# Outer Rotation Curve of the Galaxy with VERA I : Trigonometric Parallax of IRAS 05168+3634

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Precise structure and dynamics of the Milky Way Galaxy are still relatively ambiguous due to difficulties of precise distance measurements. In particular, for the outside of the solar circle region, distance measurements have large uncertainties since the tangent velocity method can not be used in the place (e.g., [1]). To overcome the distance uncertainties, we have been using VERA (VLBI Exploration of Radio Astrometry) to measure parallactic distances and proper motions of starforming regions located at the outer region (outside the solar circle). Our results can be used to understand not only precise structure of the Milky Way Galaxy (e.g., spiral arm location), but also mass distribution of the Galaxy. In this paper, we report one of our results for IRAS 05168+3634 as a high-mass star-forming region [2].

Eleven VLBI observations with VERA obtained between October 2009 and May 2011 yielded the trigonometric parallax and proper motion of IRAS 05168+3634. The parallax is 0.532±0.053 mas, corresponding to a distance of $1.88 \pm^{0.21}_{0.17}$ kpc. The proper motion components are $(\mu_\alpha \cos\delta, \mu_\delta) = (0.23 \pm 1.07, -3.14 \pm 0.28)$ mas yr$^{-1}$. Our result places the source in the Perseus arm. Combining the distance and proper motion with the systemic velocity results in a rotation velocity of $227^{+9}_{-11}$ km s$^{-1}$ at the source, assuming $\Theta_0 = 240$ km s$^{-1}$. The result corresponds to marginally slower rotation with respect to the flat Galactic rotation curve, $\Theta(R) = \Theta_0$. In addition, the slower rotation is almost consistent with previous VLBI results in the Perseus arm (see Fig. 1).

Fig. 1 shows the peculiar (non-circular) motions based on VLBI observations of the Perseus arm after subtractions of the Galactic rotation and the solar peculiar motions. Note that a flat Galactic rotation curve —$\Theta(R) = \Theta_0$— was assumed to derive the peculiar motions. Obviously, almost all sources in the Perseus arm are moving systematically toward the Galactic Center, and lag behind the Galactic rotation. These motions are consistent with the prediction of the density wave theory which showed that large peculiar motions, toward Galactic center and counter to the Galactic rotation, are occurred at the inner edge of the spiral arm in the case of inner co-rotation radius [3].

We have been observing Galactic star-forming regions with VERA, which will allow us to understand not only the mass distribution of the Galaxy (as part of the VERA outer rotation curve project), but also whether the density-wave theory is correct or not in the near future.

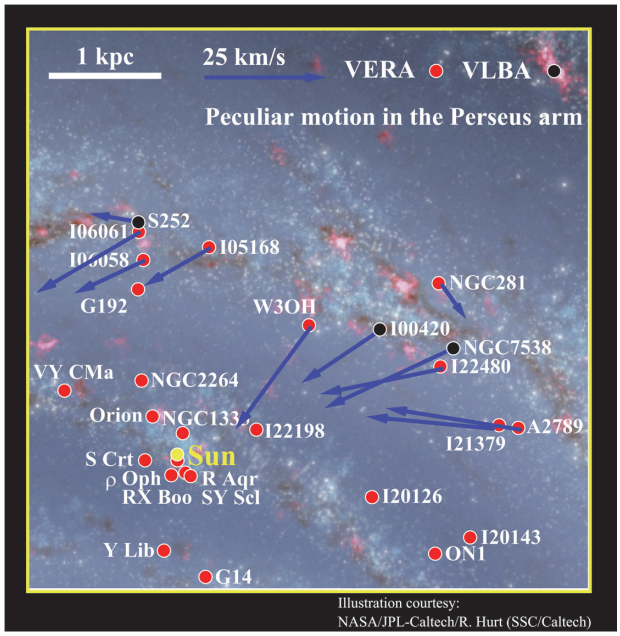


**Figure 1**: Peculiar motions in the Perseus arm. The arrows represent peculiar motions for the sources located in the Perseus arm based on VLBI observations. Note that a at Galactic rotation curve —$\Theta(R) = \Theta_0$— was assumed to derive the peculiar motions. Based on the figure, almost all sources in the Perseus arm are moving systematically toward the Galactic Center and lag behind the Galactic rotation.

## References

[1] Sofue, Y., et al.: 2009, *PASJ*, **61**, 227.
[2] Sakai, N., et al.: 2012, *PASJ*, **64,** 108.
[3] Mel'nik, A. M., et al.: 1999, *Astron. Lett.*, **25**, 518.