Resolving the Rise and Fall of Star Formation in Galaxies
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SWAG: The Maps

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Abstract. We present maps of the "Survey of Water and Ammonia toward the Galactic center" (SWAG). SWAG was observed over three years (∼ 550h) with the Australia Telescope Compact Array (ATCA) and covers the entire Central Molecular Zone (CMZ) at about 26" or ∼ 1 pc resolution. The observed 21.2–25.6 GHz range contains tens of spectral lines and 4 GHz of continuum. Here, we present some final maps. These include multiple NH_3 lines, radio recombination lines, shock tracers like HNCO and methanol (CH_3OH), high resolution 22 GHz water masers, and a continuum map. The maps are the foundation for ongoing comprehensive temperature mapping of the CMZ, including the identification of heating mechanisms, the characterization of water maser sources as young stellar objects or AGB stars, as well as chemistry, dynamics, and star formation studies of the ISM in this unique environment.

Keywords. Galaxy: center, radio lines: ISM, ISM: molecules, masers

1. SWAG

SWAG, the "Survey of Water and Ammonia in the Galactic center" is a comprehensive survey of molecular lines in the 21.2–25.6 GHz range. The lines include species that trace temperature, shocks, ionization, and other physical parameters. SWAG covers the entire Central Molecular Zone (CMZ), the inner ∼ 500 pc of our Galaxy, a region that is dominated by the gas accretion from disk material. The history of the gas as well as strong feedback from energetic sources in the CMZ alter the state of the gas to be warmer, more turbulent and denser than disk gas. These conditions may resemble those in early galaxy formation and studying the CMZ gas properties at about ∼ 1 pc resolution allows to draw comparisons to gas at larger lookback times. Here we present maps from SWAG.

2. The Maps

Ammonia: A key molecule of SWAG is ammonia (NH_3). NH_3 is a symmetric top, that can be used as a thermometer of the gas when observing its inversion transitions. In Fig. 1 we show the NH_3 (1,1), (3,3), and (6,6) maps as an example. SWAG also covers (2,2), (4,4), (5,5), and some non-metastable transitions like (2,1), (3,2), and (4,1). Initial temperature maps are presented in Krieger et al. (2017) with a more detailed analysis, including a combination with single dish data, forthcoming in Candelaria et al. in prep.

Water: The 22 GHz maser transition of water (H_2O) is another key tracer within SWAG. This transition is a class II maser and pumped by collisions. The underlying

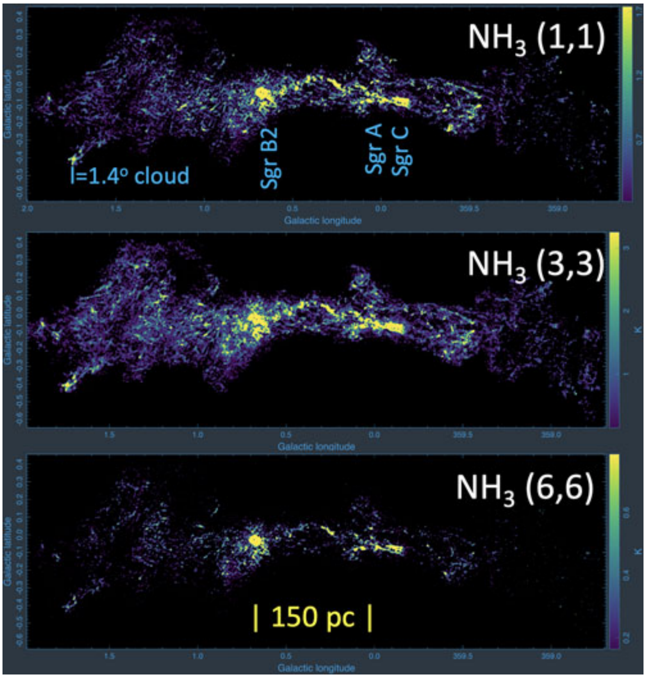

Figure 1. Ammonia (1,1), (2,2), and (3,3) maps. Some regions within the CMZ are marked in the first panel. The area between Sgr B2 and Sgr C marks the 100 pc ring, which is prominent in the dense gas signatures. The $l = 1.4°$ cloud is an accretion zone of disk material onto the 100 pc ring.

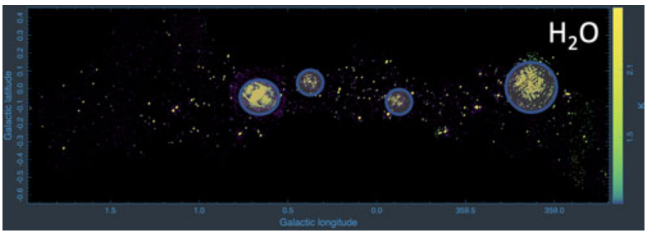

Figure 2. 22 GHz water masers. The circled, shaded regions are very strong masers that show sidelobe artifacts.

sources are typically young stellar objects (YSOs), likely associated with the CMZ molecular gas, or AGB stars across the Galaxy that shed their outer envelopes. Both sources invoke the shocks needed to turn on the H_2O masers. The SWAG map in Fig. 2 shows at least a ten-fold increase in water maser sources compared to previous survey (Ott et al. 2019; Ward et al. in prep.).

Shock tracers: Some molecules are typically formed on dust grains and only liberated by shocks of different strengths. It turns out that HNCO is mostly detected in the $l = 1.4$ deg cloud (Fig. 3). This cloud is likely the point where the gas that was transferred from the Milky Way disk to the CMZ eventually accretes on the inner 100 pc molecular ring. It appears that the gas arrives in a diversity of shock conditions. In contrast, methanol (CH_3OH), which can also be considered a shock tracer, has a very different

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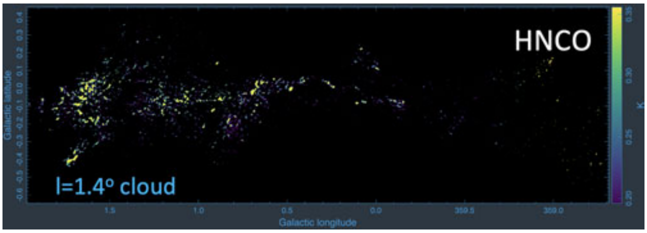

Figure 3. HNCO($1_{01} - 0_{00}$).

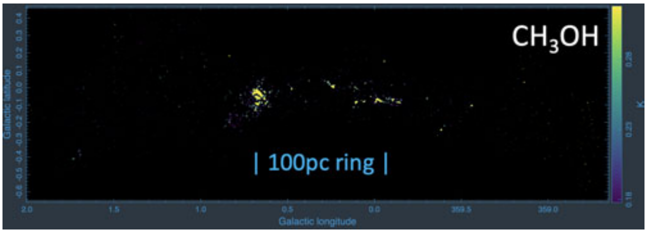

Figure 4. $CH_3OH(2_{02} - 1_{01})$.

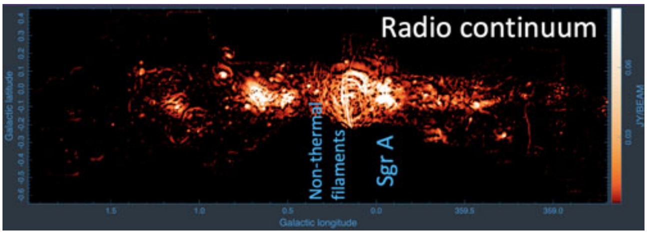

Figure 5. 1.3 cm Radio Continuum.

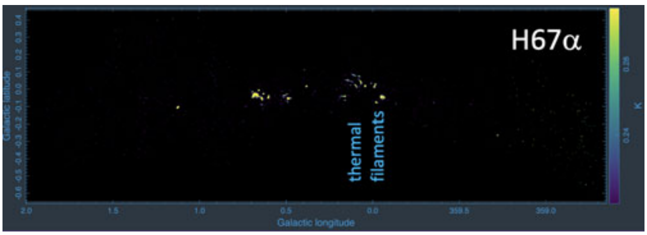

Figure 6. H67α radio recombination line.

distribution (Fig. 4). It is mostly found in the 100 pc ring itself. This may indicate different shock strengths between the gas accretion zone and the 100 pc ring and may show the evaporation of molecules from dust grains.

Radio Continuum: SWAG also observes K-band ($\sim$ 23 GHz) 4 GHz-wide radio continuum(Fig. 5). The resulting map shows the individual radiation processes from point and extended regions, like Sgr A, which contains the supermassive black home Sgr A*, the star forming regions Sgr B and C, thermal and non-thermal filaments, as well as individual supernovae can be detected.

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Radio Recombination Lines: Radio recombination lines, such as H67a, trace ionized gas. In the case of the CMZ, this gas is mostly correlated with the thermal radio continuum, as well as individual star forming regions (Fig. 6).

References

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