

RADIO MAPPING OBSERVATION OF L1521F USING HCN(J=1-0) LINE



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ABSTRACT : We investigate the kinematical properties of the L1521F-IRS in Taurus Molecular Cloud region using observations in HCN(J=1-0) hyperfine lines. 12m telescope of Arizona Radio Observatory was used. Observing coverage is about 3.7'x3.7' area around the center of the target with 5x5 grid mapping. L1521F which harbors the faint infrared L1521F-IRS, displays a strong central concentration of integrated intensity in HCN without serious molecular depletion. We find that blue asymmetric and red asymmetric profiles are distributed in East-West direction, and that this distribution of HCN line profiles is well coincident with the conic shape of the Spitzer's image of L1521F-IRS, confirming the existence of gaseous bipolar outflows emanating from L1521F-IRS.

1 INTRODUCTION

BACKGROUND

Table 1. Kinematical properties of the baby star L1521F-IRS

Observation	Result
HCO(3-2) Mapping	Ohnishi et al., 1999 Prominent feature at wings of profile
CS(2-1) Pointing	Lee et al., 1999 Crapsi et al., 2005 Significant evolved starless core
CS(2-1) Mapping	Lee et al., 2001 Mixture of blue and red asymmetric features
CO(2-1) Mapping	Lee et al., 2001 No evidence of bipolar outflow
Spitzer IRS	Young et al., 2004 Bourke et al., 2006 Discovered an infrared source in the center of L1521F
HCN(1-0) Pointing	Sohn et al., 2007 Complicated kinematics in the core

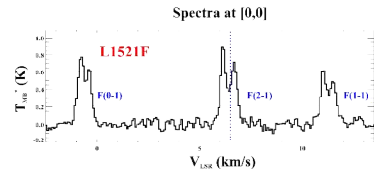


Figure 1. HCN(1-0) profile of L1521F in the central region (Blue dashed line indicates the velocity of N₂H⁺)

POINT

- ★ HCN(1-0) mapping observation around L1521F-IRS
 - ★ Investigating kinematics occurred from dense core region
 - A blue asymmetry profile is not necessarily undergoes the inward motion
 - The asymmetry of the spectra maybe in reality due to other motions such as rotation or outflow
 - ★ Mapping observation with high spatial resolution
 - Kinematical structure of L1521F-IRS
 - Probing spatial variation of the inward motion

2 OBSERVATIONS

SOURCE

★ L1521F-IRS

- ★ The "critical state" under the gravitational instability
 - Density : n(H₂) ~ 10⁶/cm³
 - High CO depletion rate in the central 20"

Table 2. L1521F-IRS source parameters

R.A.(J2000)	Dec.(J2000)	L _{IR} (L _⊙)	Distance(pc)
04:28:39.8	+26:51:35.0	0.02	140

OBSERVATION

★ Arizona Radio Observation (ARO), Tucson, U.S.A.

Figure 2. ARO 12m

Table 3. HCN(1-0) observation parameters

Telescope	<T _{MB} >	<VN ₂ H ⁺ >(km/s)	R _{CS} (pc)
ARO 12m	0.72	6.48±0.01	0.07

T _{sys} (K)	HPBW	Efficiency	Mode
160-210	70" (88GHz)	0.95	FSW

Table 4. Millimeter Autocorrelator (MAC) Configurations

Total Bandwidth (MHz)	Useable Bandwidth (MHz)	Channels	Δν ² (kHz)	Spectral Resolution (kHz)
100	75	16384	6.1	12.2

★ HCN(1-0) : 3 hyperfine lines

- HCN(J=1-0, F=1-1) : 88630.4157 (±0.001) MHz
- HCN(J=1-0, F=2-1) : 88631.8473 (±0.001) MHz
- HCN(J=1-0, F=0-1) : 88633.9360 (±0.001) MHz

★ Analysis Software

- ★ CLASS(Buisson et al., 1994) and IDL

3 RESULTS

SPECTRUM

★ HCN Spectrum Profile around L1521F-IRS (5x5 mapping, ~44" interval)

Figure 3. HCN profile of L1521F. Blue asymmetries with double peaks are shown near the central region. Red asymmetries appear in the outer part of this plot. The spectra were obtained in the ~44" interval.

- ★ Data
 - S/N > 5,
 - Main hyperfine line (J=1-0, F=2-1) : T_{MB} = 1.7 K
 - > S/N=10
- ★ Features
 - A strong central concentration of intensity in all three HCN hyperfines
 - Brighter blue components in one side and brighter red components in the other side of the core center
 - Skewed toward shorter wavelength clearly than blue components of CS spectra

INTEGRATED INTENSITY MAP

★ Integrated intensity distributions of HCN(1-0) hyperfine lines and N₂H⁺(1-0)

Figure 4. Integrated intensity distributions of HCN(1-0) hyperfine lines and N₂H⁺(1-0)

- ★ The cross-scanned integrated intensity profile of HCN and N₂H⁺
 - Very good correlation with each other
 - No central dip in the intensity map of HCN
 - R_{HCN}(0.06 pc) ≲ R_{CS}(0.07 pc)
 - Useful to trace high dense region

δV HCN

★ The degree of a line asymmetry quantitatively

$$\delta V = \frac{V_{HCN(F=i-j)} - V_{N_2H^+}}{\Delta V_{N_2H^+}}$$

(Mardones et al. 1997)

★ Number distribution of δV

Figure 6. Histogram of δV for L1521F-IRS

Table 4. Related parameters

Hyperfine (N)	<δV _{HCN(F=i-j)} >	<δV _{HCN} > - <δV _{CS} >
F=0-1 (14)	6.46±0.04 km/s	-0.15±0.12
F=1-1 (14)	6.46±0.04 km/s	-0.31±0.18
F=2-1 (14)	6.46±0.04 km/s	-0.71±0.19

T_B/T_R DISTRIBUTION

★ Derive peak intensity ratio of the blue (T_B) to the red components (T_R)

★ A systematic increase or decrease of T_B/T_R on either side

Figure 7. The T_B/T_R distribution for each HCN hyperfine for L1521F-IRS. A half maximum contour of N₂H⁺ intensity is superimposed in each panel. The regions with T_B/T_R>1 are shown by the blue color and the region with T_B/T_R<1 is in red color. In blue region, the brighter part indicates the higher T_B/T_R, whereas the brighter part indicates the lower T_B/T_R in red regions

4 FUTURE WORK

OTHER SOURCES

★ L1544, L1552, L183, L1689B, L694-2, and L1197

Figure 7. Integrated intensity distributions of HCN(1-0) hyperfine lines and N₂H⁺(1-0) and the T_B/T_R distribution for each HCN hyperfine.

MODEL FITTING

★ Analytic radiative transfer model

- ★ Density and abundance profile
- ★ Monte Carlo model fitting

Figure 8. Density and abundance profile (Lee et al., 2000)

5 SUMMARY

- ★ L1521F-IRS displays a strong central concentration of integrated intensity in all three HCN hyperfine lines without significant molecular depletion.
- ★ A systematic increase or decrease of T_B/T_R on either side of the axis that runs through the core center.
- ★ Blue asymmetric and red asymmetric profiles are distributed in East-West direction of L1521F-IRS.
- ★ The distribution of kinematical motion is well coincident with the conic shape of the Spitzer's images of gaseous bipolar outflows emanating from L1521F-IRS.

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