Galactic rotation measurements based on water maser astrometry with VERA

Mareki Honma
Mizusawa VERA observatory, NAOJ
Status of VERA in the last maser meeting
(Pictures presented at the Maser meeting in Brazil in March 2001)

Iriki As of Feb. 2001 Mizusawa
VERA array now

Construction completed in 2002
Regular observations from 2004

All telescopes with dual-beam
Max. baseline : 2300 km
1. Astrometry of S269

S269 : Massive SFR toward anti-center (l=196 deg)

Near-IR view of S269
Jiang et al. (2003)

Maser spectrum and map with VERA
Parallax measurement

- Motions of S269 H2O maser with respect to J0613+1305 (0.7 deg separation)

East-West motion for 1 yr

North-South motion for 1 yr

\[ \pi : 189 \pm 8 \mu \text{as} \]

\[ D : 5.28 \pm 0.24/0.22 \text{ kpc} \]
S 269 proper motion

S269 motion with respect to LSR

\((V_\text{l}, V_\text{b}) = (-4.6, -4.1) \text{ km/s}\)

much smaller than galactic rotation \((\text{c.f. } \sim 200 \text{ km/s})\)

> similar galactic rotation velocity at the Sun and at S269
Constraint on the rotation curve

For S269 at R=13.1 kpc,

$$\frac{\Theta(13.1\text{kpc})}{\Theta_0} = 1.00 \pm 0.03$$

Flat rotation curve out to 13 kpc, plenty of dark matter

No dark matter

Galacto-centric distance (kpc)

Rotation velocity (km/s)
2. Proper motion of W49N

- W49N: nearly on the Solar circle
  Massive SFR at D ~ 11 kpc
Proper motion of W49N

Motion of the brightest spot near systemic velocity from Oct. 2005 ~ Oct. 2006 (with respect to J1905+0952)

Motion along the Galactic plane → galactic rotation
LSR Angular Rotation Velocity

Preliminary results from 1-yr obs.
\( \mu = 6.5 \pm 0.1 \text{ mas/yr} \)

Radial velocity measurements
\( V_r = 9 \pm 5 \text{ km/s} \)

They are consistent with
\[ \Omega = \Theta_0/R_0 = 30.0 \pm 0.6 \text{ (km/s/kpc)} \]

Second galaxy scale \( \Omega \) measurements next to Sgr A* 
c.f., Reid & Brunthaler (2004) \( \Omega = 29.45 \pm 0.1 \text{ (km/s/kpc)} \), Sgr A* for 8 yr
3. Other interesting results from VERA

Astrometry of nearby SFR

Parallax of Orion-KL & NGC 1333

\[ \pi = 2.29 \pm 0.1 \text{ mas} \]

\[ \pi = 4.06 \pm 0.34 \text{ mas} \]

Hirota, Poster 3-12
Masers in SFR

Detection of super-bubble motion? (NGC 281 west)

6.7GHz methanol maser map of Cep-A

Sato, Poster 3-18

Sugiyama, Poster 3-20
Masers in AGB stars

Parallax of semi-regular variable S-Crt

\[ \pi = 2.3 \pm 0.2 \text{ mas} \]

Phase-referencing collocation of SiO $v=1$ and 2 at 43GHz in R-Aqr

Nakagawa, Poster 5-13

Kamohara, Poster 5-11
Conclusions

• We have successfully measured the parallax and proper motions of S269 at 5 kpc to constrain galactic rotation there.

• Angular velocity of LSR is being constrained from proper motion of W49N

--- these results demonstrate potential of VERA for exploring the Milky Way Galaxy

And, more in posters !!