X-Ray Astronomy Field Guide

Comparison of a normal galaxy, active galaxy and quasar.
Credit:CXC/M.Weiss

Quasars are peculiar objects that radiate as much energy per second as a thousand or more galaxies, from a region that has a diameter about one millionth that of the host galaxy. It is as if a powerhouse the size of a small flashlight produced as much light as all the houses and businesses in the entire L.A. basin!

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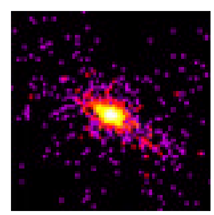
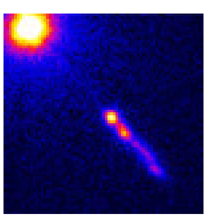
The power of a quasar depends on the mass of its central supermassive black hole and the rate at which it swallows matter. Almost all galaxies, including our own, are thought to contain supermassive black holes in their centers. Quasars represent extreme cases where large quantities of gas are pouring into the black hole so rapidly that the energy output is a thousand times greater than the galaxy itself.

A galaxy with a somewhat less active supermassive black hole is called an Active Galaxy and its black hole is called an "Active Galactic Nucleus" or AGN. Our Milky Way Galaxy and our neighbor, the Andromeda Galaxy, are examples of normal galaxies, where the supermassive black hole has very little gas to capture.



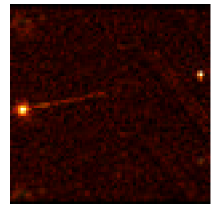
Chandra Image of NGC 4151



Chandra Image of 3C273

X-rays from quasars and AGNs are produced when in-falling matter is heated to temperatures of millions of degrees as it swirls toward the supermassive black hole. However, not all the matter in the gravitational whirlpool is doomed to fall into the black hole. Radio and X-ray observations show that matter is exploding away from some supermassive black holes in high energy jets. These jets move at nearly the speed of light in tight beams that blast out of the galaxy and travel hundreds of thousands of light years.

One possible explanation for these awesome jets is that the twisting motion of the magnetized gas in a thick disk of gas near the black hole creates an electromagnetic coil that expels the matter from the disk and pinches it into a narrow jet.



Chandra Image of Pictor A Jet

Astronomers have divided AGNs into two broad categories. **Type 1 AGNs** show evidence of energetic activity in the form of hot, rapidly moving gas clouds, bright radio, optical and X-ray emission from the nucleus. In **Type 2 AGNs** the gas is moving more slowly, radio and X-ray jets can be seen, but the radio, optical and X-ray emission from the nucleus is much weaker.

According to a popular theory, Type 1 and Type 2 AGNs are the same objects viewed from a different angle. The central black hole is assumed to be surrounded by a thick donut-shaped cloud of gas and dust. The source appears different, depending on whether it is observed from the side through the edge of the donut (Type 2), or from the top through the hole (Type 1).

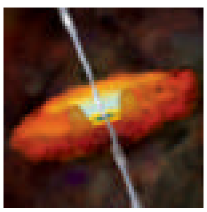


Illustration of Black Hole with Accretion Disk and Torus (CXC/M.Weiss)

This theory explains many of the observations of active galaxies, and has won widespread acceptance among astronomers, though questions remain. Chief among these is whether the theory applies to quasars whose central black hole is at least a thousand times more energetic than the typical AGN. Could a cloud of gas exist for any length of time around a giant black hole that is generating energy at such a prodigious rate? Chandra observations of quasars have shown that they can.

Several strong candidates for Type 2, or obscured quasars have been discovered. These objects are inconspicuous at optical wavelengths, so the X-ray observations have led to the conclusion that the giant black hole population in the universe is much higher than observations with optical telescopes indicate.