# The Study of Supermassive Black Holes: From X-ray to Infrared

All massive galaxies host supermassive black holes (SMBH) at their centers, and these objects are often found to be hidden behind large amounts of gas and dust. This circum-nuclear material is what eventually accretes onto the black hole, allowing it to grow, and its structure and evolution has been the subject of intense study in the past decade. In a recent issue of *Nature Astronomy*, the Chinese Academy of Sciences South America Center for Astronomy (CASSACA) postdoctoral fellow Claudio Ricci and Dr. Cristina Ramos Almeida (IAC Tenerife) reported their idea of combining results obtained from X-ray and infrared studies of the close environments of supermassive black holes. These two energy bands are highly complementary: while X-rays are produced very close to the supermassive black hole and allow the study of radiation absorbed and reflected, infrared radiation is directly produced by the dust around the black hole.

A black hole is a place in space where gravity pulls so much that even light cannot get out, and therefore is "black" in any bands. The theory of general relativity predicts that a sufficiently large and compact mass can deform space time and give birth to a black hole. Black holes of stellar masses are expected to form when very massive stars collapse at the end of their life cycle. After a black hole is formed, it can continue to grow by absorbing mass from its surroundings. By absorbing other stars and merging with other black holes, supermassive black holes of millions of solar masses may form. The first widely-accepted black hole is Cygnus X-1 discovered in 1964, and it weighs about 15 solar masses (**Figure 1**). The well-known radio
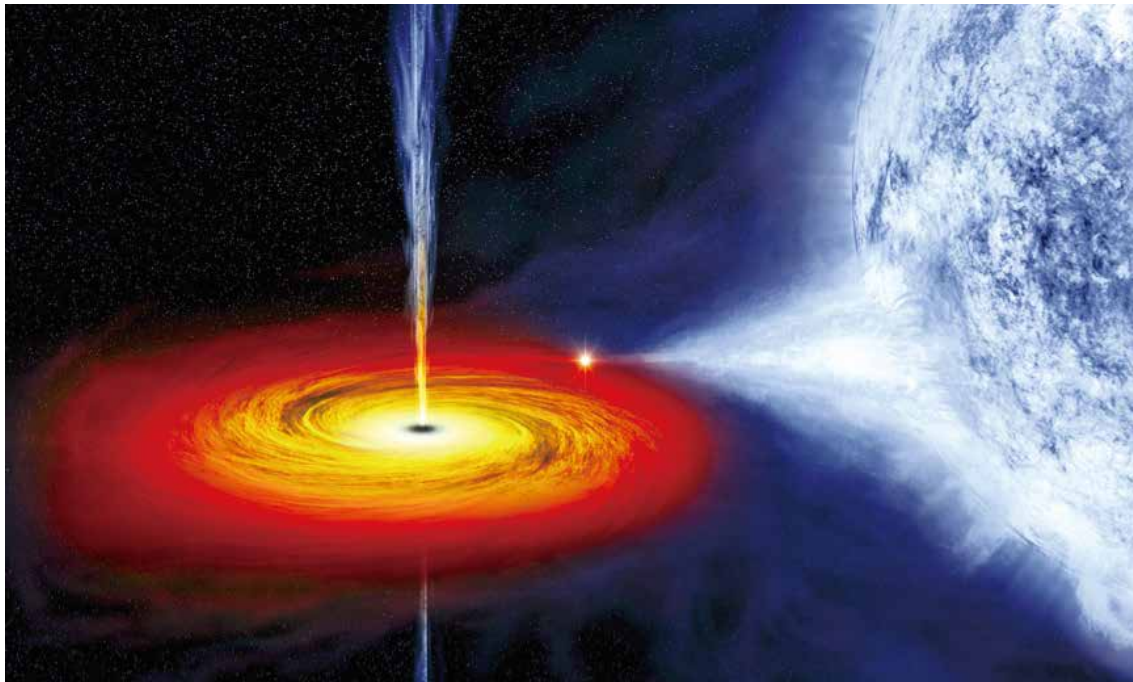

Figure 1. An artist's drawing of a black hole named Cygnus X-1. It formed when a large star caved in. This black hole pulls matter from the blue star beside it. *Credit: NASA/CXC/M. Weiss.*

source named Sagittarius A*, sitting at the core of our own Milky Way galaxy, contains a supermassive black hole of about 4.3 million solar masses.

Despite its invisible interior, the presence of a black hole can be inferred through its interactions with matter. Circum-nuclear materials fall onto a black hole, and form an AGN (active galactic nucleus), one of the brightest objects in the universe, including an external accretion disk, an X-ray emitting corona, a broad-line region (BLR), a torus and a narrow-line region (NLR) (Figure 2), which have various physical characteristics, and their radiation is widely used to study the black hole and its surroundings.

Their report summarizes the most important developments in this field over the past ten years, particularly in light of the most advanced X-ray and IR facilities. The authors discuss why the circum-nuclear material is anisotropic, clumpy, and connects with the host galaxy via gas inflow/outflows. They also highlight the importance of dust emission from the polar region of the AGN, possibly related to outflows caused by radiation pressure from the accreting supermassive black hole. Future observing facilities will allow a better understanding of the nuclear environment of AGN, and a fuller description on how it links the black hole to its
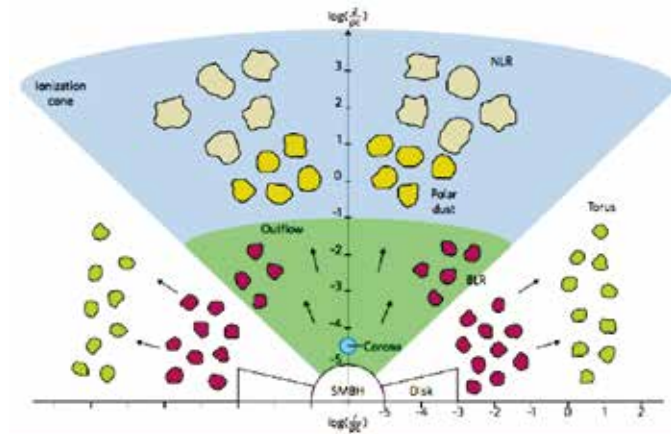
Figure 2. Sketch of the main AGN structures, seen along the equatorial and polar directions. From the center to host-galaxy scales: SMBH (Super Massive Black Hole), accretion disk and X-ray emitting corona, BLR (Broad-Line Region), torus and NLR (Narrow-Line Region). Different colors indicate different compositions or densities. *Credit: Ramos Almeida & Ricci (2017, Nature Astronomy).*

host galaxy. In particular, the upcoming James Webb Space Telescope (JWST) will allow scientists to probe the structure and evolution of AGN's polar dust, while high-resolution spectrometers, such as the ones on board XARM and Athena satellites, will shed light on the physical characteristics of the gas and dust.