

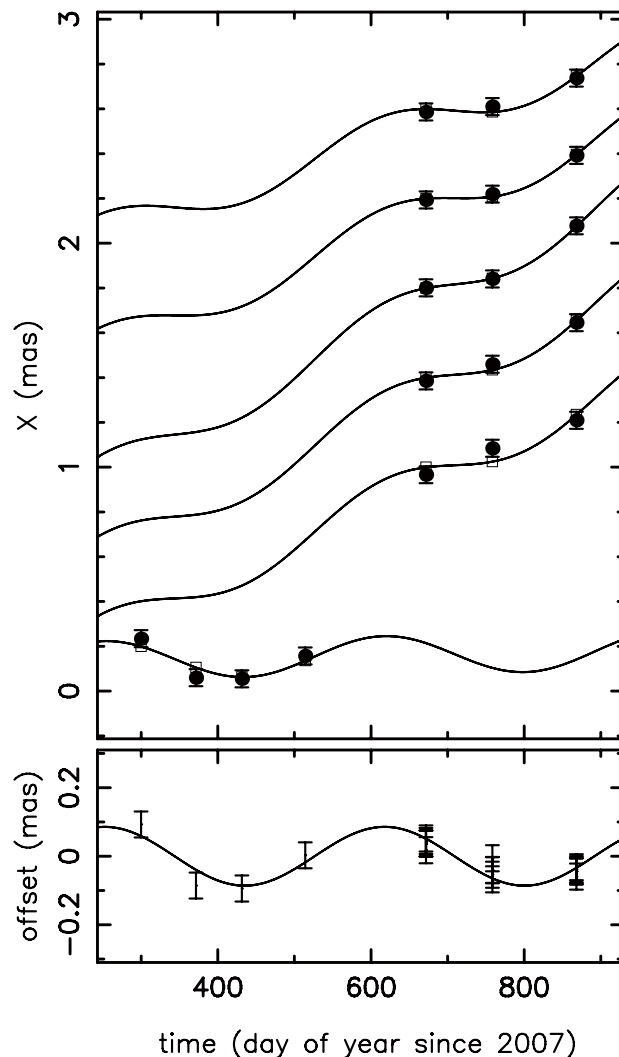
# Distance Measurement of Star-Forming Region IRAS 05137+3919 in Far Outer Galaxy

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Star forming regions in far outer Galaxy are interesting targets because they can be used to trace extent of the Galaxy disk and also because they provide a laboratory to study how star formation occurs in an extreme environment with less metallicity and without presence of spiral arm. So far several star-forming regions are expected to exist in the far outer Galaxy with a Galacto-centric distance larger than 15 kpc[1], and extensive studies have been conducted for some of these potential star-forming regions in the far outer Galaxy[2]. However, their distance estimates were based on kinematic distances and/or assumed luminosities of young stars. Therefore, it is still highly uncertain whether these star-forming regions are indeed located in such a distant area, and hence astrometric confirmations are definitely required.

As an astrometric observation of such a star-forming region in the far outer Galaxy, we have monitored an H<sub>2</sub>O maser source associated with star forming region IRAS 05137+3919, which is located toward the anti-center direction ( $l=168^\circ$ ) with its kinematic distance of 12 kpc. Although H<sub>2</sub>O maser spots in IRAS 05137+3919 are relatively variable in flux, we have determined a parallax of  $\pi=0.086\pm0.027$  mas (see Figure 1), corresponding to a source distance of  $D=11.6^{+3.3}_{-2.3}$  kpc[3]. The parallax detection is only 3- $\sigma$  level and thus the uncertainty is fairly large. Nevertheless, from this result we can strongly constrain on the minimum distance of IRAS 05137+3919, which is 8.3 kpc at 90% confidence level. This can be seen from the bottom panel of figure 1, where a parallax significantly larger than 0.1 mas is inconsistent with observations. The parallax obtained in this study is basically consistent with the previous distance estimate of 12 kpc based on kinematic distance. Assuming the Galaxy center's distance of  $R_0=8.5$  kpc, the minimum distance of 8.3 kpc is converted to a minimum Galacto-centric distance of 16.7 kpc (again at 90% confidence level). Therefore, the present study provides the first astrometric confirmation that there indeed exists a star-forming region in the far outer Galaxy.

The minimum distance obtained in this study is beyond the distance of spiral arm that is measured based on astrometry (such as Outer arm, corresponding to  $\sim 13$  kpc toward the direction of IRAS 05137+3919). This result indicates that star formation process there is triggered by other mechanism rather than spiral shocks, imposing an interesting question on how stars form in the outer region of the Galaxy.



**Figure 1:** Maser spot motions in IRAS 05137+3919 along the East-West direction. Top panel shows the observed motions of 6 spots (sum of parallax and proper motion), and bottom panel is the parallax components after removing the proper motions. Curves show the best-fit results.

## References

- [1] Diegel, S., et al.: 1994, *ApJ*, **422**, 92.
- [2] Kobayashi, N., et al.: 2008, *ApJ*, **683**, 178.
- [3] Honma, M., et al.: 2011, *PASJ*, **63**, 17.