

The dynamics and structure of present-day galaxies on kiloparsec scales are thought to result from physical processes which occurred in just a few tens or hundreds of parsecs, in their very centers. In the center of our Galaxy, molecular gas properties are markedly different from those in the Galactic disk. They are characterized by large, turbulent line widths, high temperatures, and substantial densities, however the extremes of these conditions are poorly constrained. Measuring the range of conditions that are present in the gas is critical for constraining the processes that could be responsible for shaping galaxy evolution on larger scales. My thesis comprises a multiwavelength probe of the Galactic center (GC) gas that places new limits on its temperature, density, and structure, and is a necessary first step to identifying the mechanisms which are responsible for the more extreme nature of gas in this environment.

Very Hot Molecular Gas in the GC: To investigate the highest temperatures at which GC gas exists, I led a project to survey a sample GC clouds with the Green Bank Telescope (Mills & Morris 2013). By observing highly-excited lines of ammonia (NH_3), I derived rotation temperatures of 400-500 K (Figure 1d), substantially higher than previous temperatures of 200-300 K measured for these clouds. My widespread detections of gas hotter than 400 K indicates that this hot gas must be heated by global processes such as shocks in the GC, rather than local processes such as star formation.

Dense Gas Around the Black Hole: More than any other region, the conditions in gas around the central black hole determines the fate of our GC: whether it will ultimately accrete onto the black hole, or collapse and form stars. Recent studies of this gas yield densities which are discrepant by 4 orders of magnitude. I carried out an excitation analysis of multiple transitions of HCN and HCO^+ using APEX data (Figure 1c), yielding significantly tighter limits on the density ($n < 10^7 \text{ cm}^{-3}$, Mills et al. 2013). These observations indicate that there is less gas around our black hole than previously thought, and as the bulk of the gas is not tidally stable, its apparent structure is a result of turbulent shocks, and not star formation.

Subparsec Structure of GC Clouds: Not only are the global extremes of GC gas properties poorly constrained, but the properties of the gas on subparsec scales are not well studied. This means the dependence of their temperature and density on local processes (e.g. star formation, or supernova-driven shocks) is not known. To begin to characterize the interior conditions of GC clouds, I led a VLA study of five GC clouds to determine the variation in temperature in these clouds on 0.1 pc scales and ultimately identify their heating sources. This work uncovered an unprecedented number of collisionally-excited methanol masers, indicating the importance of shocks in driving conditions in GC molecular clouds (Mills et al. 2015).

Cloud Interactions with the GC Environment: To determine the effects of the GC environment on the properties of the gas, their interactions must also be fully defined. The M-0.02-0.07 molecular cloud lies just 6 parsecs from the supermassive black hole, is being compressed by shocks from a supernova remnant (SNR), and has an embedded group of compact H II regions (Figure 1a). I led a study of the source extinctions and morphologies, determining that three of the H II regions formed at the front of the cloud, and are unaffected by the SNR. The fourth is embedded in the supernova-compressed ridge, and though younger than the other three, is still too old to be triggered by the SNR (Mills et al. 2011).

This thesis has yielded new limits on the physical conditions in some of the most extreme gas in our Galaxy. The results of this work emphasize the importance of shocks in the GC, and while they appear to be the dominant mechanism driving the extreme gas conditions in this environment, there is still no evidence that they are directly responsible for episodes of star formation.