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SiO maser emission as a stellar line-of-sight velocity tracer in the Bulge Asymmetries and Dynamical Evolution (BAaDE) survey

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Abstract. The Bulge Asymmetries and Dynamical Evolution (BAaDE) survey aims to explore the complex structure of the inner Galaxy and Galactic Bulge, by using the 43 GHz receivers at the Karl G. Jansky Very Large Array (VLA) and the 86 GHz receivers at the Atacama Large Millimeter/submillimeter Array (ALMA) to observe SiO maser lines in red giant stars. The goal is to construct a sample of stellar point-mass probes that can be used to test models of the gravitational potential, and the final sample is expected to provide at least 20,000 line-of-sight velocities and positions. A possible bias between the VLA and the ALMA SiO maser lines is explored, and the 86 GHz SiO line-peak velocities agree using either of the four sampled lines. Additionally, the SiO maser velocities agree with the OH maser derived velocities.

Keywords. masers, surveys, stars: AGB and post-AGB, Galaxy: bulge, Galaxy: evolution, Galaxy: kinematics and dynamics, infrared: stars

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1. Background

As the primary aim of the BAaDE survey is to use stars as point-mass velocity probes of the Galactic gravitational potential, it is important to ensure that no biases exist in the derived line-of-sight velocities. Possible biases may be tested, in particular whether there are any systematic shifts in the velocity derived between the different SiO transitions. Other studies have used 1612 MHz OH maser emission to derive line-of-sight velocities of stars in the Galactic plane (e.g. Habing *et al.* 2006). Thus it is also important to compare the SiO and OH maser velocities to validate our use of SiO maser peaks as stellar line-of-sight velocity probes.

2. Summary

On average, the SiO v=1 maser emission is 36% brighter at 43 GHz than at 86 GHz (Stroh *et al.* 2018). Thus, the 86 GHz Atacama Large Millimeter/submillimeter Array (ALMA) sample can only be observed to 85.9% of the distance of the 43 GHz Karl G. Jansky Very Large Array (VLA) sample if observed to the same sensitivity. Thus the

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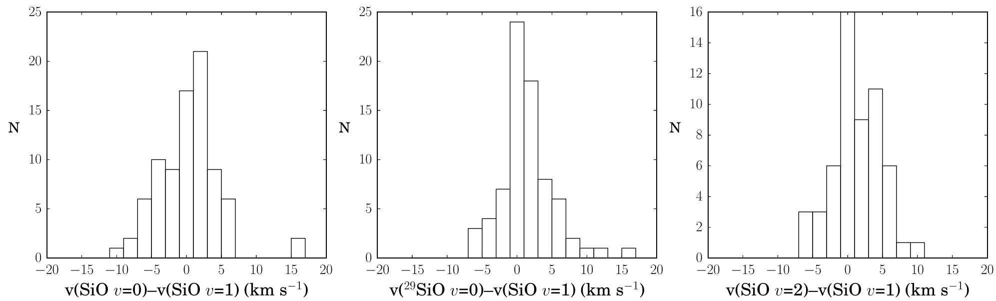

Figure 1. From left to right: histogram of v(SiO v=0), v(^{29}SiO v=0) and v(SiO v=2) relative to v(SiO v=1). All velocities are from the 86 GHz J=2 − 1 transitions observed with ALMA.

BAaDE survey has adjusted the ALMA integration time in order to compensate for this bias between the 43 and 86 GHz emission strengths.

Any of the SiO transitions is useful for deriving a stellar line-of-sight velocity as, on average, the difference between the velocities derived using different 86 GHz SiO transitions in the same source, agree within our channel widths (see Figure 1). There is no evidence of a systematic shift of any other 86 GHz SiO line-peak velocity with respect to the 86 GHz SiO v=1 maser line. This result is confirmed using the non-parametric Wilcoxon signed-rank test (Wilcoxon 1945) to test whether the line-peak velocities differed by more than the channel resolution of $\approx$0.8 km s^{-1}.

The 43 GHz SiO v=1 line-peak derived velocities are consistent with the OH maser velocities (M. C. Stroh *et al.* 2019). The mean of the v(OH)−v(SiO v=1) distribution, is less than the BAaDE VLA channel size of $\approx$1.7 km s^{-1}, suggesting that the SiO v=1 and OH maser derived velocities agree, on average.

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