EVLA Continuum Observations of the IRDC Core G11.11-0.12P1

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Abstract

Infrared Dark Clouds (IRDC) are cold, dense molecular clouds that contain compact and massive cores. Observational evidence suggests that these cores are hosting the earliest stage of high mass star formation. To understand the small scale structure and the physical processes in IRDCs, high angular resolution observations are needed. The IRDC core G11.11-0.12P1 contains water (H_2O) and methanol (CH_3OH) maser emission which are tracers of high mass star formation. A disk outflow system has been proposed to explain velocity gradients in one of its maser sources. We have used the EVLA to obtain K-band (1.3 cm) and C-band (6 cm) radio continuum observations toward G11.11-0.12P1. We detect compact emission at both wavelengths which are aligned in the direction of the putative outflow. We discuss possible physical mechanisms for the radio emission from this source. Preliminary results are discussed here.

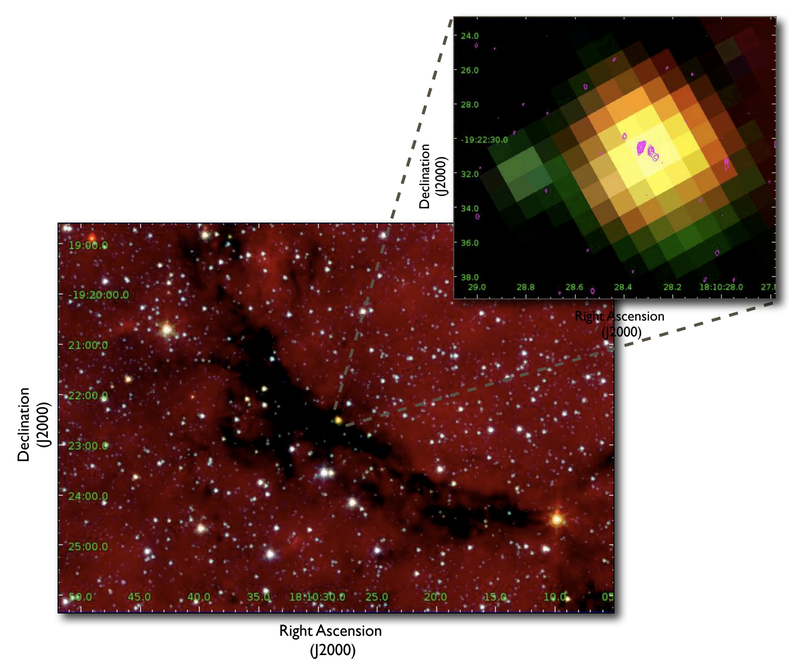

Figure 1: *Spitzer* IRAC GLIMPSE three-color image (3.6-blue, 4.5-green and 8.0-red μm) of the IRDC G11.11-0.12. The figure to the upper right shows an extended 4.5 μm emission in the region towards P1. EVLA 6 cm contours are overlaid.

Introduction

The search for jets and disks toward massive young stellar objects is important to understanding their formation mechanism (Garay et al. 2003). The filamentary IRDC G11.11-0.12, located at a distance of 3.6 kpc (Carey et al. 2003), harbors several star forming cores. G11.11-0.12P1 shows extended 4.5 μm emission (see Figure 1) indicating shocked molecular gas, which is expected when protostellar outflows collide with the surrounding interstellar medium (Cyganowski et al. 2008). Additional indications for the high mass protostellar nature of the central object in G11.11-0.12P1 are the presence of H_2O and CH_3OH maser emission, high FIR luminosity (>1000 $L_\odot$) and high extinction (Pillai et al. 2006). Therefore, G11.11-0.12P1 is a candidate of a massive young stellar object.

EVLA continuum observations provide the high sensitivity and resolution needed for the study of the earliest phases of massive star formation. In this work we have detected G11.11-0.12P1 component sources that were previously unknown in the radio continuum.

Observations

	K-Band	C-Band
Observations	2011 March 20	2011 July 27
Configuration	B	A
Primary Beam	2 arcmin	7 arcmin
Synthesized Beam	$0.7''\times0.3''$	$0.5''\times0.3''$
PA	$-33.4°$	$172.11°$
rms	8 μJy	5 μJy

Table 1: Technical information of EVLA observations of G11.11-0.12P1.

Phase center: α(J2000)= $18^h10^m28^s.40$
δ(J2000)= -19°22′29″.0
Flux calibrator: 3C286
Phase calibrator: J1820-2528

Results

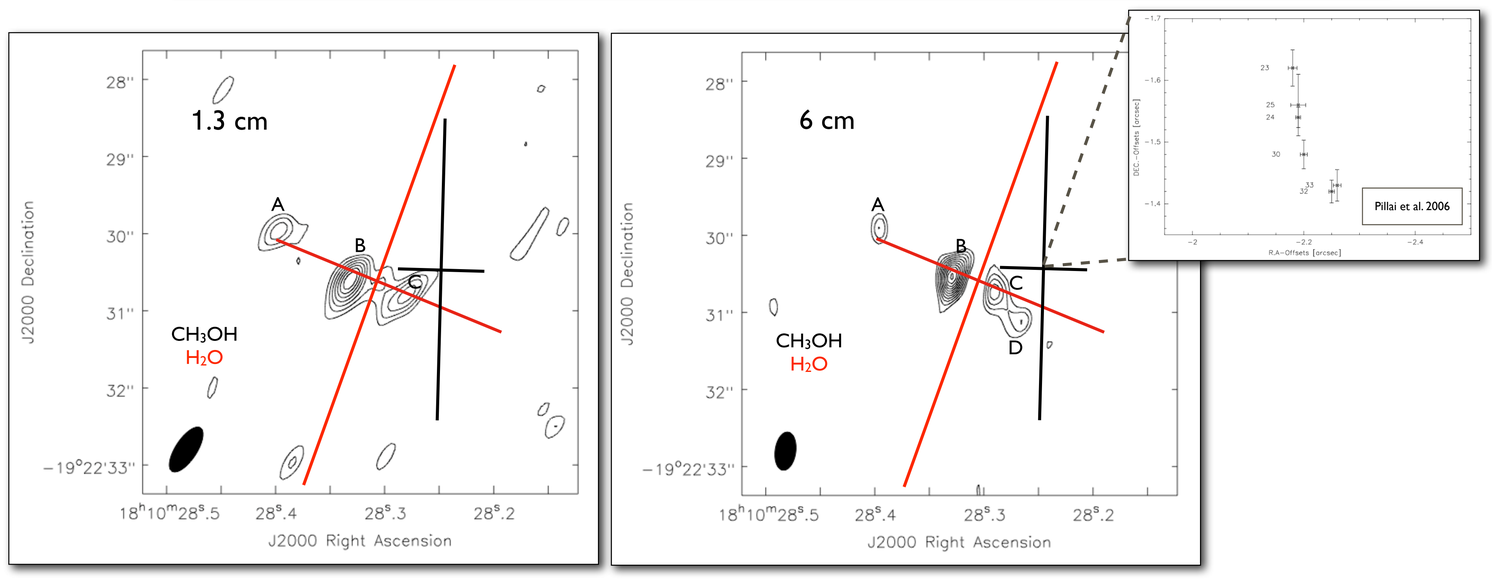

Figure 2: EVLA contour plots of 1.3 and 6 cm continuum emission toward G11.11-0.12P1. The synthesized beam is shown in the lower left corner. Relative contour levels are in steps of 1σ which is 8μJy beam^{-1} starting at 2.5σ for 1.3 cm and 5μJy beam^{-1} starting at 3σ for 6 cm. Crosses indicate the H_2O (red) and CH_3OH (black) maser location as given in Pillai et al. (2006) at 22 GHz and 6.7 GHz, respectively. The components are labeled alphabetically from east to west. The upper right figure shows the velocity structure of the CH_3OH maser which is interpreted as a keplerian disk (Pillai et al. 2006).

Component G11.11-P1	λ (cm)	R.A (J2000)	Decl (J2000)	S_ν (μJy)	I_ν (μJy/beam)	T_B (K)	Spectral index
A	1.3	18 10 28.40	−19 22 30.0	60.7(9.5)	47.1(7.4)	0.65(0.1)	+0.7
	6.0	18 10 28.39	−19 22 29.9	25.0(2.3)	23.6(2.1)	5.38(0.5)	
B	1.3	18 10 28.33	−19 22 30.6	99.3(10.0)	73.4(7.4)	1.07(0.1)	+0.2
	6.0	18 10 28.33	−19 22 30.5	78.4(4.9)	65.2(4.0)	16.89(1.1)	
C	1.3	18 10 28.28	−19 22 30.8	110(21)	39.3(7.4)	1.18(0.2)	+0.6
	6.0	18 10 28.29	−19 22 30.8	49.4(3.6)	32.1(2.4)	10.64(0.8)	
D	1.3	...	...	$< 25^a$	...	...	< -0.2
	6.0	18 10 28.27	−19 22 31.1	34.2(3.1)	25.4(2.3)	7.37(0.8)	

[a] Non-detection. Upper limit is 3σ value in map

Table 2: Continuum parameters of the components observed toward G11.11-0.12P1. The components are labeled in the same fashion as in Figure 2. There was no corresponding component D in the 1.3 cm image.

Discussion

We have detected 4 compact radio continuum sources coincident with the massive protostellar candidate in G11.11-0.12P1. The 4 sources form a linear structure which is oriented nearly perpendicular to the orientation of a putative accretion disk traced by 6.7 GHz methanol maser, thus a likely interpretation of the continuum sources is a highly collimated outflow or jet. The spectral indexes of the sources suggest emission from ionized gas, and the clumpy structure of the jet suggests that the ionization is due to the UV radiation from shocked gas along the flow. Our observations indicate that jets can be present in a very early evolutionary phase of massive star formation.

References

- Carey et al., 1998, ApJ, 508, 721
- Cyganowski et al., 2008, AJ, 136, 2391
- Garay et al., 2003, ApJ, 587, 739
- Pillai et al., 2006, A&A, 447, 929

Acknowledgments

We thank Tushara Pillai for helpful information about the maser emission. P. H. acknowledges partial support from NSF grant AST 0908901.