Internal proper motion of 6.7GHz methanol maser in the high-mass star forming region G9.61+0.19

K. Hayashi(1), K. Fujisawa(1), K. Sugiyama(2), K. Motogi(1), K. Hachisuka(1), D. Hirano(1)

1:Yamaguchi University 2:Ibaraki University

Abstract

High-mass stars play a prominent role in Galactic evolution in terms of induction of star formation and generation of heavy elements. The structure and dynamics of accretion disks around high-mass young stellar objects (HMYSOs) have been observed by sub-millimeter and infrared bands, and it has been recognized that high-mass star formation process is similar to that of low-mass stars. However, the detail of accretion process is still unknown. We have made VLBI observations of 6.7 GHz methanol maser emitted from sites of high-mass star formation because the maser is thought to be a good tool for tracing the gas around HMYSOs. We report the result of internal proper motion of maser spots of G9.61+0.19 whose spatial morphology is linear. The proper motion in this source was tend that red-shifted spots and blue-shifted spots are moving north side and south side, respectively. We also expect about the distribution and phenomenon considered from this proper motion.

Introduction

- Accretion disks around HMYSOs

Accretion disks have been thought to be associated with HMYSOs by high-resolution observations at sub-millimeter and infrared bands[1][2]. However, accretion process is unknown.

- VLBI observation of 6.7GHz methanol maser

6.7 GHz methanol maser is a good tool for tracing the motion of accretion disks. This maser is thought to be associated with accretion disks around HMYSOs. So far, proper motion measurements of this maser by VLBI observation have been reported only for small number of sources [3][4][5].

- Our observation

We perform VLBI observation using the East-Asian VLBI Network (EAVN) to detect internal proper motion of 6.7 GHz methanol maser sources[6]. We report the result of internal proper motion of 6.7 GHz methanol maser associated with high-mass star forming region (HMSFR) G9.61+0.19.

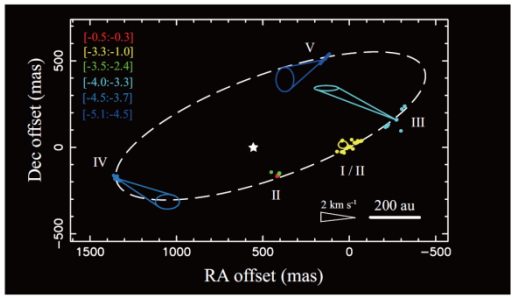
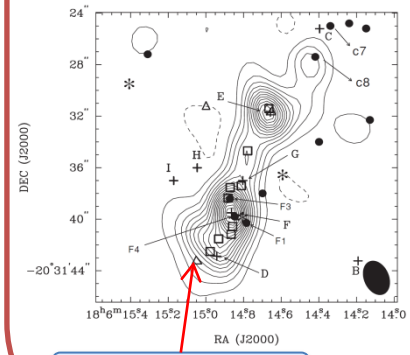


Fig1:Internal proper motion of 6.7 GHz methanol maser in HMSFR Cepheus A (Sugiyama et al. 2014).

G9.61+0.19

- Component D(Fig:2) in HMSFR complex G9.62+0.20[7]
- Distance : 5.2 kpc (Norma Arm)[6][8] [9]
- Systemic Velocity : 4.8 $\mathrm{km \cdot s^{-1}}$ ($CH_3CN(6-5)$)[10]
- Central star : B0.5 zero-age main-sequence (ZAMS) star[10]



Target source

Fig 2 : 860 μm continuum emission image of HMSFR complex G9.62+0.20 (Liu et al. 2011). Plus sigs are centimeter and millimeter continuum component labeled A-I. Open squares and triangles are 22.2 GHz water maser sources and 6.7 GHz methanol maser sources, respectively. Filled circles are near infrared sources. Asterisks are IRAC sources.

Observation

The detail of observation parameter of VLBI monitoring project using EAVN is written in Fujisawa et al. 2014.

Table1 : observation parameter of G9.61+0.19

Date	2011/11/26	2012/9/13	2013/9/20
Telescope※1	VERA, H, S, U, Y	VERA, H, Y	VERA, H, S, Y
Vel. Resolution $[\mathrm{km \cdot s^{-1}}]$	0.176		
Synth. Beam size $[\mathrm{mas^2}]$	7.99×3.00	7.05×3.23	6.59×2.78
Image RMS $[\mathrm{mJy \cdot beam^{-1}}]$	42.8	63.6	78.3

※1 : H : Hitachi, S : Shanghai, U : Usuda, Y : Yamaguchi

Discussion

➢ What is this structure?

- If an edge-on disk:

Radius : 260 AU
LSR Velocity range : $1.76\ \mathrm{km \cdot s^{-1}}$

About 1.0 M_{sun}

※The mass of high mass star is larger than $8M_{\mathrm{sun}}$.

Looking at the part of the disk

➢ What is this proper motion?

Red-shifted spots and blue-shifted spots are moving north side and south side, respectively.

	rotation	accretion	disk wind	disk dissipation	outflow
expansion	x	x	o	o	o

In this future, we will deeply discuss the phenomenon from proper motion

Result

◆ Spatial distribution

- Morphology
  Linear
- Distribution scale ※2
  $95.7 \times 24.2\ \mathrm{mas^2}$
- LSR Velocity range※2
  $6.70 \sim 4.94\ \mathrm{km \cdot s^{-1}}$

※2 : first epoch data

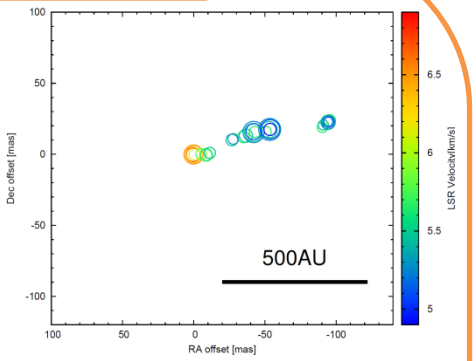


Fig3: Spatial distribution of first epoch in G9.61+0.19.

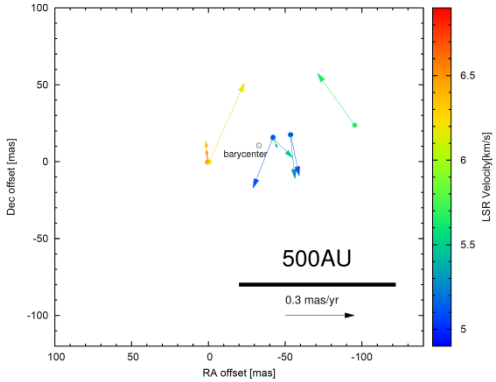


Fig4: Internal proper motion of the maser spots in G9.61+0.19. Open circle is barycenter of spots.

◆ Proper motion

- Common spots in all epochs
  10 spots
- Velocity range
  $0.05 \sim 0.38\ \mathrm{mas \cdot yr^{-1}}$
  ↓ at 5.2 kpc
  $1.24 \sim 9.28\ \mathrm{km \cdot s^{-1}}$

Reference

[1] Kraus, S., Hofmann, K. H., Menten, K. M., et al. 2010, Nature, 466, 339
[2] Sanchez-Monge, A., Cesaroni, R., Beltran, M. T., et al. 2013, A&A, 552, L10
[3] Sugiyama, K., Fujisawa, K., Doi, A., et al. 2014, A&A, 562, A82
[4] Sanna, A., Moscadelli, L., Cesaroni, R., et al. 2010a, A&A, 517, A71
[5] Moscadelli, L., & Goddi, C. 2014, arXiv:1404.3957
[6] Fujisawa, K., Sugiyama, K., Motogi, K., et al. 2014, PASJ, 66, 31
[7] Liu, T; Wu, Y; Liu, S-Y, et al 2011, APJ, 730, 102
[8] Sanna, A., Reid, M. J., Moscadelli, L., et al. 2009, ApJ, 706, 464
[9] Sanna, A., Reid, M. J., Menten, L. M., et al. 2014, ApJ, 781,108
[10] Hofner, P., & Churchwell, E. 1996, A&AS, 120, 283