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The H_2O Maser from the AGN of NGC 1052

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Abstract. We report observations of H_2O maser emission from the AGN of NGC 1052. The velocity range of the maser emission is $1450 \le V_{\rm LSR} \le 1850\,{\rm km\,s^{-1}}$, the most redshifted ever seen from this source. We detected a narrow component with a FWHM of $21\,{\rm km\,s^{-1}}$ in the maser spectrum profile for the first time. The peak flux density of the narrow feature is 47 mJy at $V_{\rm LSR} = 1787\,{\rm km\,s^{-1}}$. Over a short time interval of 3×10^5 sec, the peak flux density and the velocity width of the narrow feature appeared to change by $16 \pm 9\%$ and $-30 \pm 12\%$, respectively, with the peak flux density of the continuum emission simultaneously varying by 21 % .

We assume that the new narrow component is located within 0.05 pc of the AGN. The increasing of the peak flux density and the narrowing of the velocity width of the narrow component imply an increase in the gain of the maser through the excited molecular cloud. Since the continuum and the narrow components brightened simultaneously, the continuum are regarded as the seed photon of the maser, running behind the excited molecular gas. The masers are generated through the XDR where the knots of the continuum jet are amplified. Another possible interpretation is the interaction between the jet from the AGN and the molecular gas.

1. Introduction

Details of the accretion toward the active galactic nuclei (AGN) is still unclear. More than 30 objects are known to emit parsec-scale H_2O megamasers near the AGN, and thus H_2O maser observations provide significant information. H_2O masers are used to measure the velocity and the position of the molecular gas with the precision of $\sim 0.1\,{\rm km\,s^{-1}}$ and ~ 0.01 pc, respectively. Most megamaser objects have a narrow feature $\lesssim 20\,{\rm km\,s^{-1}}$ in their spectra, while only three objects cover a broad range $\gtrsim 100\,{\rm km\,s^{-1}}$. NGC 1052 is the nearest in the three, at a redshift: $Z = 0.0049$ ($V_{sys} = 1459.1\,{\rm km\,s^{-1}}$) (Knapp, Faber & Gallagher. 1978), and has symmetric double-sided jets (Jones, Wrobel & Shaffer. 1984). In NGC 1052 any narrow features of the masers had not appeared (Braatz et al. 2003). Claussen et al. (1998) reported that there is a gradient between the velocity and the position of the maser by $\sim 100\,{\rm km\,s^{-1}}$, and that the masers located along the western-receding jet. The motion of the bi-symmetric jets inclined 57° along the line of sight is estimated of $\sim 0.26\,c$ ($H_0 = 65\,{\rm km\,s^{-1}\,Mpc^{-1}}$) (Vermeulen et al. 2003). And there is a trous perpendicular to the jet, and the western-receding jet is attenuated by free-free absorption (FFA) in the foreground geometrically thick torus that is consisted of the cold dense plasma (Kameno et al. 2001).

The H_2O masers emerge from the excited molecular gas. An X-ray from the AGN irradiates the molecular gas, and produce a deep X-ray dissociation region (XDR) as the mean free path of X-ray is large. The molecular gas is heated above 400 K and excited. The X-ray luminosity of NGC 1052 is measured of $1.4 \times 10^{41}\,{\rm erg\,s^{-1}}$ (Kadler et al. 2004). In NGC 1052 the XDR could be created in the geometrically thick torus surrounding the AGN.

In the poster, we report the appearance of a new narrow component in the maser spectral of NGC 1052 and refer to the process of the creation of the maser by considering some possible models.

2. Observations & Results

We observed the H_2O maser emission at 22 GHz toward NGC 1052 by using Nobeyama 45-m radio telescope during four days, 2003 May 30 - June 2. A resolutions were $0.26\,{\rm km\,s^{-1}}$ and $1.6\,{\rm km\,s^{-1}}$.The mean system noise temperatures were 189 K on May 30 and 164 K on June 2, on the other hand $400 - 2000$ K on May 31 and June 1, hence the data of these two days were discarded.

The velocity range of the maser emission was $1450 \le V_{\rm LSR} \le 1850\,{\rm km\,s^{-1}}$ (Fig. 1). This is more redshifted than ever observed (Braatz et all. 2003). The peak flux density of the maser emission is 89 mJy at $1786\,{\rm km\,s^{-1}}$. In this maser, we detected a bright, narrow feature of FWHM = $21\,{\rm km\,s^{-1}}$, for the first time (Fig. 2). Its peak flux density is 47 mJy at $V_{\rm LSR} = 1787\,{\rm km\,s^{-1}}$, i.e., redshifted by $328\,{\rm km\,s^{-1}}$ with respect to the systemic velocity. Furthernore the peak flux density of the narrow feature increased from 44.3 ± 2.5 to 51.1 ± 2.6 mJy by 2σ, while the FWHM decreased from 23.1 ± 2.3 to $16.2 \pm 1.0\,{\rm km\,s^{-1}}$ by 2.7σ during May 30 though June 2. At the same time the peak flux density of the continuum emission increased from 642 ± 33 to 775 ± 24 mJy.

3. Discussion

If we suppose the velocity gradient of $\sim 100\,{\rm km\,s^{-1}}$ (Claussen et al. 1998) still applies at the time the new narrow component appeared, the position of the new narrow component is surmised to be within 0.05pc from the center.

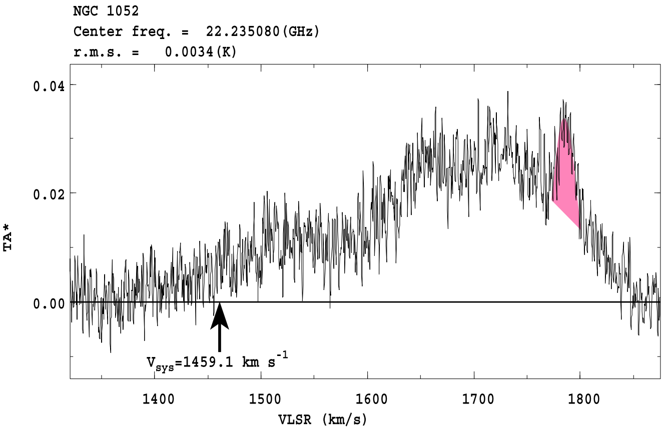

Fig. 1. The H_2O maser spectrum.

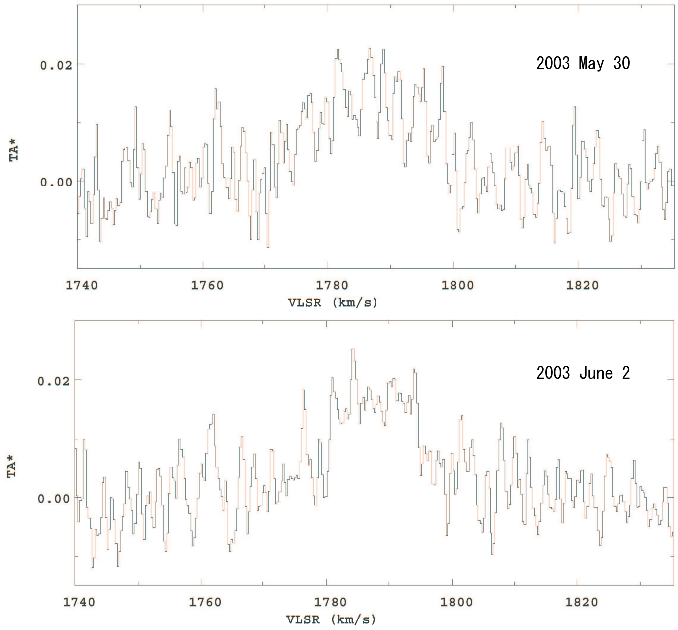

Fig. 2. A spectral profile of the new narrow component on May 30 (top) and June 2 (bottom).

An output intensity of masers is the product of an input intensity of seed photons and a gain of masers (Dopita & Sutherland 2003). Thus the increase of the peak flux density and the decrease of the velocity width of the narrow component suggest that the gain of the maser emission increases.

Since the masers are located in only the western-receding jet (Claussen et al. 1998), and the molecular torus is in front of the western-receding jet along the line of sight, we can assume that the increasing of the continuum implies increasing of the input photons, and therefore the receding jet provides the seed photons for the maser. In this model the seed photons from the continuum jet are amplified through XDR, and the gain increases and the intensity of the maser emission increases as a result.

Another possible model is the molecular gas, excited by the interaction with the jet, emits the maser. For the jet velocity of $\sim 0.26\ c\,\mathrm{km\,s^{-1}}$ (Vermeulen et al. 2003), a kinetic power of the jet could be estimated of $\sim 6 \times 10^{42}\,\mathrm{erg\,s^{-1}}$. Thus the estimated power of the jet exceeds the observed X-ray luminosity of $1,4 \times 10^{41}\,\mathrm{erg\,s^{-1}}$ (Kadler et al. 2004), but this can arise (Isobe 2002). In this model the new narrow feature could be produced as the maser emerged through the molecular gas, excited by the shock with the jet, which extends along the line of sight. However it is unclear why only redshifted masers were detected, but blueshifted masers are not.

4. Conclusions

We observed the H_2O maser of the AGN of NGC 1052. The range of the maser emissoin is most redshifted ever seen for NGC 1052. We detected a narrow component, FWHM = $21\,\mathrm{km\,s^{-1}}$ and the peak flux density ~ 47 mJy, in the maser spectrum profile for the first time. The peak flux density and the velocity width of the narrow feature increased by 16 ± 9 % and narrowed by 30 ± 12 %, respectively. And the peak flux density of the continuum emission also brightened by 21 % at the same time. The increasing of the peak flax density and the narrowing of the velocity width of the narrow component imply an increase in the gain of the maser through the excited molecular cloud. Therefore the possible model is the maser result from the continuum component behind the torus amplified through XDR. Alternatively, it may be possible by the interaction between the jet from the AGN and the molecular gas.

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