High-Velocity Gas Near S106

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Abstract We here presented the mapping data of ^{12}CO $J = 1 - 0$ and found there was a complex bipolar molecular outflow, which had four red clumps and two blue clumps. We analyzed the outflow and calculated the parameters of it and found it was a massive outflow. From Simbad data we found many IRS sources and masers near this region. We drew a conclusion that S106 was a well-developed star formation region.

1 Introduction

S106 is one of the most studied nearby regions of massive star formation (Bally & Yu 1998) located at a distance of 600 pc (Eiroa, Elsasser & Lahulla 1979), and has a bipolar H II region (Sharpless 1959). An elongated double structure of molecular line emission was found for HCN (Churchwell & Bieging 1982), CO and its isotopes (Bally & Scoville 1982) and NH3 (Little et al 1979), which was interpreted as a biconical nebulae constitute. There are two lobes of emission surround an obscured central star.

2 Observations and Results

The observation of the ^{12}CO $J = 1-0$ mapping data was carried out by the 13.7 m radio telescope of Qinghai Observing Station in April 2001. The 14×17 points maps were made centered on S106. The grid spacing was near $1'$, and the integration time was 2 minutes for each position. Data were reduced with Drawspec software package, and Winsurf was used for analysis of the contours.

We analyzed every CO spectrum, calculated the emission intensities and made contours for S106. We found that it has three primary physical characteristics: the high velocity, the large measurable extents and the bipolar structure (See Figure 1). These three points suggest that the wings result in outflow motions rather than rotation, turbulence or collapse (Lada 1985, Myers 1988).

The contour map of wing integrated intensity of S106, integrated over the red wing ($4 \leq$ VLSR$\leq$ 12 km/s) (solid) from 30 K km/s to 120 K km/s and the blue wing ($-13 \leq$ VLSR ≤ -3.5 km/s) (dashed) from 30 K km/s to 120 K km/s. they increase in steps of 10 K km/s. The stars represent the IRAS sources and the triangles represent the IRS sources. There are also two masers near IRAS20255+3712 (the central star), which are lapped, so we did not mark them. The coordinates of these objects are listed in Table 1.

Table 1 The coordinates of Objects in the region

Source Name	$\alpha(1950)$	$\delta(1950)$
IRAS20252+3717	$20^h25^m12.0^s$	$+37°17'12''$
IRAS20255+3712	$20^h25^m33.5^s$	$+37°12'50''$
IRAS20259+3708	$20^h25^m59.6^s$	$+37°08'14''$
IRS1	$20^h25^m32.2^s$	$+37°12'36''$
IRS2	$20^h25^m32.5^s$	$+37°13'00''$
IRS3	$20^h25^m32.8^s$	$+37°12'45''$
IRS3S	$20^h25^m33.9^s$	$+37°12'47''$
IRS3W	$20^h25^m33.6^s$	$+37°12'50''$
IRS4	$20^h25^m32.8^s$	$+37°12'50''$
IRS5	$20^h25^m33.9^s$	$+37°12'59''$
IRS6	$20^h25^m34.1^s$	$+37°12'29''$
IRS7	$20^h25^m34.5^s$	$+37°12'41''$
IRS8	$20^h25^m34.9^s$	$+37°13'03''$
Maser076.36-00.60	$20^h25^m32.8^s$	$+37°12'54''$
Onsala 134	$20^h25^m32.7^s$	$+37°12'54''$

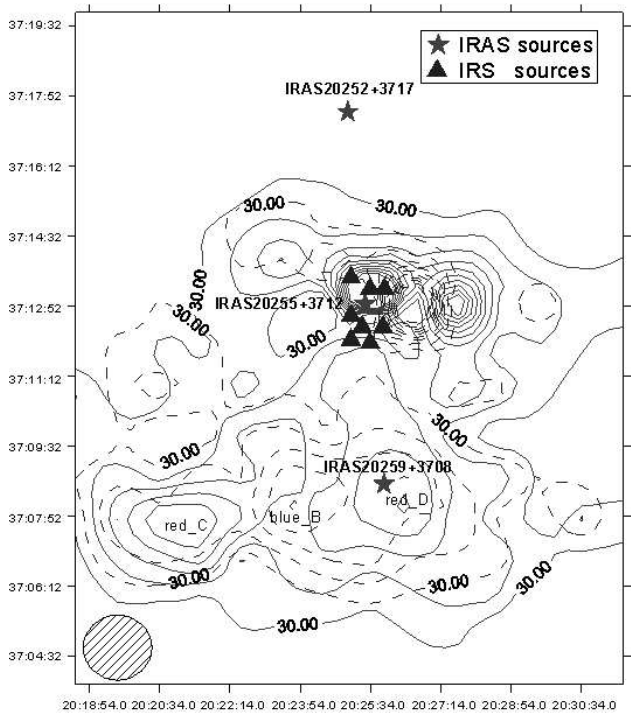

Fig. 1 The contour map of wing integrated intensity of S106

There is a bipolar outflow in this region. The center of S106 is $\alpha(1950) = 20^h25^m34.0^s$, $\delta(1950) = 37°12'52''$. We can see that the red-shifted component has four clumps: two are near the center and the other two are marked “red_C” and “red_D”(See Figure 2), which are similar with the ^{13}CO map of S106 (Pipher et al 1970). The blue-shifted component has two clumps:one is near the center, which is among the two red clumps; and the other is marked “blue_B”(See Figure 2), which is among the other two red clumps: “red_C” and “red_D”. IRAS20255+3712 is located near the center of the S106, surrounded by one blue clump and two red clumps; IRAS20259+3708 is surrounded by one blue clump and one red clump;

IRAS20252+3717 is out of the integrated intensity region. The reason of the complexity of this outflow may be that the first two sources both drive their own outflows, in other word, the clumps may come from different outflows. The radiation of IRAS20252+371 may impact this region and lead to the compact part near the source.

By using the method by Goldsmith et al. (1984), we calculated the outflow parameters. Under the assumption of LTE and the optical thin wing, the total column density of CO molecules can be calculated as following:

$$N_{\rm CO} = \frac{4.2\times 10^{13}}{\exp(-5.5/T_{\rm ex})} T_{\rm ex} \int T_R(v)dv ({\rm cm}^{-2})$$

Here, $T_{\rm ex}$ is excited temperature and T_R is the radiation temperature. If we further assume a CO abundance $X_{\rm CO} = [{\rm CO}]/[{\rm H_2}] = 10^{-4}$, the column density of the high-velocity gas is $N = N_{\rm CO}/X_{\rm CO}$. All results of calculation are given in Table 2. Table 3 lists the parameters of these three IRAS sources.

Table 2 Outflow parameters

size (pc)	V ($\rm km\,s^{-1}$)	M ($\rm M_\odot$)	P ($\rm M_\odot\,km\,s^{-1}$)	E (erg)
0.6	8.63	151.92	1312.56	1.09×10^{47}
t (yr)	F($\rm M_\odot\,km\,s^{-1}\,yr^{-1}$)	$L_{\rm mech}$ ($L_\odot$)	$M_{\rm loss}$ ($\rm M_\odot\,yr^{-1}$)	
8.22×10^4	1.59×10^{-2}	10.8	5.3×10^{-5}	

Table 3 Parameters of the IRAS sources

Source Name	F_{12}(Jy)	F_{25}(Jy)	F_{60}(Jy)	F_{100}(Jy)	$L_{\rm bol}$ ($L_\odot$)
IRAS20252+3717	2.07	1.10	16.8	16.8	2621.74
IRAS20255+3712	205	2510	10100	13100	10693.11
IRAS20259+3708	1.26	5.44	31.0	113	46.65

From these Tables, we know this outflow is middle-size one and the bolometric luminosity of IRAS20255+3712 is $10693.11L_\odot$, which is a massive star. We compared the bolometric luminosity with the mechanical luminosity, and found that the ratio is 990.10, which means that the radiation of the central young stellar object (YSO) can drive the outflow.

3 Summary

We have observed the high-velocity ^{12}CO gas near S106 and found the complex bipolar molecular outflow. We estimated the parameters by using the method of Goldsmith et al (1984) and found it was a middle-size molecular outflow.

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References

Eiroa C., Elsasser H., Labulla J.F., A&A, 1979, 74: 89
Roberts D.A., Crutcher R.M., Troland T.H., ApJ, 1995, 442: 208
Churchwell E., Bieging J.H., ApJ, 1982, 258: 515
Jijina J., Myers P.C., Fred Database C., ApJS, 1999, 125: 161
Bally J., Scoville N.Z., ApJ, 1982, 255: 497
Little L.T., Macdonald G.H., Riley P.W., et al, MNRAS, 1979, 188: 429
Goldsmith P.F., Snell R.L., Hemeon-Heyer M., et al, ApJ, 1984, 286: 599
Sharpless S., ApJS, 1959, 4: 257
Wood, Douglas O.S., Ed Churchwell, ApJ, 1989, 340: 265