*Cosmic Masers: Proper Motion toward the Next-Generation Large Projects*
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# Water Masers in the Galactic Center

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**Abstract.** The Central Molecular Zone (CMZ) makes up roughly the inner 500 pc of the Milky Way and has a large amount of dense hot gas, strong magnetic fields, and highly energetic particles. The Survey of Water and Ammonia in the Galactic Center (SWAG) is a major imaging line survey using the Australia Telescope Compact Array with the goal to map out the molecular content in the entire CMZ. SWAG data includes the 22 GHz $H_2O$ maser transition which is typically used as a tracer for phases of star formation, including both young stellar objects (YSOs) and evolved stars, such as asymptotic giant branch (AGB) stars. The SWAG $H_2O$ survey is significantly deeper with better resolution than existing surveys that cover the entire CMZ. The goal is to create a robust catalog of the maser positions, spectral properties, and the sources they trace. The $H_2O$ maser catalog shows 703 $H_2O$ masers which increases the amount of detected $H_2O$ masers in the CMZ by more than an order of magnitude. The $H_2O$ masers have a more symmetric distribution in the Galactic center than that of the gas. Cross-correlation with other observations and catalogs will provide information relating maser properties to YSOs and AGB stars, for which multiple maser components will provide outflow properties. We will also connect the surrounding molecular gas to the YSO maser velocities.

**Keywords.** maser, Galaxy: center, stars

## 1. Introduction

The inner 500 pc of the Galactic center is known as the Central Molecular Zone (CMZ). The CMZ contains a large amount of dense molecular gas, shows an asymmetric distribution of gas, has higher temperatures and pressures compared to the disk, and is believed to undergo star formation in an episodic nature (Bryant 2021). Thus, the CMZ is a favorable region to study $H_2O$ masers. The 22 GHz $H_2O$ maser traces young and evolved stars and is unaffected by optical extinction, so it can be observed in the Galactic center. The observations were carried out with the Australia Telescope Compact Array in a mosaic of $\sim$6500 pointings over $\sim$600 hours spread over 3 years.

## 2. Results

The maser positions were gathered using the astrodendro python package as a clump finding tool with a minimum detection limit of $5\sigma$, which is equivalent to $\sim$ 0.45 K. The $H_2O$ maser positions can be seen as orange circles plotted over an integrated intensity map of ammonia in Figure 1. For the first step of the data analysis, the luminosity of each maser was calculated using 8.178 kpc for the distance to Galactic center, determined by GRAVITY (2019). From this, Figures 2(a) and 2(b) were created. Figure 2(a) shows the maser positions plotted over the field of view where the larger the circles represent larger luminosities. Figure 2(b) is a histogram of the number of sources in a certain luminosity range, where the green line represents a maser with a mean $5\sigma$ luminosity above the noise. The amount of masers drops sharply at $L > 10^{-6} L_{\odot}$ which is similar

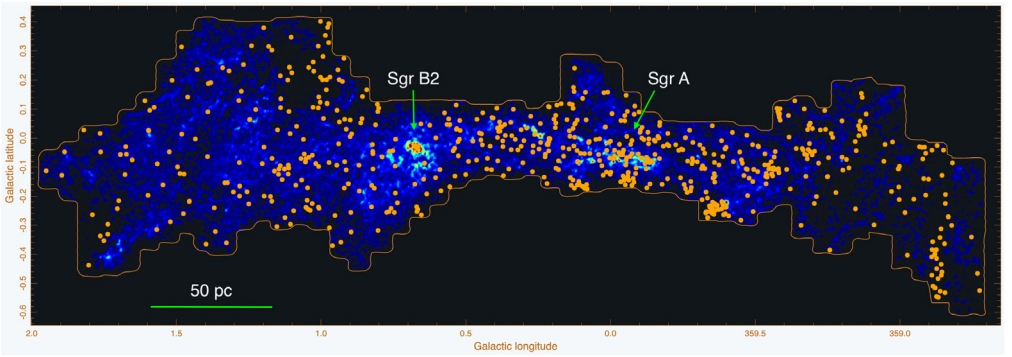


**Figure 1.** The orange outline represents the survey's field of view. $H_2O$ maser locations are represented as orange circles plotted over an integrated intensity $NH_3$ (3,3) map (in blue).

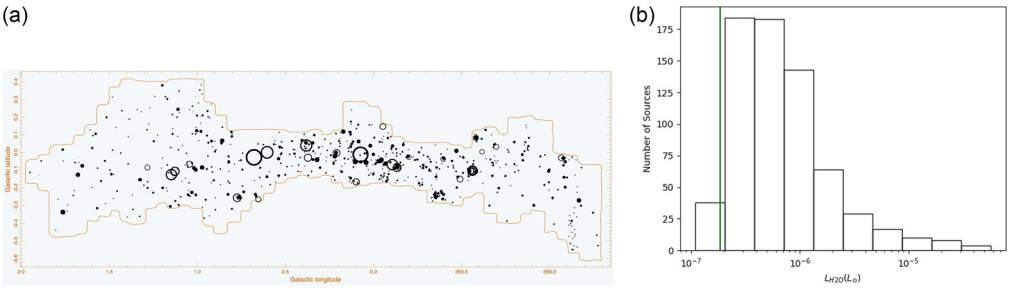


**Figure 2.** a) Shows maser positions vs luminosity. Larger circles represent higher luminosities. b) Histogram of luminosity of the masers. The green line represents a maser with a mean $5\sigma$ luminosity.

to $H_2O$ luminosity for evolved stars from Palagi (1993). However, if the sources are in the disk, then the luminosities will be off by a factor of 4. This analysis was done before source identification has been completed.

## 3. Future Work

Once the sources have been identified by cross-correlation with other catalogs, the luminosity histogram will be split into 2 separate histograms: one for young stars and one for evolved stars; this will provide a much better statistical study on $H_2O$ masers in the Galactic center than Palagi (1993). After the luminosity analysis has been completed, a comparison to the spectral properties of $CH_3OH$ and SiO masers from other catalogs at the same location of the $H_2O$ masers will be done.

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## Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1743921323001977

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