VLBI imaging of 44 GHz methanol maser sources with KVN+VERA array

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Introduction:
- About 44 GHz methanol masers (Class I) and 6.7 GHz methanol masers (Class II).

Observation:
- KVN+VERA observation of 44 GHz methanol maser toward G18.34+1.78 SW.

Result & Discussion:
- Spectrum (AC/XC) of G18.34+1.78SW
- Spacial distribution of G18.34+1.78SW
- Maser spot size and brightness tempereture of G18.34+1.78SW
Methanol maser around Massive star forming regions

Class I methanol maser (44GHz $7_0-6_1A^+$ etc.)
There are dozens interferometer images, but no VLBI images.

Class II methanol maser (6.7GHz $5_1-6_0A^+$ etc.)
Over 1,000 sources have already detected by large survey projects. There are some statistical study with VLBI imaging.

VLBI can detect proper motions and spacial distributions in circumstellar gases with few milli arc second scale.

G19.01-0.03 (EGO) Cyganowski+2009

8.0 μm 4.5 μm 3.6 μm 24μm
1st imaging observations of 44GHz methanol maser sources with KVN+VERA

- Date: Apr. 8, 2012, UT 17h - 24h
- Line: 44 GHz Class I methanol maser
- Target: G18.34+1.78 SW
- \( D_{\text{kin}} \): \( \sim 2.7 \) kpc
- Data1: KVN(2)+VERA(3) recorded with DIR1000 (16 MHz x 2 ch)
- Data2: KVN(3) recorded with DiFX(16 MHz x 2 ch, \( \sim 0.22 \) km/s/ch)
UV coverage is improved with KVN+VERA

G18.34+1.78 SW (Apr. 8, 2012)

100[M\lambda] = 680[km]

Red: fringe detected.

DIR1000, Mark5B

KVN+VERA observations produce a complementary effect.
Detected AC/XC spectrum

AC: ~400 Jy
XC: ~75 Jy (max) >10 Jy (Typ.)

44GHz methanol maser toward G18.34+1.78 SW (Apr. 8, 2012)
44GHz methanol maser line have almost systemic velocity.
&
44 GHz methanol maser line does not trace the red-shifted component showing in SiO thermal line.
Detected 3 maser features
44 GHz methanol maser toward G18.34+1.78 SW

(0, 0) position is corresponding to
RA: 18h17m49.95s±0.02s
Dec: -12d08'6.48”±1.0”

This is away from MM2 dust peak by
dRA~ -2.2s,
dDec~ -18.5s.
44 GHz methanol (Class I) @MM2

6.7 GHz methanol (Class II) @MM1

MM2 is younger than MM1.

Class I is younger than Class II.

Support Ellingsen+07
Maser spot size & Brightness temperature

**G18.34+1.78SW**

**Spot size:**
- $6.0 \times 3.8 \text{ mas}^2$
  (PA: 51.2°)

**Typical size:**
- $\sim 6 \times 3 \text{ mas}^2$
  ($\sim 16 \times 8 \text{ AU} @ D = 2.7 \text{kpc}$)

From gaussian fitting:
- Peak flux = $14.3 \pm 0.1 \text{ [Jy/beam]}$
- $T_b \sim 9.0 \times 10^9 \text{ [K]}$

Cf. NGC6364I:
- $T_b \sim 3.6 \times 10^8 \text{[K]}$
- Kogan&Slysh 1998
Summary

- VLBI imaging observations of 44 GHz methanol maser were conducted in 2012~2013 with KVN+VERA array.

- For G18.34+1.78 SW (Matsumoto et al.):
  - $V_{\text{LSR}}$ is almost the systemic velocity.
  - Detected 3 compact maser features.
  - Brightness temperatures $\sim 10^{8-9}$[K].
  - Typical maser spot size $\sim 6 \times 3 \text{ mas}^2 (~16 \times 8 \text{AU}^2 @ D = 2.7 \text{kpc})$.

- There are compact maser spots in 44 GHz methanol maser.

- 44 GHz methanol maser is younger than 6.7 GHz methanol maser in G18.34+1.78 region, which support Ellingsen+2007.

- We need more sample for static investigation about maser spot size of 44 GHz methanol maser.
Fin.