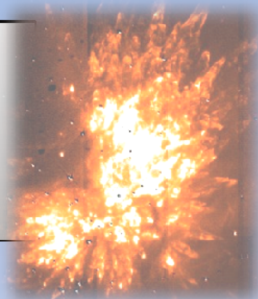
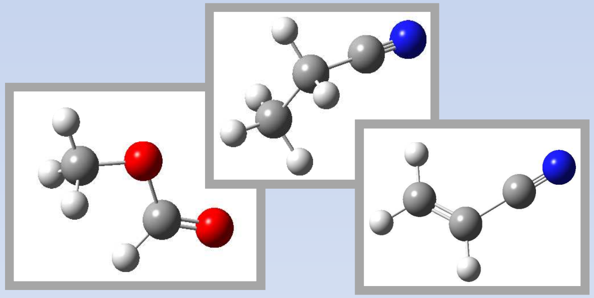
Organic molecules in the massive star forming region Orion-KL



PhD student: Alicia López Jiménez,

Dir.: José Cernicharo Quintanilla (CAB, INTA-CSIC)

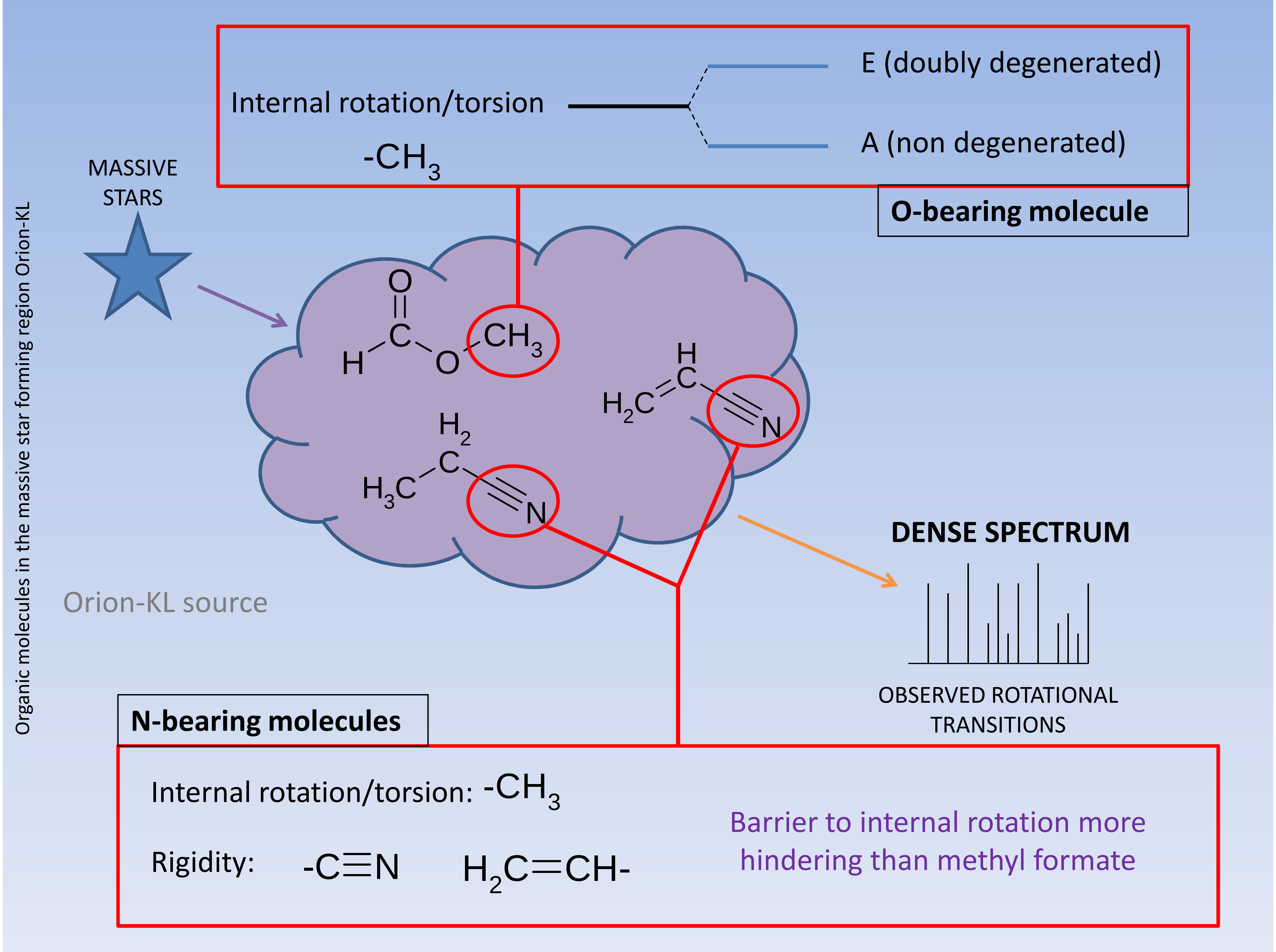
Co-dir.: JoseLuis Alonso Hernández (QUIFIMA, UVA)



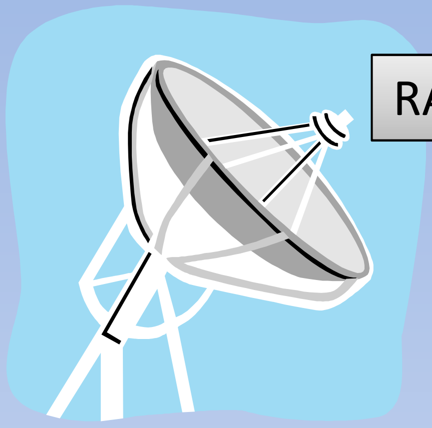
CENTRO DE ASTROBIOLOGÍA

ASOCIADO AL NASA ASTROBIOLOGY INSTITUTE

CSIC INTA


Internal rotation/torsion
-CH3
E (doubly degenerated)
A (non degenerated)
O-bearing molecule
MASSIVE STARS
Organic molecules in the massive star forming region Orion-KL
O
C
H
O
CH3
H
C
H2C
N
H2
C
H3C
N
Orion-KL source
DENSE SPECTRUM
OBSERVED ROTATIONAL TRANSITIONS
N-bearing molecules
Internal rotation/torsion: -CH3
Rigidity: -C≡N H2C=CH-
Barrier to internal rotation more hindering than methyl formate

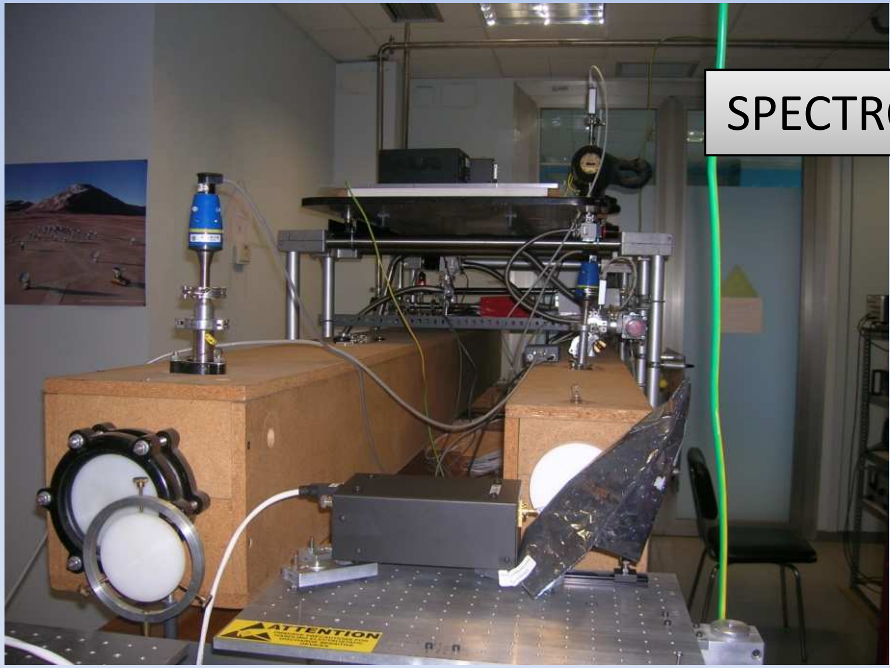
METHODS



RADIOASTRONOMICAL OBSERVATIONS

30m-IRAM (3, 2, 1.3 mm)

1-1.25 MHz



SPECTROSCOPY LABORATORY

- **Stark modulation (100-700 V)**
- **Frequency-modulated spectrometers**

26-110 GHz (170 GHz, multipliers & detectors)
240-360 GHz (FM modulation)

0.5 KHz

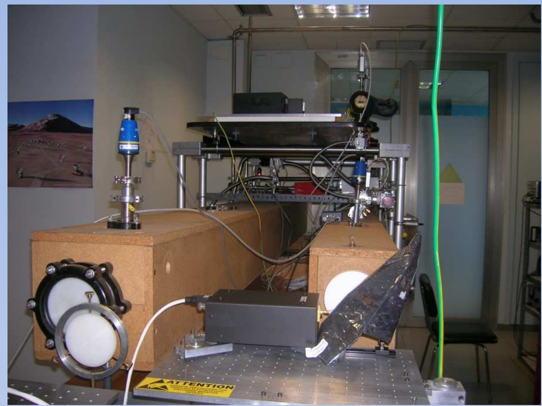
THEORIC CALCULATIONS
AND
PREDICTIONS

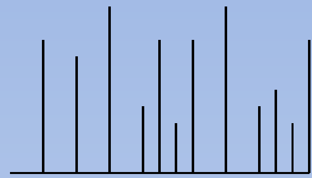
RADIATIVE TRANSFER MODEL
AND
ANALISYS **LTE**

SPECTROSCOPIC STUDY

Organic molecules in the massive star forming region Orion-KL

ORGANIC MOLECULE
(gas phase)



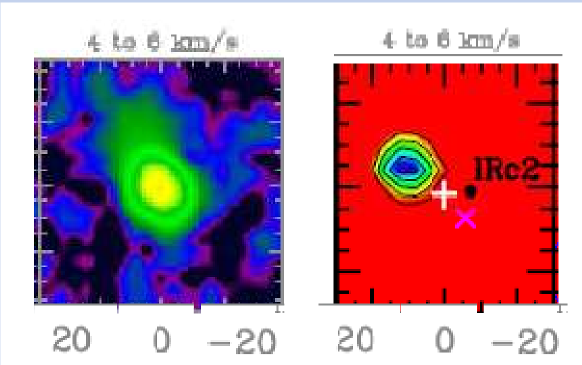


CALCULATED ROTATIONAL TRANSITIONS

SPECTROSCOPIC PARAMETERS

A, B, C,
D_i, Φ_i, ϕ_i,
L_i, l_i, P_i, p_i

SPECTROSCOPIC ANALISYS



>1000-2000 detected lines (80-280 GHz) of $HCOOCH_3$, CH_3CH_2CN or CH_2CHCN

- Model emission lines
  (excitation and radiative transfer code)
  - Observed parameters: v_{LSR}, Δv,Ta (gaussian fit)
  - T_{rot} (rotational diagrams)
  - Offset and diameter (2D maps)

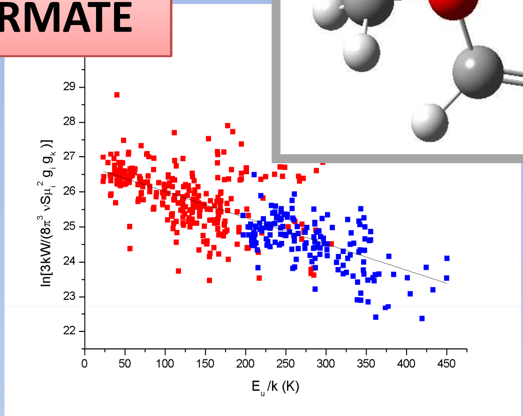
Column density N (cm^{-2}) = **?**

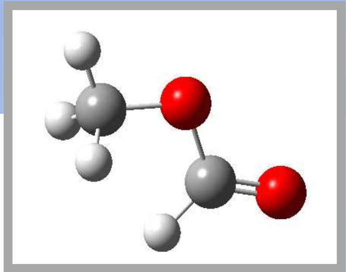
Detect and identify vibrationally excited states in our **LINE SURVEY** → ⬇ **U-lines**

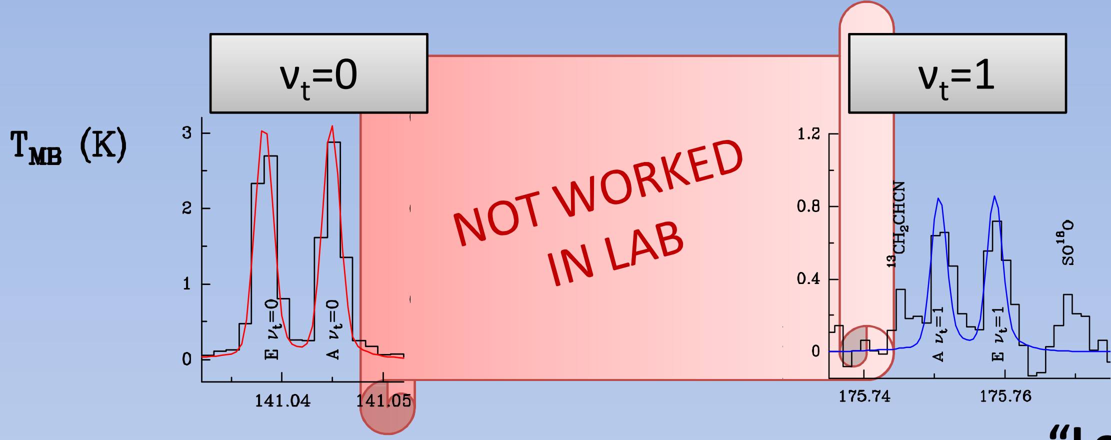
RESULTS

Organic molecules in the massive star forming region Orion-KL

METHYL FORMATE

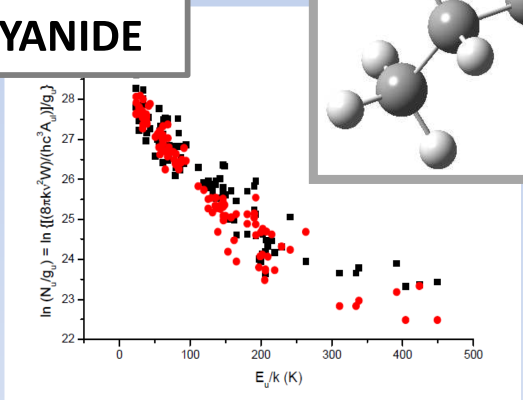


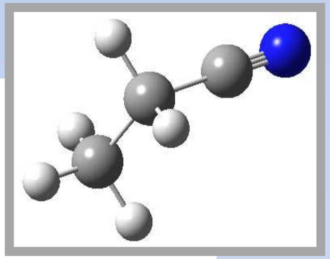


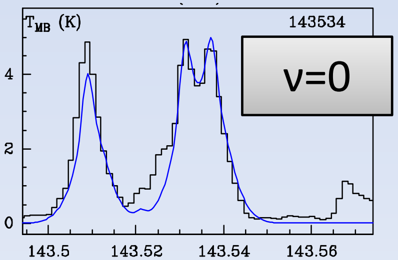


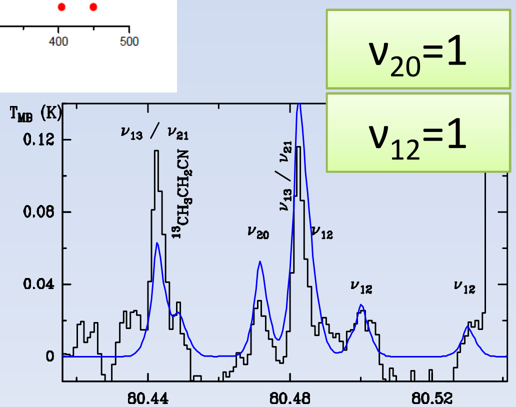
“Low-lying energy excited states”

ETHYL CYANIDE

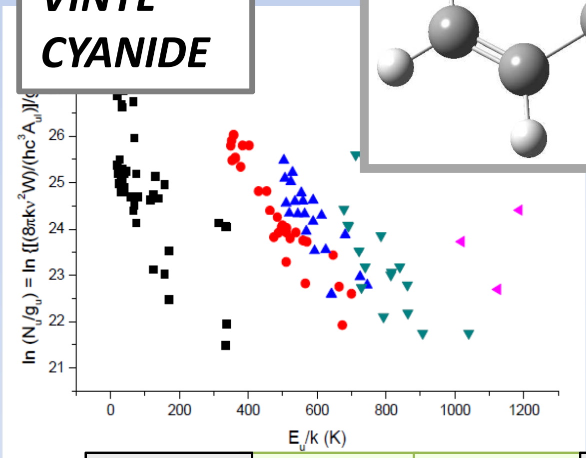


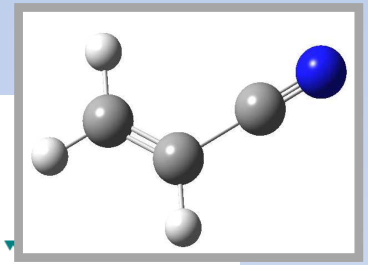


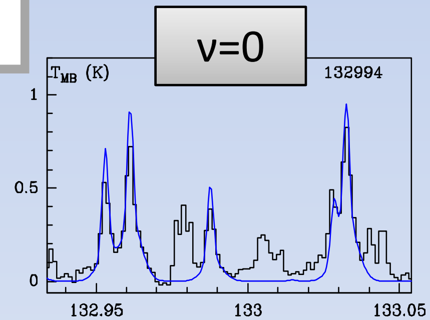


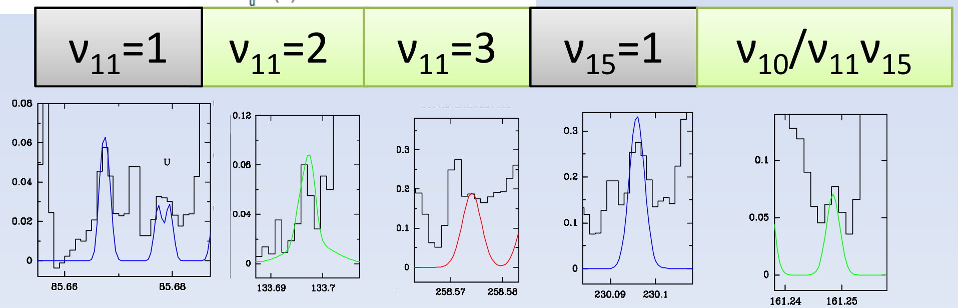


VINYL CYANIDE





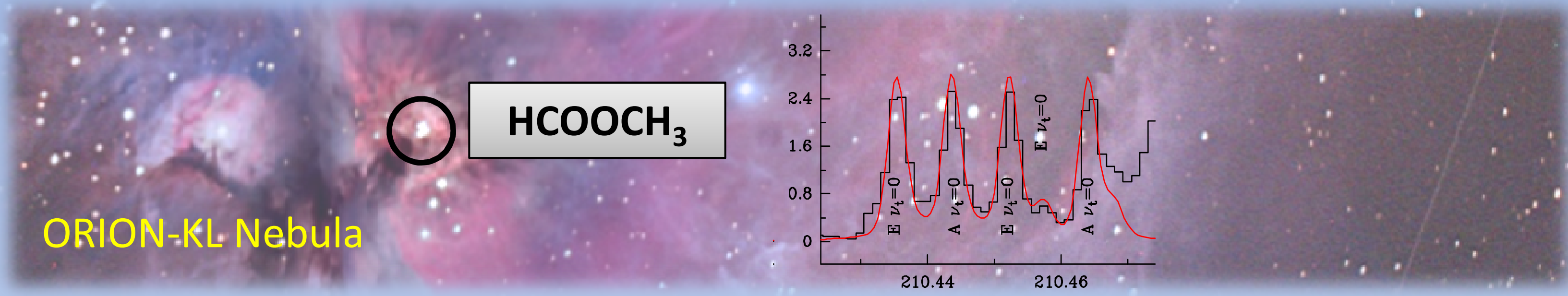




RESULTS

Methyl formate

Organic molecules in the massive star forming region Orion-KL



PLATEAU (30'', **9** Km s^{-1} respect to LSR, **25** Kms^{-1} line width, 5x10^6 cm^{-2})

COMPACT RIDGE (15'', **7.7** Km s^{-1} respect to LSR, **4** Kms^{-1} line width, 1x10^6 cm^{-2})

HOT CORE (10'', **5.5** Km s^{-1} respect to LSR, **9** Kms^{-1} line width, 5x10^7 cm^{-2})

EXTENDED RIDGE (120'', **8** Km s^{-1} respect to LSR, **4** Kms^{-1} line width, 1x10^5 cm^{-2})

HOT COMPACT RIDGE (7'', **7.7** Km s^{-1} respect to LSR, **4** Kms^{-1} line width, 5x10^6 cm^{-2})

▲	150 K	60 K	110 K	300 K	250 K
A & E-HCOOCH$_3$ (v_t=0)	N (cm^{-2}) = (2.8±0.8)x10^{16}				
A & E-HCOOCH$_3$ (v_t=1)	N (cm^{-2}) = (9±3)x10^{15}				

> 1000 detected lines in each v_t =0 y v_t =1 **HCOOCH$_3$**

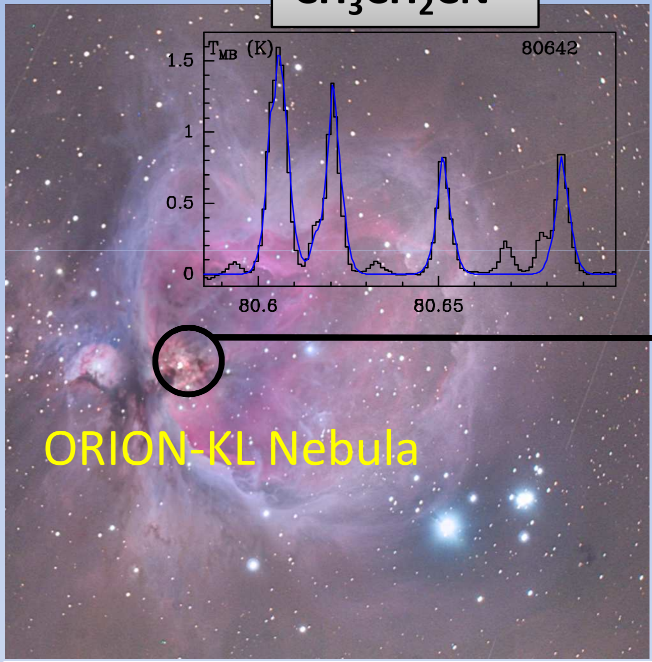
X $_{[N (HCOOCH3)/N(H2)]}$ **TOTAL = (1.5±0.8)x10^{-7}**

RESULTS

Ethyl cyanide

Organic molecules in the massive star forming region Orion-KL

CH_3CH_2CN



LABORATORY MEASUREMENTS – RADIO ASTRONOMICAL OBSERVATIONS

HOT CORE COMPONENT 1
(4'', **5** Km s^{-1} respect to LSR, **5** Kms^{-1} line width)

HOT CORE COMPONENT 2
(10'', **3** Km s^{-1} respect to LSR, **13** Kms^{-1} line width)

HOT CORE COMPONENT 3
(25'', **3** Km s^{-1} respect to LSR, **22** Kms^{-1} line width)

N (cm^{-2})	**275 K**	**130 K**	**65 K**
$N(CH_3CH_2CN$ g.s.) (cm^{-2})	**N (cm^{-2}) =** $(4\pm1)x10^{16}$		
$N(CH_3CH_2CN\ v_{13}=1/\ v_{21}=1)$ $N(CH_3CH_2CN\ v_{20})$ (cm^{-2}) $N(CH_3CH_2CN\ v_{12})$ (cm^{-2})	**N (cm^{-2}) =** $(7\pm3)x10^{15}$		
$N(^{13}C_1\text{-},\ ^{13}C_1\text{-},\ ^{13}C_1\text{-})$ (cm^{-2}) $N(^{15}N)$ (cm^{-2})	**N (cm^{-2}) =** $(3.2\pm0.9)x10^{15}$		

>2000 detected lines CH_3CH_2CN

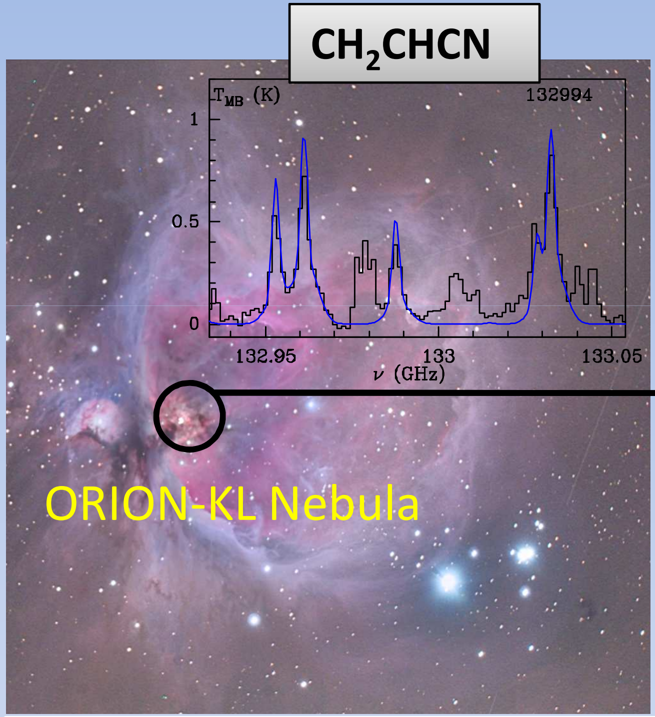
N^er detected lines (free of blending): 66 (v_{20} =1) and 56 (v_{12} =1)

$X_{[N (CH3CH2CN)/N(H2)]}$ TOTAL = $(1.3\pm0.4)x10^{-7}$

RESULTS

Vinyl cyanide

Organic molecules in the massive star forming region Orion-KL



LABORATORY MEASUREMENTS – RADIO ASTRONOMICAL OBSERVATIONS

HOT CORE COMPONENT 1	HOT CORE COMPONENT 2
(4'', **5** Km s^{-1} respect to LSR, **5** Kms^{-1} line width)	(15'', **3** Km s^{-1} respect to LSR, **17** Kms^{-1} line width)

N (cm^{-2})	**235 K**	**130 K**
N(CH_2CHCN g.s.) (cm^{-2})	**N (cm^{-2}) =** $(1.1\pm0.3)\times10^{16}$	
N(CH_2CHCN v_{11}=1) (cm^{-2}) N(CH_2CHCN v_{11}=2) (cm^{-2}) N(CH_2CHCN v_{11}=3) (cm^{-2}) N(CH_2CHCN v_{15}=1) (cm^{-2}) N(CH_2CHCN v_{10}/ $v_{11}v_{15}$) (cm^{-2})	**N (cm^{-2}) =** $(5\pm2)\times10^{15}$	… … … … …
N($^{13}C_1$-, $^{13}C_1$-, $^{13}C_1$-) (cm^{-2}) N(^{15}N) (cm^{-2})	**N (cm^{-2}) =** $(8.5\pm4.2)\times10^{14}$	

>2300 detected lines CH_2CHCN

N^er detected lines (free of blending): 40 and 16 (v_{11}=2,3), and 33 ($v_{10}/v_{11}v_{15}$ =1)

X $_{[N (CH3CH2CN)/N(H2)]}$ **TOTAL = $(4\pm1)\times10^{-8}$**

CONCLUSIONS

- Detection of new species in ISM regions allow us to improve our knowledge about physico-chemical conditions of astrophysical source.

DETECTED LINES (80-280 GHz):

> 2000 ($HCOOCH_3$) **>2000 (CH_3CH_2CN)** **>2300 (CH_2CHCN)**

For the first time we have detected in the ISM:
2 new states for **CH_3CH_2CN** and **3** new states for **CH_2CHCN**

- Organic saturated molecules have **many transitions**, constraining physical parameters in the region and being very **located in a specific component** **(**$HCOOCH_3$ from compact ridge, **CH_3CH_2CN** and **CH_2CHCN** from hot core**)** so we can derive the T and N gradient:

"POSSIBLE SCENARIO OF STAR FORMATION IN THEIR INNER PARTS"
(region could be internally heated)

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