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A preview look at the maser cloudlet evolution in the HMSFR IRAS 20126+4104

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We present preview results of the milliarcsecond resolution study of the 6.7 GHz methanol maser evolution in the high-mass star-forming region IRAS 20126+4104 (also known as G78.122+3.633). Using the data of the European VLBI Network (EVN) for 2019 and of the EVN Archive, we have analysed the 15-year evolution of single maser cloudlets. The source has been variable, as noted in the single-dish monitoring using the Irbene RT-32 and RT-16 radio telescopes. The VLBI imaging shows that the overall maser structure has stayed almost unchanged over 15 years. However, detailed analysis indicates that the maser cloudlets may change significantly.

Keywords: HMSFR IRAS 20126+4104, VLBI, methanol masers

1 Introduction

The formation of high-mass stars is an interesting subject in modern astronomy. High-mass star-forming regions (HMSFRs) are difficult to study in detail due to distances to them, their heavy obscuration, and rapid evolution. The 6.7 GHz methanol maser transition is therefore important in these types of studies since it is associated with the environment of HMSFRs [1, 2]. In the last decades, very large baseline interferometry (VLBI) milliarcsecond (mas) scale studies showed a variety of structures, from simple, linear to more complex like arcs, rings and without any regularities [3–5]. We monitored the HMSFR G78.122+3.633 (also known as IRAS 20126+4104) using the Irbene radio telescopes at the (5_1-6_0 A^+) 6668.519 MHz methanol maser line and also observed it using the European VLBI Network (EVN). Here we present preliminary results of the variability of the source and the single maser cloudlets' analysis.

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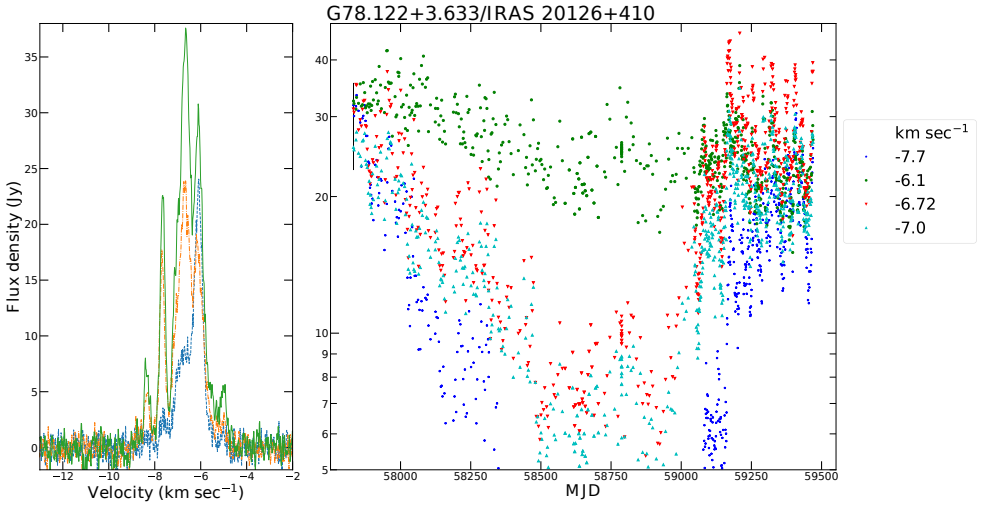


Figure 1 The spectra of the 6.7 GHz methanol maser line in IRAS 20126+4104 / G78.122+3.633 in three epochs (left). The variability of different spectral features as indicated (right).

2 Observations

Single dish monitoring for these three sources was carried out by the Irbene radio telescopes starting from March 2017 [6]. Observations were made seven times per month on average with the standard setup for methanol maser monitoring (1.5 MHz band, 0.022 km s^{-1} spectral resolution and 15 min signal accumulation time). Due to the interesting behavior of the target, we successfully applied the EVN observations. These were carried out on October 31, 2019 under the program code EA063. The standard spectral line setup at C band was used. Data were reduced with the Astronomical Image Processing System (AIPS) following the standard data processing procedures and guidelines. In order to compare the structure variability, we extracted previous data for the target from the EVN archive (http://jive.nl/select-experiment), projects EL032 (PI: van Langevelde), EM64C and EM64D (PI: Moscadelli) and ES66E (PI: Surcis).

3 Results

The HMSFR IRAS 20126+4104 / G78.122+3.633 has been monitored for 4 full years from March 2017 to August 2021. The results are summarized in Fig. 1. Shortly after the beginning of monitoring, blue-shifted lines started dimming indicating the low-activity state of the source. After about a year it has become active and the flux density raised again. Recently, a quasi-periodic and simultaneous variability of all features has been noticed.

We imaged the methanol emission in IRAS 20126+4104 using 9 EVN antennas. The distribution of the spots covers the area of 400 mas times 400 mas (Fig. 2).

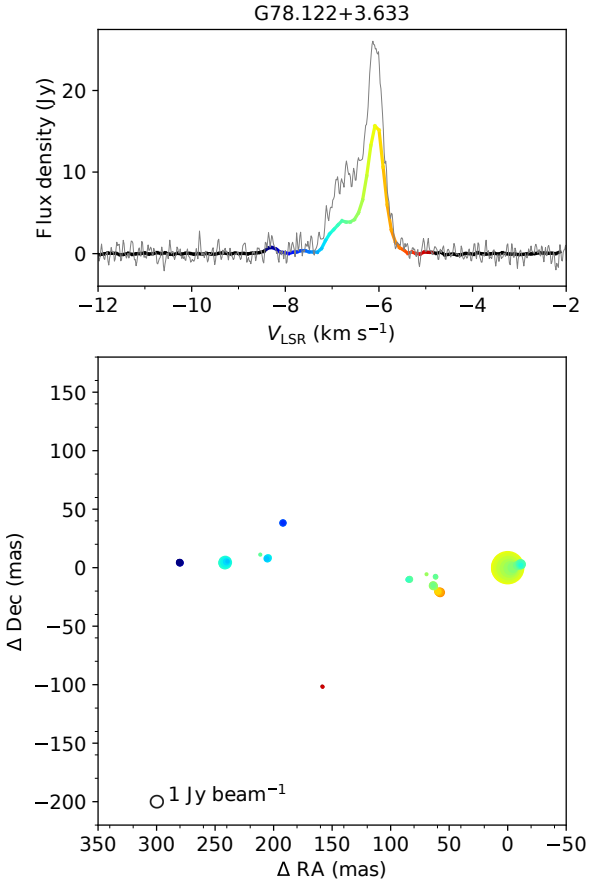


Figure 2 The top panel shows the spectrum obtained using EVN on 31/10/2019 and single dish spectra (grey line) obtained by RT-16, the bottom panel shows maser spots' distribution. Their colours correspond to the Local Standard of Rest (LSR) velocities as indicated on the spectrum. Their size is proportional to the logarithm of the peak flux density of each spot.

When we compare with the archive data, we notice that the structure remains stable in the overall morphology and is consistent with [7, 8].

Analysing the variability of the brightest maser cloudlet, we fitted the Gaussian profiles to the spectra and measured the extension of maser distribution. It is presented in Fig. 3. We conclude that an additional structure appeared, enlarging the size of the cloudlet from 13 to 35 au assuming a distance of 1.64 kpc as derived by [7]. Blue-shifted spots appeared in 2009 and were visible in 2019. The values of FWHM of the Gaussian profiles have increased systematically for the red-shifted feature from 0.33 km s^{-1} in 2004 to 0.41 km s^{-1} in 2019. The peak flux varies from heights' value ∼60 Jy in 2007 to a low value ∼8 Jy in 2019. There is a velocity gradient over the whole structure seen in all epochs, its value ranges from 0.107 to 0.492 km s^{-1} mas.

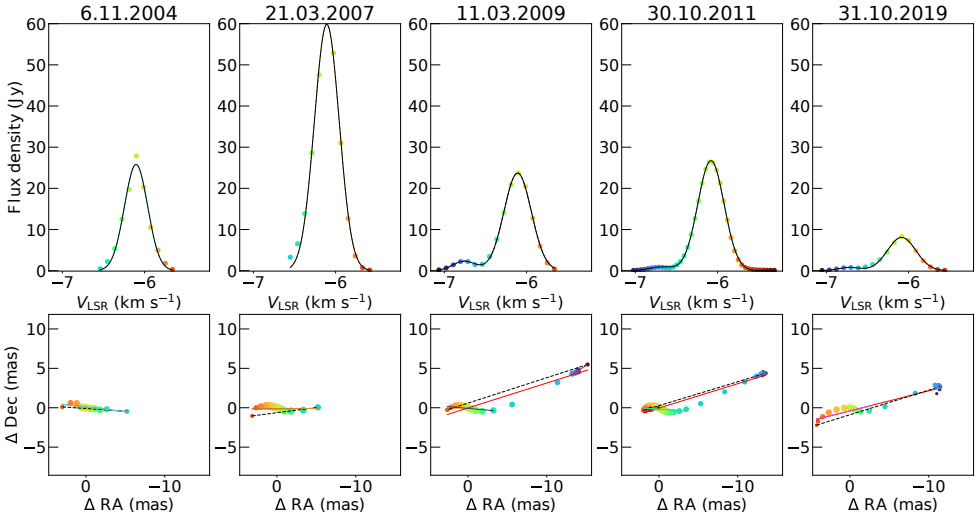


Figure 3 An example of single cloudlet analysis. The brightest cloudlet was detected in all epochs of observations. The solid lines represent the Gaussian profiles fitted to the spectra on the top panels, and the major axes of the spot distributions on the bottom panels. The (0,0) point is centred to the brightest spot at the LSR velocity of –6.086 km s^{-1}. The dotted lines represent the maximum separations between two spots.

4 Conclusions

Preliminary results from EVN observations of IRAS 20126+4104 suggest that the overall structure of the methanol maser cloudlets' positions has been stable over a period of 15 years. However, the individual cloudlet morphology and flux density have been variable. In total, we found six cloudlets that were detected in all epochs of EVN observations. They show a variability in the internal structure, and may indicate a rotation of the whole maser cloudlet. The majority of cloudlets are elongated with the typical size of 5 mas (i.e. 8.5 au) with the velocity gradients of 0.13 km s^{-1} au^{-1}.

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