# The Galactic Center through the Eye of *Webb*

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The center of our Milky Way is a unique environment when compared with the rest of the Galaxy. The central 400 pc defines a Central Molecular Zone (Figure 1) that contains 10% of all the molecular gas in our Galaxy in only 0.02% of the volume (Morris & Serabyn 1996 and references therein). The high stellar densities also make the Galactic Center an excellent place to study extremely rare stellar populations. There are several very active and massive star-forming regions, such as Sagittarius B2, and at least three young star clusters over 10,000 solar masses: the Arches, Quintuplet, and Young Nuclear Cluster. At the very heart of the Galactic Center lies a supermassive black hole of 4 million solar masses that sputters along in a fairly under-luminous state, given the amount of gas we think it consumes. Occasionally, as will be the case this spring, the black hole may disrupt a passing star or cloud and activity levels may rise. Other physical conditions that make this environment unique include higher magnetic fields, higher ambient ultraviolet and X-ray radiation fields, and molecular clouds that are denser, hotter, and more turbulent than their counterparts in the Galactic disk. Taken all together, the Galactic Center represents one of the most extreme environments in the Galaxy.

*Webb* can address a number of fundamental questions through studies of the Galactic Center. First, we can investigate how supermassive black holes grow and influence their environment at a level of detail that is not possible in other galaxies. We can learn how nuclear star clusters form, and whether their growth is related to the growth of the black hole in some fashion. Last, we can investigate how the extreme conditions in this region affect the star-formation process.

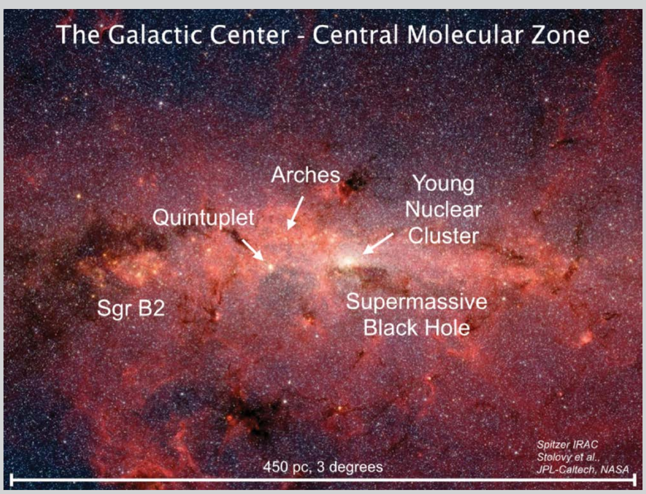


**Figure 1:** *Spitzer* Infrared Array Camera image of the Galactic Center. The Central Molecular Zone is ~400 pc across and contains 10% of the Milky Way's molecular gas in just 0.02% of the volume. This region also hosts three young star clusters over 10,000 solar masses (Arches, Quintuplet, Young Nuclear Cluster), several actively star-forming giant molecular clouds (e.g., Sgr B2) and the supermassive black hole at the very center.

One of the key advancements for Galactic Center studies is *Webb*'s increased spatial resolution over *Hubble*. Figure 2 shows an image of the Galactic Center taken with *Hubble*'s Wide Field Camera 3, compared with *Webb*'s Near Infrared Camera at infrared wavelengths. *Webb* can easily overcome the crowding seen in the *Hubble* image. The Galactic Center stars are bright, and *Webb*'s narrow-band filters are essential for obtaining deep images without saturating the brightest stars ($K = 9$). With *Webb*'s imaging capabilities, we will routinely detect emission from the black hole's accretion and watch individual stars orbit around the black hole—something that has thus far been possible only with the largest ground-based telescopes equipped with adaptive optics. Simultaneously, *Webb*'s large imaging field of view will allow us to measure the precise brightness, color, and motion of half a million stars in order to reconstruct the star-formation history and dynamical evolution of the surrounding nuclear star cluster.

With *Webb*'s integral-field unit on the Near Infrared Spectrograph, we can measure the fundamental properties of stars (temperature, metallicity, luminosity) at the Galactic Center down to stellar masses that are ten times lower than can be observed today (1 $M_\odot$ vs. 10 $M_\odot$). In addition to the stars, we can also trace the flow of gas as it makes its final journey from the inner parts of the Central Molecular Zone, through the central parsec, and possibly into the black hole. Figure 3 shows velocity slices of hot-hydrogen-gas emission in the vicinity of the Galactic Center (from a mosaic of star-subtracted integral-field spectra). The reservoirs and streams of gas that *Webb* will find can be modeled to estimate the rate at which gas accretes at different spatial scales. *Webb*'s 3D spectra will cover larger areas far more efficiently and with a wider range of gas emission lines as a result of *Webb*'s combination of high spatial resolution and high sensitivity over a large range of infrared wavelengths.

**For more Galactic Center information, animations, and figures, see:**

**http://www.galacticcenter.astro.ucla.edu**
**http://www.mpe.mpg.de/ir/GC**

Morris & Serabyn 1996, Annual Review of Astronomy & Astrophysics, 34, 645
Genzel, Eisenhauer, & Gillessen 2010, Reviews of Modern Physics, 82, 3121

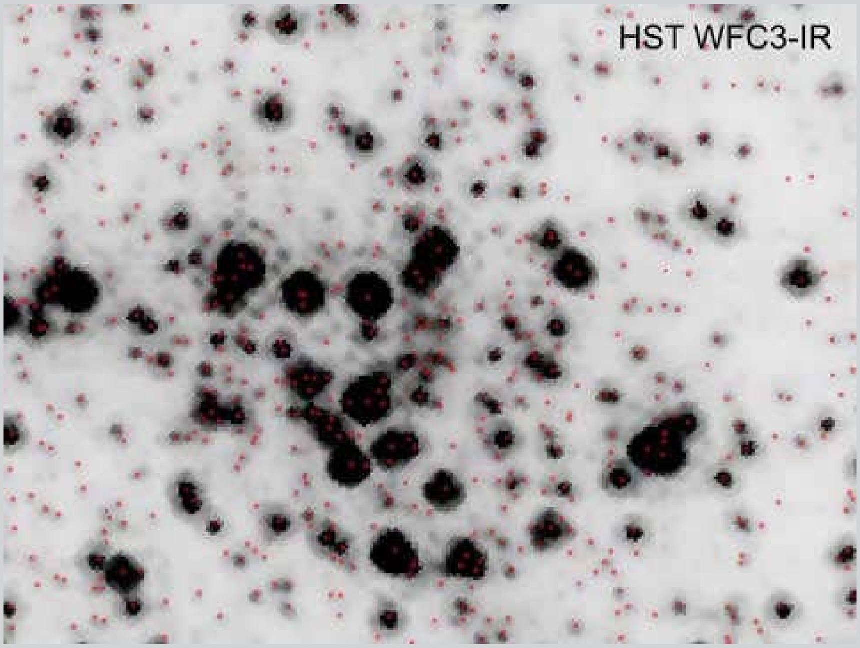


**Figure 2:** Images of the central 0.4 pc of the Galactic Center from *Hubble*'s Wide Field Camera 3 (observed) and *Webb*'s Near Infrared Camera (simulated). *Webb* will provide enormous gains in spatial resolution, which is essential for resolving the crowded region immediately around the supermassive black hole located at the center of the image. *Webb*'s resolution and sensitivity in the infrared will allow us to measure the precise brightness, color, and motion of half a million stars in order to reconstruct the star-formation history and dynamical evolution of the surrounding nuclear star cluster. The red points on the left are the stars used in the simulation on the right.

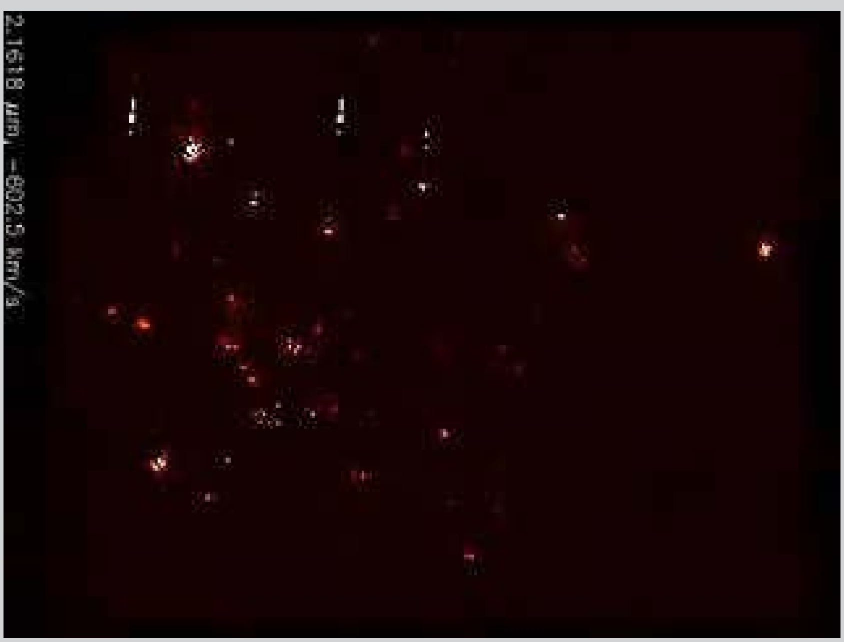

**Figure 3:** Snapshots of hot hydrogen gas emission (Brackett gamma) at various line-of-sight velocities as the gas orbits around the supermassive black hole. Similar measurements by *Webb* over a larger field and for different gas emission lines will allow us to constrain the physical mechanisms that drive gas in to the black hole or expel gas out into the rest of the Galaxy. Velocities increase from top to bottom in the first column and continue in the second column. This 10 × 7 arcsec mosaic was constructed with the OSIRIS instrument (OH-Suppressing Infrared Integral Field Spectrograph) at the W. M. Keck Observatory, which produces a spectrum at each pixel in the image. *Webb* will produce these types of measurements more efficiently, and for many different gaseous emission lines.

To view this article's video figures, it is necessary to use either Adobe Acrobat or Reader.