CHANDRA EXPLORES "DOWNTOWN" IN THE MILKY WAY

The word galaxy comes from the Greek word meaning "milky circle" or, more familiarly, "milky way." The white band of light across the night sky that we call the Milky Way was poetically described long before Galileo. But with his small telescope, what he discovered was a multitude of individual stars, "so numerous as almost to surpass belief."

Today we know that the Milky Way is our home galaxy—a vast rotating spiral of gas, dust, and hundreds of billions of stars. The Sun and its planetary system formed in the outer reaches of the Milky Way about 4.5 billion years ago.

In the center of the Galaxy is the bar-shaped Galactic bulge which harbors a supermassive black hole with a mass equal to that of about 3 million suns. Surrounding the central bulge is a relatively thin disk of stars about 2,000 light years thick and roughly 100,000 light years across. Giant clouds of dust and gas in the disk and bulge absorb starlight and give the Galaxy its patchy appearance.

The Milky Way is home to generations of stars past. Many stars become small, dense white dwarfs after a bloated 'red giant' phase. Other, more massive stars explode as supernovas, enriching the Galaxy with heavy elements manufactured in their cores, and leaving behind either neutron stars or black holes.

The Galaxy's bright stellar disk is embedded in a faint disk of old stars which is about 3 times thicker than the thin disk. Surrounding the thick Galactic disk is an extremely faint halo that contains the oldest stars in the Galaxy. The Galactic halo is dominated by dark matter, a still mysterious form of matter that cannot be observed directly.

CHANDRA MOSAIC OF THE GALACTIC CENTER

"There is a way on high, conspicuous in the clear heavens, called the Milky Way, brilliant with its own brightness."

Ovid (43 BC - 17 AD), Metamorphoses

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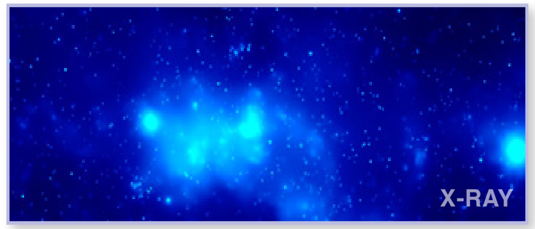
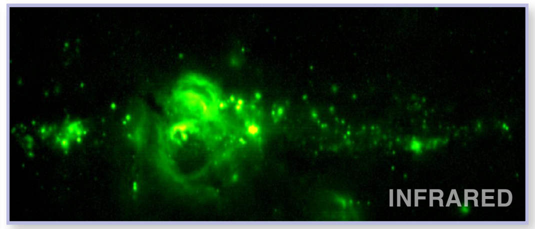
Most of the action in our Milky Way takes place in its crowded center, the bustling "downtown", so to speak, of our Galactic metropolis. With Chandra's keen X-ray vision, scientists are trying to determine how this relatively small patch of Galactic real estate affects the evolution of the Galaxy as a whole. For example, Chandra sees large quantities of extremely hot gas apparently escaping from the center. This outflow of gas—enriched with elements like iron, carbon, and silicon from the frequent destruction of stars—is distributed into the rest of the Galaxy. These elements are crucial to the formation of stars and planets, including Earth.





Dust and gas produced by millions of massive stars makes it difficult for optical telescopes to see into this region. However, other wavelengths can reveal certain features in the Galactic Center. A composite of images made at X-ray (blue), infrared (green), and radio (red) shows the relation between hot gas (X-ray), cool gas and dust (infrared) and high energy electrons trapped in the magnetic field in the Galactic Center (radio). Because it is only about 25,000 light years from Earth, the center of our Galaxy provides an excellent laboratory to learn about the cores of other galaxies.

Credits (Left-Right, Top-Bottom): Chandra broadband X-ray (NASA/UMass/D. Wang et al.), Infrared (MSX), Radio (VLA/NRL/N. Kassim)

THE GALACTIC CENTER: A panoramic X-ray view, covering a 900-by-400 light-year swath, shows that the center of the Galaxy is a teeming and tumultuous place. There are supernova remnants: SNR 0.9-0.1, Sagittarius A East, and probably the X-ray Thread. There are many bright X-ray sources, which astronomers believe are binary systems—or pairs of orbiting objects—that contain a black hole or a neutron star (the 1E sources). There are hundreds of unnamed point-like sources that scientists think are solo neutron stars or white dwarfs, which all light up the region. In addition, the massive stars in the Arches and other star clusters (the DB sources) will soon explode to produce more supernovas, neutron stars, and black holes.

Additional telescopes have also found other exotic members of this cosmic zoo. Infrared and radio observations find giant molecular clouds (Sagittarius A, B1, B2, and C, and the Cold Gas Cloud near the Radio Arc) where stars form. Normally too cool to be detected in X-rays, the edges of these clouds have been heated, allowing Chandra to see their X-ray glow.

All this commotion takes place in a diffuse cloud of hot gas that shows up as extended X-ray emission. This diffuse X-ray glow gets brighter toward the Galactic Center. Sagittarius A (Sgr A), the bright blob in the center, is composed of three main parts: Sgr A East, Sgr A West, and Sgr A*. Sgr A East is the remnant of a supernova that stirred things up about 10,000 years ago. Sgr A West is a spiral-shaped structure of gas that may be falling toward Sgr A*, the supermassive black hole that marks the center of the Milky Way Galaxy. Sgr A* contains about 3 million times the mass of the Sun, and is gaining weight daily as it pulls in more material.

Coordinates (J2000): RA 17h 45m 23s I Dec -29°01'17"
Constellation: Sagittarius
Observation Date: July 2001 (30 separate pointings)

Observation Time: 94.2 hours total
Color Code: Energy
Instrument: ACIS

MORE ON THE MILKY WAY

CHANDRA X-RAY CENTER

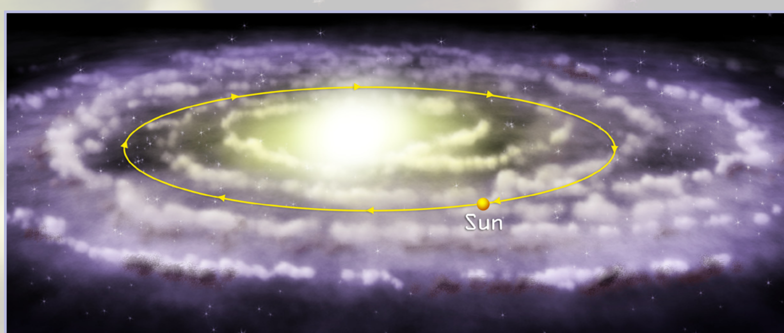
How can you take a picture of our Galaxy if we are in it? Since our Solar System is embedded within our Galaxy, we can only show an artist's representation of what it looks like from the outside. From our vantage point, we only have an edge-on view of the Milky Way, but this is still very useful. Different types of astronomical observations — some that trace the spiral arms, others that detect stars or gas and dust — can be pieced together. Combined with images from other galaxies that are the same type as ours, this allows scientists to construct a view of what the Milky Way would look like from the outside.

How far are we from the Galactic plane and the center of the Galaxy? The Earth is a few tens of light years above the middle of the thin disk where most of the stars in the Galaxy are found, also known as the "Galactic plane." This is actually rather close given the scale of the Galaxy. On the other hand, the Earth is approximately, 25,000 light years away from the center of the Galaxy. To put this into context, that places us in a spiral arm about 2/3 of the way to outer edge of the Galaxy.

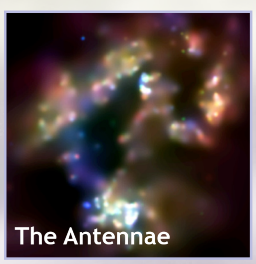
SgrA*

How do we know there's a supermassive black hole in the center of the Milky Way? Astronomers have used careful observations of the motions of stars around the center of our Galaxy to make inferences about the mass of the object that lies at the center. They have concluded that these stars orbit a dark massive body, with a mass approximately 3 million times that of the Sun. The only known object that could be so massive and still be dark is a supermassive black hole.

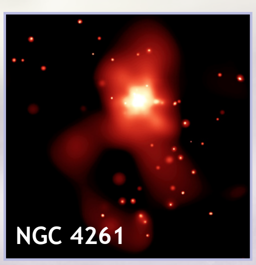
Could a black hole in our Galaxy ever be strong enough to pull our solar system into it? It would have to be so close that its gravity could overcome the orbital acceleration of our solar system around the center of the Galaxy. That would be well within a light year, even for a million solar mass black hole, which we would definitely know about!



Is our solar system traveling within our Galaxy? Our solar system travels in an orbit around the center of the Galaxy at a velocity (i.e. speed) of a few hundred kilometers per second, completing one orbit around the center of the Milky Way about every 230 million years. In addition, the solar system is moving at about 20 kilometers per second with respect to the nearby stars. There is also a small amount of motion with respect to the plane of the Galaxy. Currently, the solar system is heading outwards but the gravitational pull of the stars in the galactic plane will eventually cause it to stop and then move back towards the galactic plane. Our whole Galaxy is also traveling through space. Within the local group of galaxies, the Milky Way's velocity is several hundred kilometers per second.



The Antennae



NGC 4261

What would happen if the Andromeda Galaxy and the Milky Way galaxy collided? This collision won't happen for several billion years, but if it does, enormous numbers of new stars should form, as gas from the two galaxies is squeezed together. Large numbers of massive stars should explode as supernovas, spreading heavy elements like iron and magnesium outwards. An example of this effect can be seen in the Antennae galaxies. Chandra observations (left) of these colliding galaxies have revealed hot gas containing extremely high concentrations of heavy elements. These elements were created by nuclear fusion reactions in the centers of massive stars, and were dispersed by supernova explosions. The motions of the stars in the original spiral galaxies are radically changed by a galactic collision, and eventually a large elliptical galaxy should form. This process is believed to have taken place a few billion years ago in NGC 4261. This large elliptical galaxy shows no trace of its violent history in optical images, but Chandra observations (right) are thought to show remnants of a galactic collision.

MORE INFORMATION ON THE MILKY WAY IS AVAILABLE AT

http://chandra.harvard.edu/xray_sources/milky_way.html

http://chandra.harvard.edu/photo/category/milkyway.html

Credits – Milky Way illustration: CXC/M.Weiss; Galactic Center image: NASA/U Mass/D.Wang et al.; Milky Way with Sun Orbit illustration: CXC/M.Weiss; The Antennae Diffuse: NASA/CXC/SAO/G.Fabbiano et al.; NGC 4261: NASA/CXC/A.Zezas et al.; SgrA*: NASA/CXC/MIT/F.K.Baganoff et al.