Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
Proceedings IAU Symposium No. 380, 2024
T. Hirota, H. Imai, K. Menten, & Y. Pihlström, eds.
doi:10.1017/S1743921323002387

Searching masers from the Sagittarius stellar stream

Yuanwei Wu[1], Bo Zhang[2], Yan Gong[3], Wenjin Yang[3] and Nicolas Mauron[4]

[1]National Time Service Center, Chinese Academy of Sciences, Xi'an 710600, China.
email: yuanwei.wu@ntsc.ac.cn

[2]Shanghai Astronomical Observatory, Chinese Adademy of Sciences, Shanghai 200030, China

[3]Max-Plank-Institut *für* Radioastronomie, auf dem H*ü*gel 69, 53121 Bonn, Germany

[4]Universit*é* de Montpellier, Laboratoire Univers et Particules de Montpellier CNRS/UM, Place Batailon, 34095 Montpellier, France

Abstract. Large scale optical and infrared surveys have revealed numbers of accretion-derived stellar features within the halo of the Galaxy. These coherent tail-like features are produced by encounters with satellite dwarf galaxies. We conducted an SiO and H_2O maser survey towards O-rich AGBs towards the orbital plane of the Sgr Stellar Stream from 2016. Up to now, maser emissions have been found from 60 sources, most of which are detected for the first time. However, their distances and kinematics suggest they are still disk stars.

Keywords. Masers, stars: AGB and post-AGB, Galaxy: structure

1. Motivation

It is well known that our milky Way is a barred spiral galaxy. Within the past decade, the spiral strcuture and kinematics of the Milky Way have been well studied by measuring parallaxes and proper motions of interstellar masers (Reid et al. 2019). Apart from spiral features in the disk, giant stellar features also exists in the halo of the Milky Way.

According to the hierarchical galaxy formation theory, the Milky Way was assembled through the accretion of smaller systems (Blumenthal *et al.* 1984). The interaction between the Milky Way and its satellite galaxies can produce large-scale tidal streams in the halo region with galactocentric distances ranging from ∼10 kpc to more than 100 kpc (Lynden-Bell & Lynden-Bell 1995). During the last two decades, various optical and infrared surveys, as well as recent Gaia data, have identified more than 90 stellar streams in the Milky way (Mateu 2023).

Once maser emissions were found in a stellar stream, it will be possible to use masers to study kinematics of the stream. Therefore, we launched a maser survey towards the Sagittarius stellar stream (hereafter Sgr stream), the most prominent and well-studied stream in the Milky way halo.

2. Sample and Survey Results

Up to now, we have searched around 400 sources selected from two samples. The 1st sample was selected from the WISE all-sky point source catalog by their infrared color and magnitude. Details of this WISE selected sample can be found in Wu *et al.* (2018). The 2nd sample was selected from Mauron *et al.* (2019)'s O-rich AGB star catalog. Figure 1 shows the infrared color-color and color-magnitude diagram of these two samples.

Table 1. Summary of Sgr stream Maser Survey

Telescope	Maser	Frequency	Observed	Detected	Obs. Dates	Ref.
Nobeyama 45m	H_2O	22.235 GHz	49	42	May 2016	Wu *et al.* (2022)
Tidbinbilla 70m	H_2O	22.235 GHz	127	7	Nov. 2016, Mar. 2017	Wu *et al.* (2022)
Nobeyama 45m	SiO	42.820, 43.122 GHz	221	44	Apr., May 2016	Wu *et al.* (2018)
Effelsberg 100m	SiO	42.820, 43.122 GHz	52	8	Sep. 2022 ∼ Feb. 2023	Yang *et al.* (2023)
Tianma 65m	SiO	42.820, 43.122 GHz	50	0	Jan. 2023	Yang *et al.* (2023)

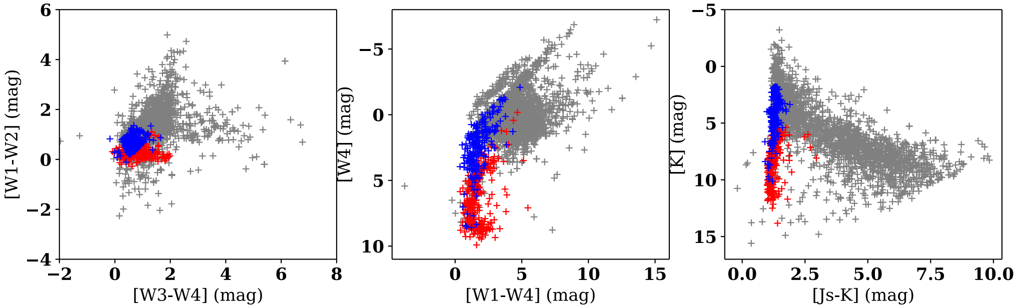

Figure 1. Infrared color-color and color-magnitude diagrams of O-rich AGB stars.The grey dots show the Galactic disk O-rich AGBs associated with SiO masers. The blue plus signs are the 1st sample selected from WISE all-sky catalog (Wu *et al.* 2018). The red plus signs are the 2nd sample selected from Mauron *et al.* (2019)'s O-rich stars in the Galactic halo and Sgr stream. The grey plus signs are disk SiO masers.

In Table 1, we summarize the survey results currently finished. In year 2016 and 2017, we searched SiO masers towards 221 sources and H_2O masers towards 176 sources. In the survey, 52 sources are found to be associated with at least one transitions of SiO or H_2O masers, including 43 SiO maser emissions and 21 H_2O maser emissions (Wu *et al.* 2018, 2022). In year 2022 and 2023, we searched SiO masers towards 102 sources selected from Mauron *et al.* (2019), and found maser emissions from 8 sources (Yang *et al.* 2023).

3. Discussions

We investigate the Galactic location and kinematics of these sources. All these sources are within 8 kpc of the Sun, including the newest 8 detections found by Effelsberg 100m (Yang *et al.* 2023). The 3D velocities of these sources are more aligned with the Milky Way plane rather than the Sgr stellar stream orbital plane, suggesting these sources are actually still disk stars rather than Sgr stream debris (Wu *et al.* 2022; Yang *et al.* 2023). The faintest SiO maser has a flux density of 0.16 Jy, which is detected above 5σ at a noise level of 0.02 Jy. Frankly speaking, detecting masers beyond 10 or even 20 kpc towards the Sun can be very challenging task, but still possible.

Kinematically, these maser traced O-rich stars are nearly all move away from the Galactic center, which is also founded for solar neighbourhood Miras (within 2 kpc) (Feast & Whitelock 2000). On the other hand, the lag ($\sim$100 km s^{-1}) of rotational speed of nearby Miras reported by (Feast & Whitelock 2000) is not seen for the maser-traced AGB stars found in this survey.

References

Blumenthal, G. R., Faber, S. M., Primack, J. R., & Rees, M. J. 1984, *Nature*, 311, 517
Feast, M. W., & Whitelock, P. A. 2000, *MNRAS*, 317, 460

https://doi.org/10.1017/S1743921323002387 Published online by Cambridge University Press

Lynden-Bell, D., & Lynden-Bell, R. M. 1995, *MNRAS*, 275, 429
Mateu, C. 2023, *MNRAS*, 520, 5225
Mauron, N., Maurin, L. P. A., & Kendall, T. R. 2019, *A&A*, 626, A112
Reid, M. J., Menten, K. M., Brunthaler, A., *et al.* 2019, *ApJ*, 885, 131
Wu, Y., Zhang, B., Li, J., & Zheng, X.-W. 2022, *MNRAS*, 516, 1881
Wu, Y. W., Matsunaga, N., Burns, R. A., & Zhang, B. 2018, *MNRAS*, 473, 3325
Yang, W. J. Wu, Y. W., Gong, Y., Zhang, B., & Mauron, N. 2023, in preparation

Review talk in the session Structure of the Milky Way by Kazi L. J. Rygl. Taken by Ka-Yiu Shum.

https://doi.org/10.1017/S1743921323002387 Published online by Cambridge University Press