THE FIRST HOT CORINO IN A CLASS I OBJECT IN PERSEUS AS OBSERVED BY ASAI

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ABSTRACT

Astronomical complex organic molecules (COMs; > 6 atoms) have been detected towards the early stages of Sun-like star formation (prestellar cores, Class 0 objects) as well as towards the Solar System, demonstrating the existence of efficient pathways to chemical complexity. However the COMs observations in intermediate stages (Class I / Class II objects) are still missing. In the framework of the ASAI IRAM large program, we report here the first detection of a chemical rich hot corino around a Class I object, SVS 13 A.

1. THE ASAI PROJECT

The goal of ASAI (Astrochemical Survey At IRAM 30m; PI: B. Lefloch & R. Bachiller) is to obtain an unbiased spectral survey (@ 1, 2, and 3 mm) of a carefully selected sample of template sources, which cover the full formation process of solar-type stars, from prestellar cores to protoplanetary disks. The project joins the efforts of specialists in Astrochemistry to a complete census of the gas chemical composition, including pre-biotic molecules, and its evolution along the main stages of the star formation process. The observations are complemented with radiative transfer and chemical modelling.

2. SVS 13 CLUSTER

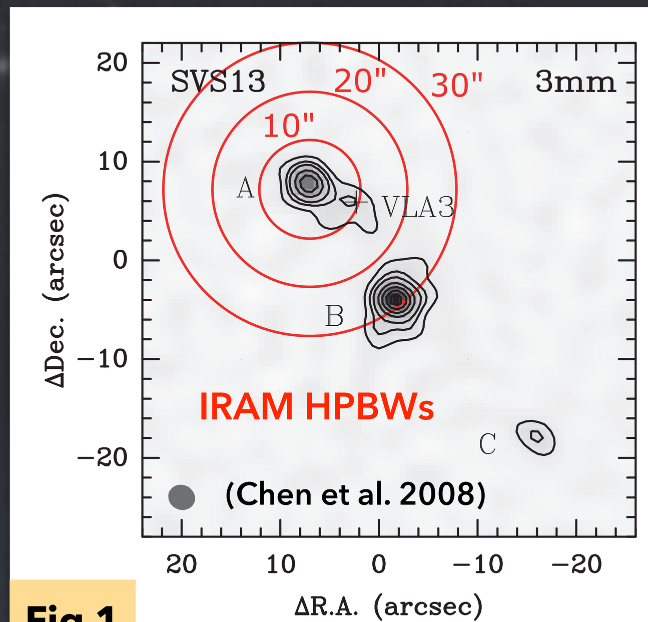

Fig 1

This object is located in the NGC1333 star forming region (d ~ 235 pc) (Hirota et al. 2008). It is associated with several young stellar objects and in particular with two main bright mm-sources called A and B. SVS13A is tought to be a Class I object (driving the well known HH7-11 chain) while SVS13B should be younger (Class 0) as suggested by its association with a collimated jet (Bachiller et al. 1998).

3. THE FIRST HOT CORINO AROUND A CLASS I OBJECT

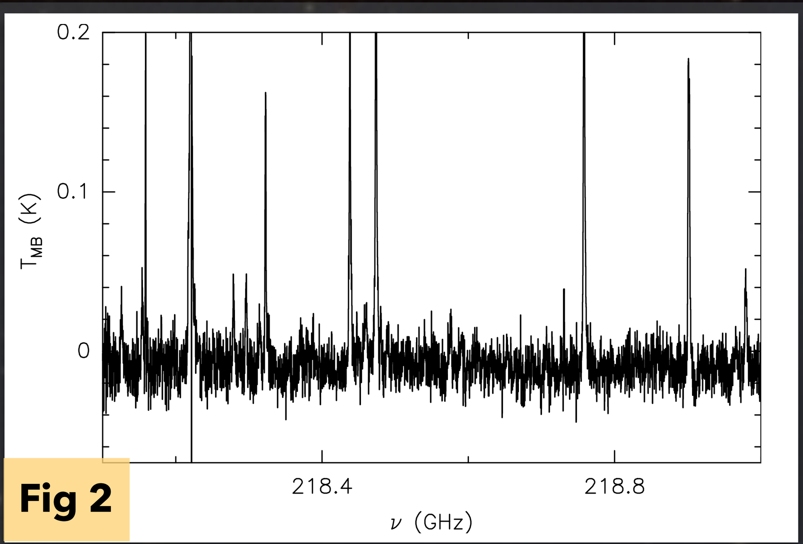

Fig 2

The ASAI data show a forest of emission lines towards SVS 13 A. For this reason great care must be taken in the process of the identification of the lines. We applied several criteria, such as the line profile shape, line blending and consistent FWHMs. COMs lines were identified using the JPL and CDMS molecular databases. Line fitting was performed using the GILDAS-CLASS package.

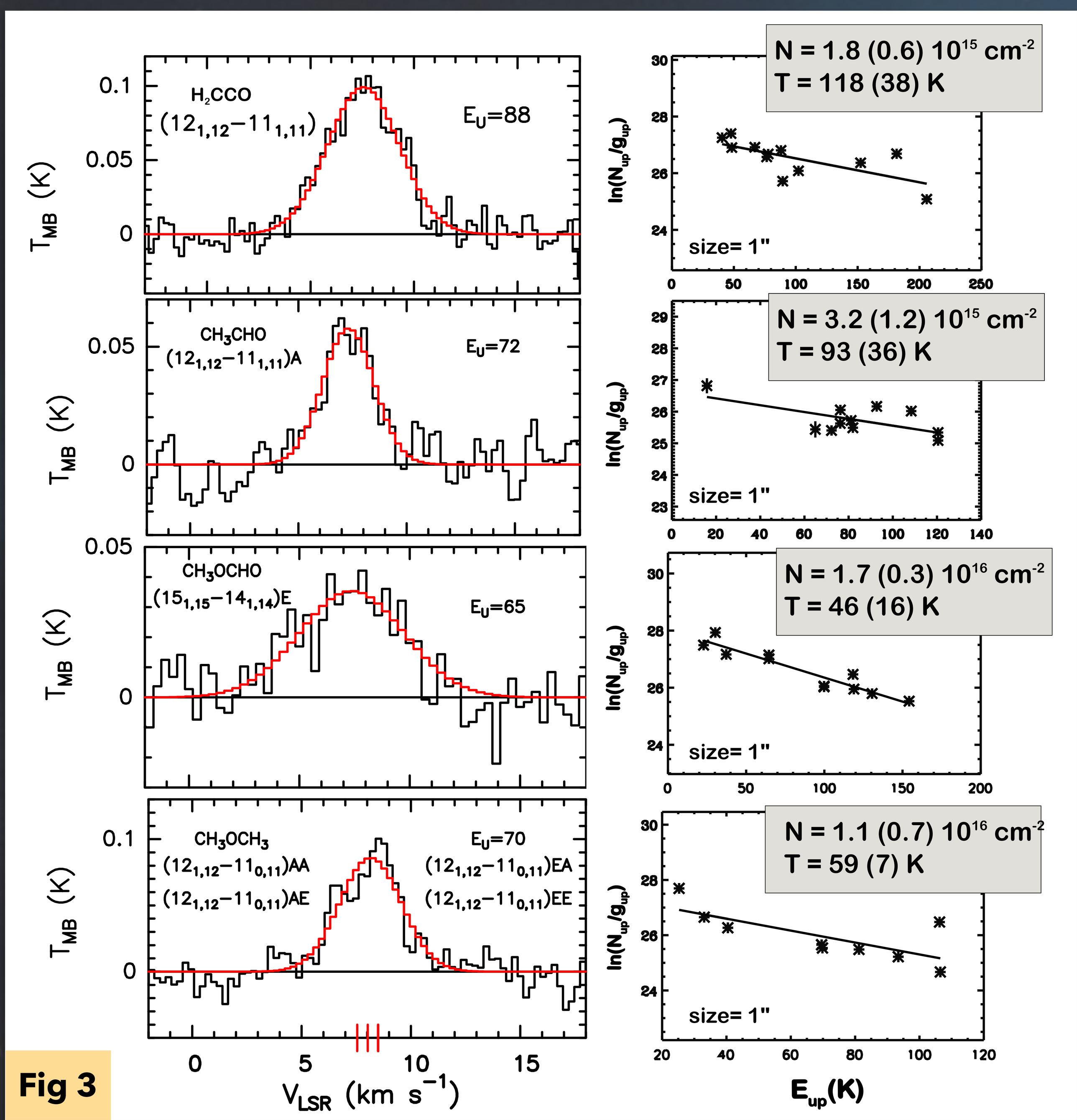

Fig 3

All the identified lines show a typical peak velocity of ~ 8-9 km/s. The COMs lines have been mainly detected at 1mm, due to a beam filling factor effect (HPBW ~ 10”, 20”, 30” at 1, 2, 3 mm, respectively). In other words the COMs are detected only towards the more evolved Class I (~ 10^5 yr) object SVS13 A and not towards the less evolved Class 0 (~ 10^4 yr) object SVS13 B. We detected several COMs: Ketene (H_2CCO), Acetaldehyde (CH_3CHO), Methyl formate ($HCOOCH_3$), Dimethyl ether (CH_3OCH_3), and Formamide (NH_2CHO). The observed lines cover a wide range of excitation, up to E_U ~ 200 K and are quite broad, with typical FWHM of ~ 4–6 km/s. We build rotational diagrams for the detected species assuming that the lines are optically thin and in LTE.

List of molecular species observed with IRAM 30m toward SVS13A.

Specie	E_u range	T_{RD} [a] (K)	N_{RD} [a] (cm^{-2})
Detected COMs			
H_2CCO	40-206	118 ± 38	$(1.8 \pm 0.6) \times 10^{15}$
$^{13}CH_3OH$	20-175	49 ± 7	$(2.1 \pm 0.6) \times 10^{16}$
CH_3CHO	16-120	94 ± 25	$(3.2 \pm 0.7) \times 10^{15}$
$HCOOCH_3$	23-154	59 ± 7	$(1.7 \pm 0.3) \times 10^{16}$
CH_3OCH_3	25-148	46 ± 16	$(1.1 \pm 0.6) \times 10^{16}$
NH_2CHO[b]	15-130	40 ± 4	$(3.2 \pm 0.6) \times 10^{14}$
Undetected COMs			
Specie		T [c] (K)	N (cm^{-2})
C_2H_5OH		80	$\lesssim 5 \times 10^{15}$
$HCOOH$		80	$\lesssim 8 \times 10^{14}$
$HCCCOH$		80	$\lesssim 2 \times 10^{15}$
$HCOCH_2OH$		80	$\lesssim 3 \times 10^{14}$
CH_3NH_2		80	$\lesssim 3 \times 10^{15}$
CH_3COCH_3		80	$\lesssim 2 \times 10^{15}$
CH_3O		80	$\lesssim 5 \times 10^{14}$

[a] Parameters refer to an assumed source size of 1 arcsec.
[b] López-Sepulcre et al. 2015
[c] Assumed.

Table 1

Table 1 reports the derived T_{rot} and column densities. We determine rotational temperatures of ~ 40-120 K and column densities of N ~ 10^{14} - 10^{16} cm^{-2}. These values are in perfect agreement with similar observations performed towards typical hot corinos in Perseus. We determined also upper limits on Methoxy (CH3O) emission with is considerred a precursor of DME and MF challengeng chemical models.

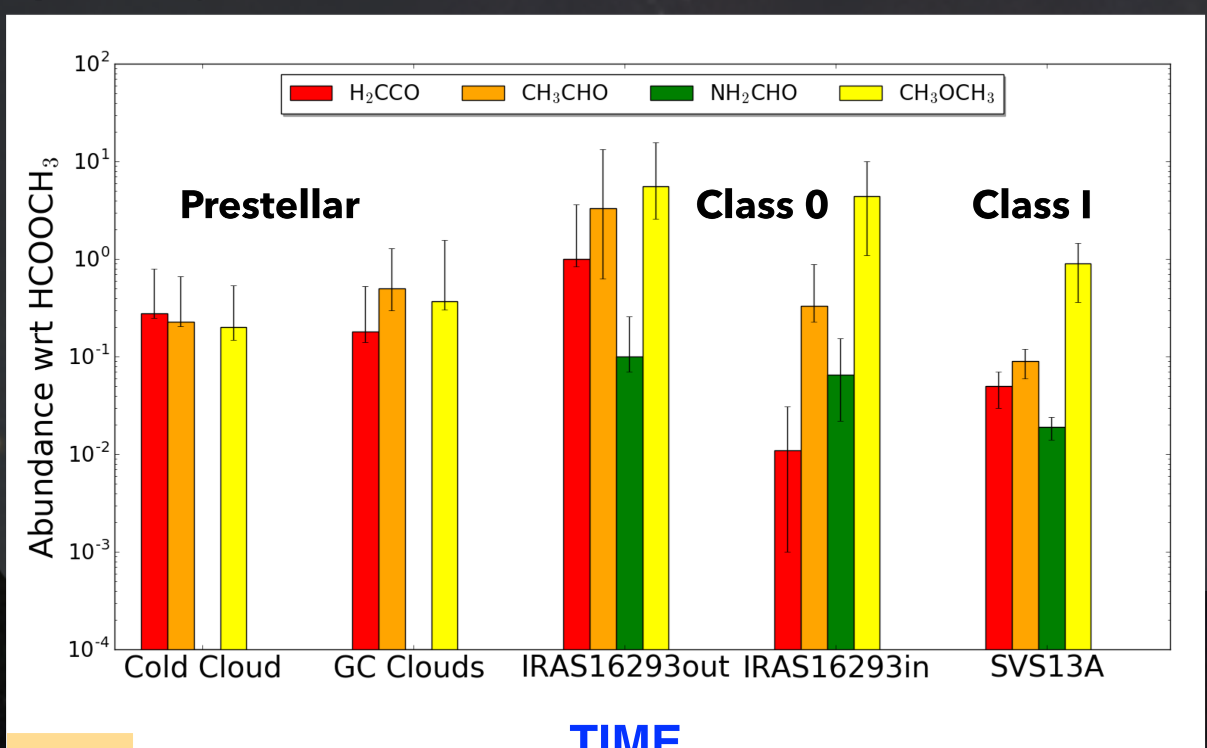

Fig 4

4.CONCLUSIONS AND FORTHCOMING RESULTS

Figure 4 compares the chemical richness of the Class I SVA13A with those derived in objects in earlier phases of star formation. We note that the chemical richness seems to be the same moving from Class 0 (~ 10^4 yr) to Class I (~ 10^5 yr). This trend has to be verified observing other Class I objects. In other words in the future we should verify whether the chemical complexity observed in the solar system is inherited by the chemical richness bloomed at 10^4-10^5 yr.

On the opposite, deuteration (see Fig 5, Bianchi et al. in prep.) seems to quickly disappear in the gas phase as the star forming process evolves.

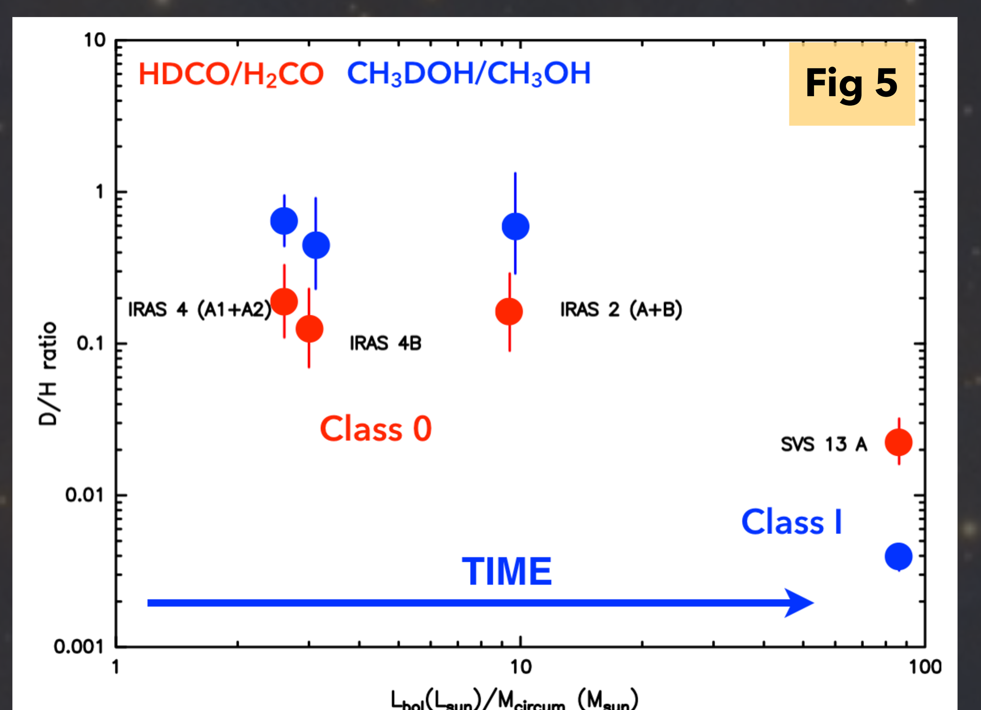

Fig 5

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