Cosmic Masers - from OH to H_0
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Internal Proper Motion of 6.7 GHz Methanol Masers in Ultra Compact HII Region S269

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Abstract. We present the internal proper motion of 6.7-GHz methanol masers in S269, an Ultra Compact HII region. The maser distribution in S269 consists of several maser groups, and the spatial structure of the main groups A and B are consistent with the past VLBI image. The remarkable result of comparing the two VLBI maps is that 6.7-GHz methanol maser distribution and velocity range within each group have been kept for eight years. Angular separation between the two groups A and B increases by 3.6 mas, which corresponds to a velocity of 11.5 km s^{-1}.

Keywords. masers – ISM: HII regions – stars: formation

1. Introduction

S269 is an Ultra Compact HII region in the outer Galaxy (Sharpless 1959), and harbors two bright near-IR sources, IRS1 and IRS2. In IRS2, several star-forming activities such as OH, H_2O masers and CO wings have been detected. Recent near-IR images imply that several H_2 knots are distributed across IRS2, which suggest a bipolar outflow, powered by sources in IRS2 (Jiang *et al.* 2003). The past VLBI observations of the 6.7-GHz methanol maser in S269 detected two groups (A & B), separated by ∼60 mas in 1998 November (Minier *et al.* 2000). The observations have suggested that the 6.7-GHz methanol masers are probably associated with IRS2. We observed the 6.7-GHz methanol masers in S269 in 2006 September using the Yamaguchi 32-m telescope and the Japanese VLBI Network (JVN).

2. Maser distributions and internal proper motion

The spectrum detected with the Yamaguchi 32-m telescope reveals the brightest peak at velocity of 15.2 km s^{-1}, and blue-shifted and red-shifted spectral components at peak velocities of 14.7 and 15.9 km s^{-1}, which are consistent with the past single-dish observations (Szymczak *et al.* 2000, Goedhart *et al.* 2004). Flux densities at the peaks of 14.7, 15.2 and 15.9 km s^{-1} are 9.8, 19.0 and 6.1 Jy, respectively. The flux density values agree well with an extrapolation of the sinusoidal time variation of the methanol maser emission (Goedhart *et al.* 2004).

The maser distribution consists of several maser groups. The most luminous maser spot at 15.2 km s^{-1} belongs to group B. The velocity range of group B is 15.02 to 15.38 km s^{-1}. Group A is the second brightest group, and consists of two maser spots at velocities of 14.67 and 14.85 km s^{-1}, and is located ∼60 mas east from group B. The red-shifted maser component is marginally detected and divided into two spectral channels at velocities of 15.73 and 15.90 km s^{-1} with the JVN. The spots form another

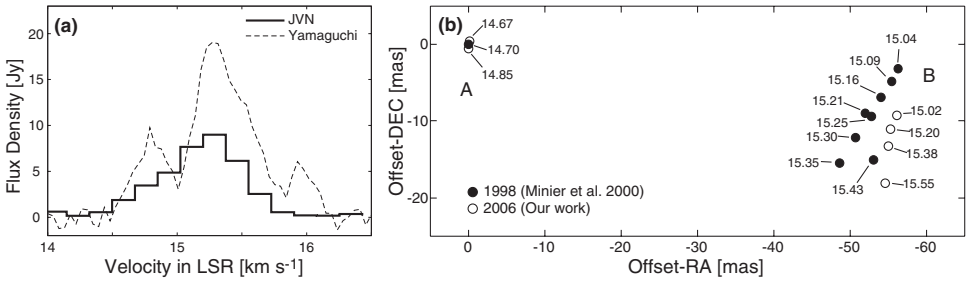

Figure 1. (a) The cross-power spectrum obtained from our JVN observations on 2006 September 10 (Solid line), and the spectral profile measured with the Yamaguchi 32-m telescope averaged spectra observed from 2006 September 4 to 7 (Dashed line). Velocity resolution is 0.178 km s^{-1} and 0.044 km s^{-1}, respectively. (b) Superposed maps of 6.7-GHz methanol maser distribution in 1998 (Minier *et al.* 2000) and 2006 (our work). For the distribution in 1998, Coordinate origin (0,0) is set to (i) the maser spot at velocity of 14.70 km s^{-1} in 1998, and (ii) the middle point of the two spots at velocity of 14.67 and 14.85 km s^{-1} in 2006.

group, −95 mas west from group A. On the other hand, the blue-shifted maser spots at velocities of 14.32, 14.50, 14.67 and 14.87 km s^{-1} have a wider distribution, spanning 250 mas along the southeast-northwest direction. Those maser spots except for groups A and B are not visible in the EVN observations of 1998 November (Minier *et al.* 2000). The maser peaks at 14.7 and 15.9 km s^{-1} could be at the minimum phase in intensity at that time, as Goedhart *et al.* (2004) has shown.

The structures of groups A and B are consistent with the past VLBI image of Minier *et al.* (2000). The remarkable result of comparing the two VLBI maps is that the 6.7-GHz methanol maser distribution and velocity range within each group have been maintained for eight years. Superposition of the two VLBI maps (Figure 1b) reveals that the distance between the two groups A and B increased by 3.6 mas over 7.8 years, which corresponds to a velocity of 11.5 km s^{-1}. The motion is along the direction of position angle ∼80°, almost parallel to the east-west direction.

The velocity gradient in the overall distribution could roughly be seen along the direction of position angle of ∼80°. However, a more rigorous inspection for the individual maser groups indicates that the velocity gradient is not simple. Velocities of the individual groups spread across the direction at a position angle of ∼80°.

The increasing angular separation between groups A and B could trace the outflow powered by IRS2. In order to confirm the movement, we have performed a follow up observation of the 6.7-GHz methanol masers in October 2011.

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