CO Studies of IRAS 00117+6412

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Abstract CO $J = 3-2$ maps and ^{13}CO $J = 1-0$ maps were made for IRAS 00117+6412. A bipolar molecular outflow is certified, which is driven by the center IRAS source. There is approximately 45.5 $M_\odot$ of molecular materials in the outflow. The mass loss rate is 0.04×10^{-3} $M_\odot$/yr, and the bolometric luminosity and dust temperature are 4.6×10^3 $L_\odot$ and 30.2 K, respectively. The spectrum also exhibits a well-behaved power-law fit. The molecular core has 4×10^3 $M_\odot$ materials. All of the results indicate that it is a high mass star formation region and has a short time scale. The FIR source is deeply embedded in dense molecular core and associated with two water masers and it may be the driving source of the outflow.

Key words star: formation – ISM: clouds, outflow –ISM: kinematics and dynamics

1 Introduction

Bipolar outflows play a very important role in the course of star formation (Lada 1985). They provide abundant information for dynamic process of star formation. Search of outflows and their driving sources is also a crucial work.

IRAS 00117+6412 (R.A.= $00^h11^m44.6^s$, Dec.= $64^\circ\,12'04.01''$) is an infrared source and associated with water masers. Wu et al. (2001) have already shown its bolometric features as a candidate of outflow with CO $J = 1-0$ observations. Their results indicated that the source had evidence of red-wing, which implies it is a good candidate for our research on molecular cores and outflows.

2 Observation

Observation of the CO $J = 3-2$ transition was made with KOSMA 3 m telescope in April, 1999. The half-power beam width of the telescope was $80''$ at 345 GHz. The pointing accuracy was better than $10''$. The main beam efficiency was 100% at 345 GHz and the forward efficiency was 93%.

Another observation was conducted with PMO 13.7 m telescope on ^{13}CO $J = 1-0$ transition in March, 2002. The central frequency is 110.2 GHz with the efficiency of 50%. The beam size is $55''$, and the pointing and tracking accuracy is better than $10''$.

The CO data were reduced by CLASS and Greg, and the ^{13}CO data by Drawspec.

3 Results and Conclusion

3.1 Dense Molecular Core

From the maps of the region, we can see IRAS 00117+6412 has an isolated core, with relatively stable ambient. It has two water masers associated with the center FIR source, which indicates it is still undergoing a young evolution stage (Zhang et al. 2001). With the data of Wu et al. (2001), we have derived the mass of the molecular core, to be $4\times10^3\,\mathrm{M}_\odot$. We also get the bolometric luminosity of $4.6\times10^3\ \mathrm{L}_\odot$ with IRAS fluxes. The source satisfies the criteria of Wood & Churchwell (1989), but it is not really an ultra compact HII region. It is probably a high mass star formation region (HMSF).

Another FIR source, IRAS 00115+6413 is located to the northwest of the center. Because it is far away from the center of the core, it cannot be the driving source.

3.2 The outflow

The morphology and contours of the FIR source IRAS 00117+6412 show that there is a bipolar outflow in the region, with a scale of 0.81pc. We derived the distance of 3.3 kpc using the rotational curve (Wouterlovt & Brand, 1989). Under the assumption that the $T_{\mathrm{ex}} = 15\,\mathrm{K}$ and $[\mathrm{H_2}]/[\mathrm{CO}]=10^{-4}$, we also obtained the parameters of the outflow, which is listed in Table 1.

Table 1 The parameters of the molecular outflow

D	$R_{\max}$	Mass	M_{lost}	P	E	t	L_{bol}	L_{mech}	F	T_D
kpc	pc	$\mathrm{M}_\odot$	$\mathrm{M}_\odot\cdot\mathrm{yr}^{-1}$	$\mathrm{M}_\odot\cdot\mathrm{km}\cdot\mathrm{s}^{-1}$	erg	yr	$\mathrm{L}_\odot$	$\mathrm{L}_\odot$	$\mathrm{M}_\odot\cdot\mathrm{km}\cdot\mathrm{s}^{-1}\cdot\mathrm{yr}^{-1}$	K
3.3	0.81	45.5	4×10^{-5}	321.8	8×10^{47}	0.8×10^5	4.6×10^5	8.2	4×10^{-3}	30.2

There is $45.5\,\mathrm{M}_\odot$ materials in the high velocity components and the mass loss rate is $4\times10^{-5}\,\mathrm{M}_\odot/\mathrm{yr}$. Its momentum is $321.8\,\mathrm{M}_\odot$ km/s, and the kinetic energy is 0.8×10^{47} erg, all of which are obviously larger than those of low mass stars.

IRAS 00117+6412 may be the driving source, because it is close to the center and associated with water masers. The ratios $\log(\frac{L_{\mathrm{bol}}}{L_{\mathrm{co}}}) \ll 1$,& $\frac{L\mathrm{bol}}{cF} \ll 1$, suggest that despite of the strong radiation from the center source, the radiation pressure still cannot supply enough force to drive such a massive outflow (Wu et al. 1998).

To see its difference from low mass stars, we assume T_A as a function of $|V_0 - V_{\mathrm{LSR}}|$ and get a power-law fit. The result shows there is a break between the high velocity and low velocity components in the red lobe. The slope of both blue and red lobes is relatively high than those of low mass stars (Shepherd et al. 1998), which shows the difference between high mass stars and low mass ones, although they maybe have a similar evolution process (e.g. Henning et al. 2000, Zhang et al. 2001).

4 Summary

In summary, we have presented the results of IRAS 00117+6412 by mapping the CO $J = 3-2$& ^{13}CO $J = 1-0$ transition. The molecular core is isolated and relatively young. Its mass is $4\times10^3\,\mathrm{M}_\odot$. An asymmetric bipolar outflow with $45.5\,\mathrm{M}_\odot$ materials is identified, its kinetic energy, luminosity, and other parameters are derived too. The center FIR source seems to be the driving source. And its difference with low mass outflows is highlighted by the power-fit.

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