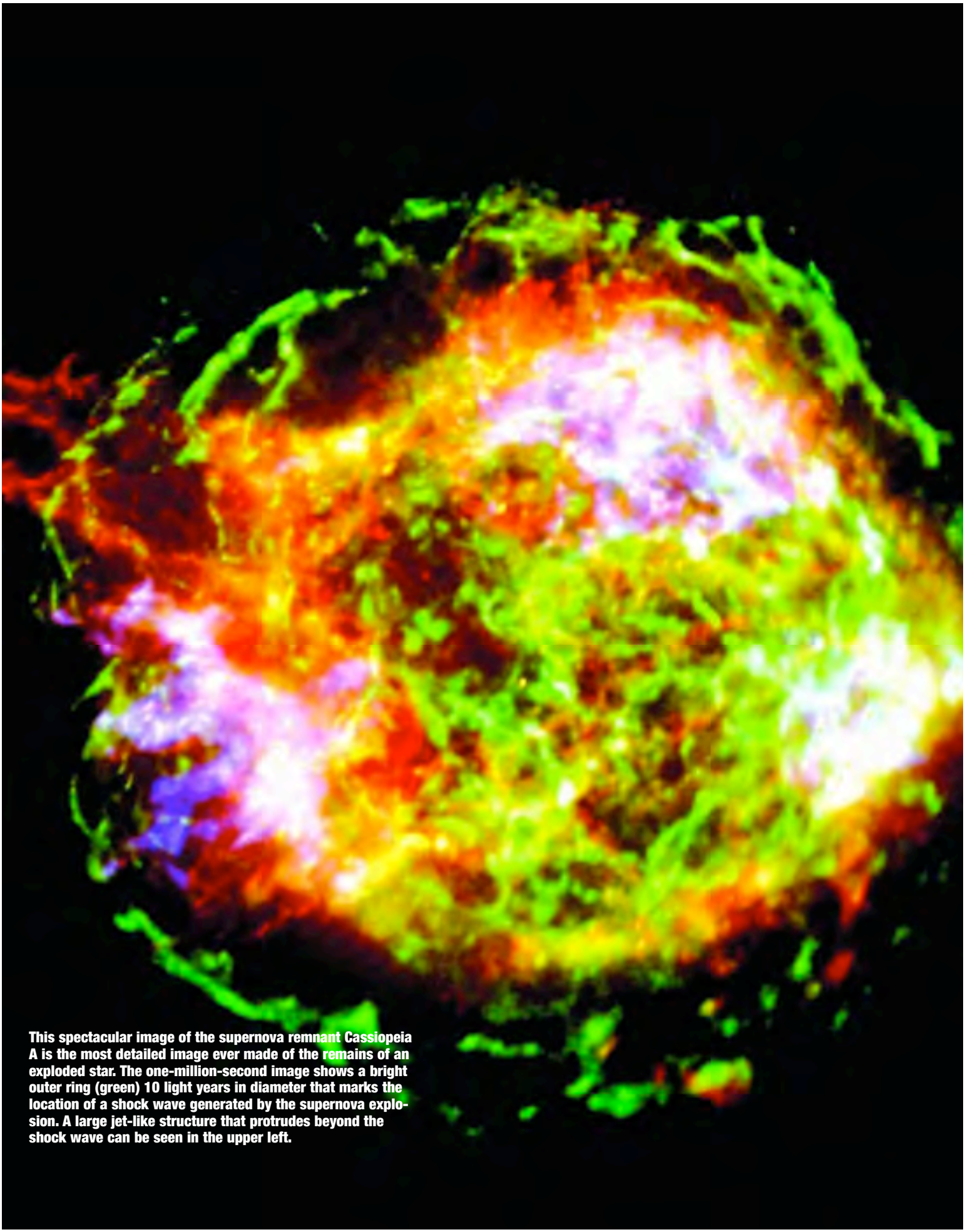


This Chandra image shows two vast cavities — each 600,000 light years in diameter — in the hot, X-ray emitting gas that pervades the galaxy cluster MS 0735. Though the cavities contain very little hot gas, they are filled with a two-sided, elongated, magnetized bubble of extremely high-energy electrons that emit radio waves.

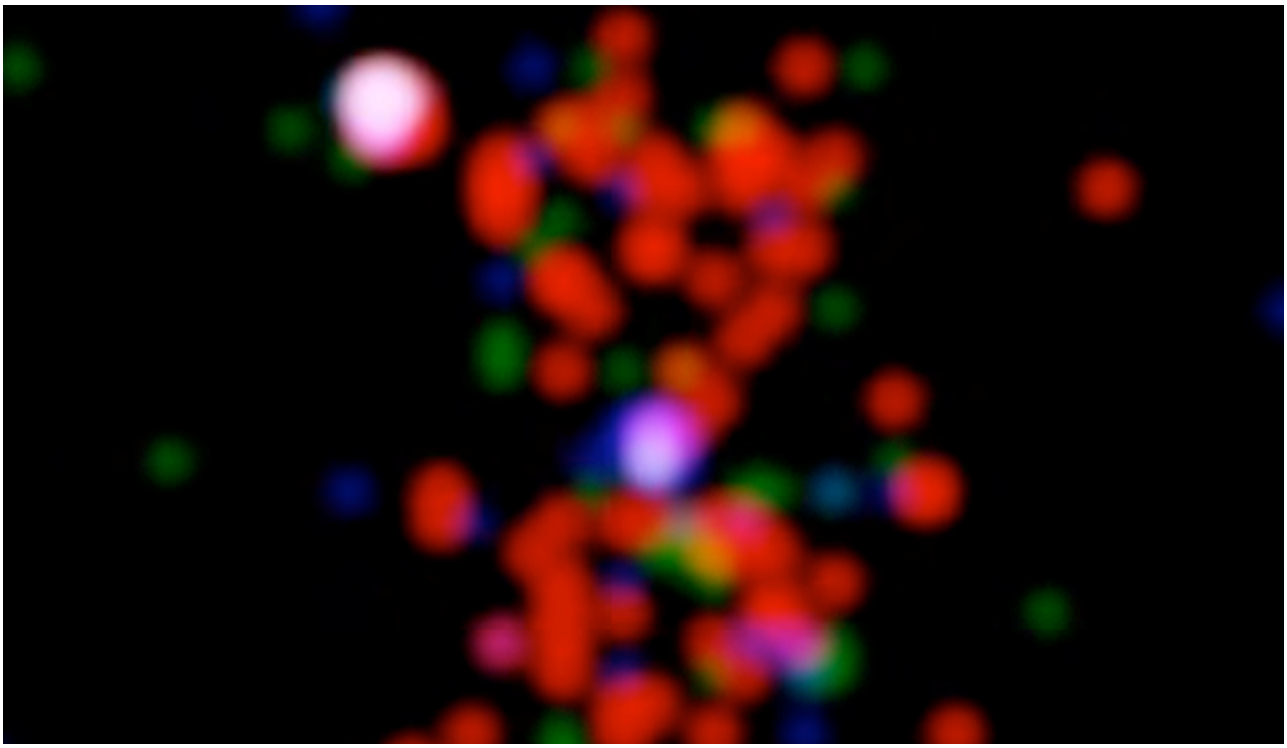
NASA experts say Jupiter's auroras are the most spectacular and active auroras in the solar system. Extended Chandra observations revealed that the planet's auroral X-rays are caused by highly charged particles crashing into the atmosphere above Jupiter's poles. These results gave scientists the information needed to compare Jupiter's auroras with those from Earth, and determine if they are triggered by different cosmic and planetary events.

Mysterious X-rays from Saturn also received attention, as Chandra completed the first observation of a solar X-ray flare reflected from Saturn's low-latitudes, the region that correlates to Earth's equator and tropics. This observation led scientists to conclude the ringed planet may act as a mirror, reflecting explosive activity from the sun. The results imply scientists could use giant planets like Saturn as remote-sensing tools to help monitor X-ray flaring on portions of the sun facing away from Earth's space satellites.

Another Chandra discovery — gleaned from the deepest X-ray



This spectacular image of the supernova remnant Cassiopeia A is the most detailed image ever made of the remains of an exploded star. The one-million-second image shows a bright outer ring (green) 10 light years in diameter that marks the location of a shock wave generated by the supernova explosion. A large jet-like structure that protrudes beyond the shock wave can be seen in the upper left.



This Chandra image shows hot gas enveloping the extremely distant galaxy known as 3C294. Astronomers believe this is the most distant cluster of galaxies ever detected in X-rays, capturing it when the universe was only 20 percent of its current age.

observation of any star cluster — offered insights on Earth's survival in its infancy. Chandra's focus was the Orion Nebula, which contains at least 1,400 young stars, 30 that are prototypes of the early sun.

Using Chandra, scientists learned these young stars produce violent X-ray flares much more frequently and energetically than anything seen today from our 4.6 billion-year-old sun. This implies super-flares torched our young solar system and likely affected the planet-forming disk around the early sun, enhancing the survival chances of Earth.

"Space is a harsh environment with extreme temperatures, harmful radiation and none of the protection offered by Earth's atmosphere," says Chandra Program Manager Keith Hefner of the Marshall Center.

"Ironically," Hefner adds, "the fact that our atmosphere absorbs harmful X-rays is the very reason for Chandra's existence. Getting outside the absorbing atmosphere of the Earth requires space-based observatories, and viewing the universe in multiple wavelengths is necessary to fully study cosmic events. Chandra's continued outstanding performance after six years of operation under such harsh conditions is evidence that it is, indeed, an engineering marvel."

The Marshall Center manages the Chandra program for NASA's Science Mission Directorate in Washington. Northrop Grumman of Redondo Beach, Calif., was the prime development contractor for the observatory. The Smithsonian Astrophysical Observatory controls science and flight operations from the Chandra X-ray Center in Cambridge, Mass.

The Marshall Space Flight Center has been a key contributor to significant NASA programs throughout the space agency's 45-plus-year history — from the 1961 flight of the first U.S. astronaut into space, the Apollo missions to the moon, and the development and operation of America's space shuttle fleet.

Marshall's role is that of a systems developer and integrator for exploration and scientific missions. The Center is experienced in transportation systems development and integration; scientific spacecraft and habitable systems development and integration; and scientific research and instrument development and integration. The Marshall Center currently has a significant role in meeting NASA's exploration mission objectives.■