Spectral Line Survey of R CrA IRS7B with ASTE II

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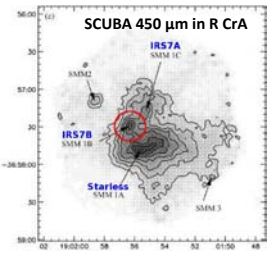
Abstract We have conducted a spectral line survey in the 332 - 364 GHz band with ASTE toward a low mass class 0 protostar in the Corona Australis (R CrA IRS7B), which has been recognized as a hot corino candidate because of its bright emissions of H_2CO and CH_3OH. We have also performed supplementary observations in the 450 GHz band. In total, 16 molecular species and 16 isotopomers are identified. Strong emissions of CN, and CCH are observed, whereas, complex organic molecules and long carbon-chain molecules are not detected. The rotation temperature of CH_3OH is evaluated to be ~31 K, which is much lower than that in the typical hot corino IRAS 16293-2422 (~85 K). The deuterium fractionation ratios for CCH and H_2CO are obtained to be 0.05-0.04, which are significantly lower than that found in the hot corino. Furthermore, c-C_3H_2, whose production pathway is related to carbon-chain molecules, is abundant, and its rotation temperature is similar to that of CH_3OH. From these results, it is likely that the RCrA IRS7B would be a intermediate characteristic between the hot corinos and the WCCC sources. Alternatively, the photodissociation effect by the Herbig Ae star, R CrA, may affect the chemical composition. This observation indicates futher chemical complexity in low-mass star forming regions.

Chemical composition in low-mass protostars

Recently, it is established that chemical compositions of low mass star forming regions harboring the Class 0 protostar are different from source-to-source (Schoier et al. 2002; Cazaux et al. 2003; Sakai et al. 2008 etc.). One extreme case is a hot corino, where various complex organic molecules like $HCOOCH_3$ are abundant. These complex molecules may be related to the pre-solar materials found in meteorites. It is very important to understand the chemical composition in hot corinos and its variation in detail, and for this purpose, a spectral line survey toward hot corinos is useful. However, such a survey has so far been carried out only toward IRAS 16293-2422 (van Dishoeck et al. 1995, Blake et al. 1994, Caux et al. 2011). Therefore, we have conducted a sensitive line survey in the 345 GHz band toward RCrA IRS7B with ASTE.

RCrA IRS7B

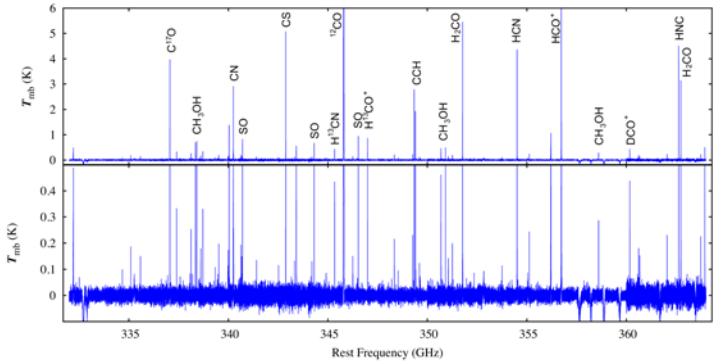
- A class 0 object in Corona Austrina
- d = 170 pc (Kunde & Høg 1988)
- A hot corino candidate , because of detecion of the high excitation lines of H_2CO and CH_3OH (Schoier et al. 2006)



Observation summary

Position α_{J2000} :	$+19^h01^m56^s.4$
δ_{J2000} :	$-36^\circ57'28.3''$
Telescope :	ASTE
Date :	11 – 26 Jun 2010
Frequency :	332 – 362 GHz
Resolution :	0.5 MHz
T_{sys}:	140 – 350 K
R.M.S. noise :	12 – 23 mK (T_{mb})

Overview of the Spectra

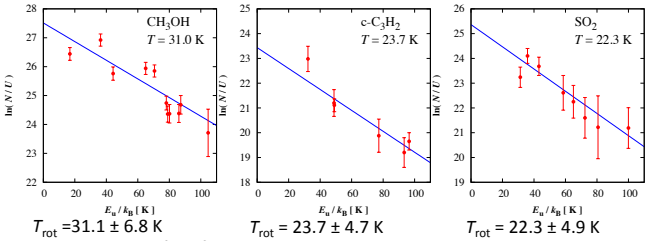


Identified Species

CCH, CCD, CN, ^{12}CO, ^{13}CO, C^{17}O, H^{13}CN, HC^{15}N, DCN, HN^{13}C, HC^{17}O$^+$, HC^{18}O$^+$, DCO$^+$, H_2CO, HDCO, D_2CO, $H_2{}^{13}CO$, NO, CH_3OH, CS, C^{34}S, HCS$^+$, H_2CS, SO, SO_2, c-C_3H_2, C

- 16 fundamental molecular species and 16 isotopomers
- No complex organic molecules and long carbon-chain molecules, which consist 4 heavy atoms or more
- No CO^+ and HOC^+ which are characteristic in photodissociation regions (PDRs)

Rotation Temperatures



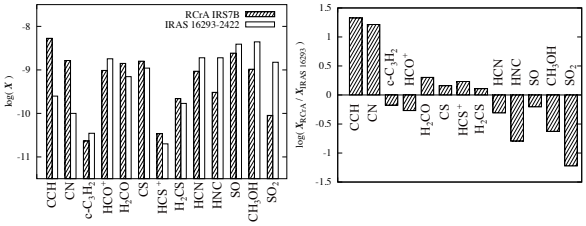
T_{rot} =31.1 ± 6.8 K, N =(1.1±0.6)x10^{13} cm^{-2}

T_{rot} = 23.7 ± 4.7 K, N =(2.4±1.7)x10^{12} cm^{-2}

T_{rot} = 22.3 ± 4.9 K, N =(1.2±0.7)x10^{14} cm^{-2}

- Rotation diagrams for c-C_3H_2, CH_3OH, SO_2, CCH, and H_2CO (K_a=1)
- The excitation temperatures range from 16 K to 31 K, which is significantly higher than those (<10 K) found in cold dark clouds, but is much lower than those found in the typical hot corino IRAS 16293-2422 (~85K; van Dishoeck et al. 1995)

Comparison with IRAS 16293-2422



- Abundances of SO_2 and CH_3OH are lower than that in IRAS 16293-2422 by an order of magnitude.
- The HCN abundance is comparable to that in IRAS 16293-2422, but HCN/HNC is slightly lower.
- The CCH and CN abundance are higher than that in IRAS 16293-2422 by an order of magnitude.
- **Hot corino activity is weak in R CrA IRS7B!**

Deuterium Fractionation

- Deuterated molecular species such as DCN, DCO^+, CCD, HDCO, and D_2CO are detected.
- The $HDCO/H_2CO$, D_2CO/H_2CO, CCD/CCH ratios are lower than those in IRAS 16293-2422 (e.g. van Dishoeck et al. 1995)
- The DCN/HCN and DCO^+/HCO^+ ratios are similar to those in IRAS 16293-2422

Molecule	Ratio
CCD / CCH	0.038 ± 0.016
HDCO / H_2CO	0.050 ± 0.024
D_2CO / H_2CO	0.030 ± 0.136
DCN / HCN	0.009 ± 0.025
DCO^+ / HCO^+	0.0025 ± 0.004

Summary

No long carbon molecules ⇨ ~~WCCC source~~

No complex organic molecules
Low excitation temperatures
Low deuterium fractionation ⇨ ~~Hot corino~~

Further chemical complexity !

Intermediate (or normal) characteristics between hot corino and WCCC source in R CrA IRS7B

Another possibility is a photodissociation effect by the Herbig Ae star R CrA.

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