Outer Rotation Curve of the Galaxy with VERA III: Astrometry of IRAS 07427+2400 and Test of the Density-wave Theory

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Spiral arm is the most prominent structure in disk galaxies. However, the origin and evolution are still unknown. Since the 1960s theoretical and observational studies about the spiral arm have been conducted and “the density-wave theory” and “the dynamical spiral theory” were proposed. In the deinsity-wave theory, the spiral arm regarded as quasi steady structure (static external potential) is incorporated into a basic equation of stellar disk or gas disk, and one can explore the dynamical evolution of the disk. On the other hand, the dynamical spiral theory has been proposed based on a N-body simulation in which the spiral arm is destroyed and regenerated within several rotational periods.

A big issue on the spiral arm research is that there have been no observational data which can be compared with the theories. Since the 2000s astrometry observations (obtaining 6D kinematic information) by VLBI technology have been conducted on the Milky Way scale (~20 kpc). Especially for the Perseus arm as solar neighborhood arm, the Galactic shock predicted from the deinsity-wave theory has been observed in the arm. (e.g. Sakai et al. 2012 [1]). We aimed to do astrometry observation toward the infrared source IRAS 07427+2400 associated with the Perseus arm and to verify analytic solution based on the density-wave theory (Piñol-Ferrer et al. 2012 [2]) by combining previous VLBI results.

We conducted VLBI astrometry observations with VERA and measured a trigonometric parallax of 0.185 ± 0.027 mas for IRAS 07427+2400. Combined with previous VLBI results (total 27 sources), we compared those with the dynamical model. As a result, we succeeded to make a spiral potential model which can reproduce observed non-circular motions (= observables − circular motion model[1])(**Fig. 1**). In Fig. 1 gas orbit model (••) is also represented and we can see an offset between crowded gas orbits and the bottom of the spiral potential model.

Given that a dominant component in a galactic disk is star, fig. 1 suggests an offset between star and gas distributions. In external disk galaxies, it has been reported that galactic (spiral) morphology varies at different observing wavelengths (Griv et al. 2015 [3]). Recent N-body/hydrodynamic simulation has showed the “offset” described above (Baba et al. 2015 [4]).

In Autumun of 2016 stellar astrometry results will be provided by the Gaia satellite. It is expected to understand spiral arm physics in detail by directly confirming the “offset”.

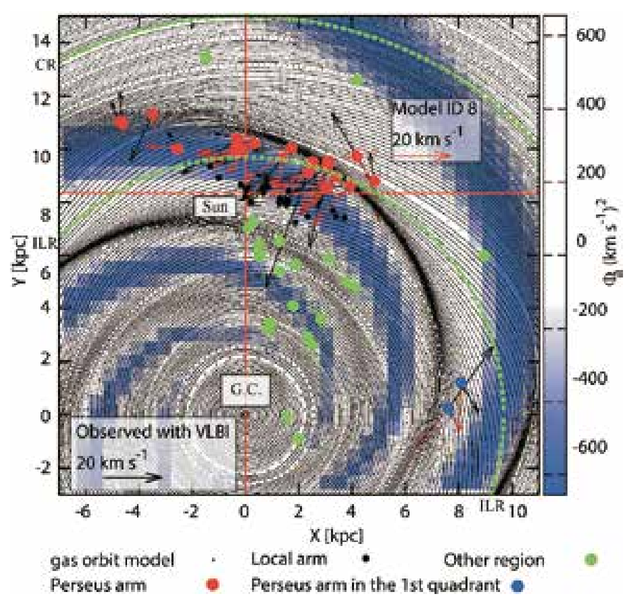

Figure 1: Sakai et al. (2015) [5]. Astrometry results for the Perseus arm (27 sources) and comparison with the dynamical model of the gas disk (Piñol-Ferrer et al. 2012). Blue denotes the bottom of the spiral potential model, which deviates from crowded gas regions.

References

[1] Sakai, N., et al.: 2012, *PASJ*, **64**, 108.
[2] Piñol-Ferrer, N., Lindblad, P. O., Fathi, K.: 2012, *MNRAS*, **421**, 1089.
[3] Griv, E., et al.: 2015, *MNRAS*, **453**, 1981.
[4] Baba, J., Morokuma-Matsui, K., Egusa, F.: 2015, *PASJ*, **67**, L4.
[5] Sakai, N., et al.: 2015, *PASJ*, **67**, 69.

[1] For a circular motion model, a flat rotation curve was assumed with $\Theta(R)$ = 240 km s^{-1}.}