Origins: From the Protosun to the First Steps of Life
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Deuteration of formaldehyde - an important precursor of hydrogenated complex organic molecules - during star formation in our Galaxy

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Abstract. Formaldehyde (H_2CO) and its deuterated forms can be produced both in the gas phase and on grain surfaces. However, the relative importance of these two chemical pathways is unclear. Our recent single dish observation of formaldehyde and its deuterated species suggests that they form mostly on grain surfaces although some gas-phase contribution is expected at the warm HMPO stage. Since the single dish beam is larger, and since these high-mass star-forming regions are clustered and complex, it is however unclear whether the emission arises from the protostellar sources or from starless/pre-stellar cores associated with them. Therefore, interferometric observations are needed to separate the emission originating from the small and dense cores, to disentangle their formation routes and then being able to use them as powerful diagnostic tools of the physical and chemical properties of high-mass star forming regions.

Keywords. astrochemistry, molecular data, ISM: molecules, stars: formation

1. Introduction

H_2CO is crucial in any chemical networks because it is very abundant and it is an important precursor of hydrogenated complex organic molecules. Our single dish observation of high-mass star-forming cores in the Galaxy in different evolutionary stages suggests that formaldehyde and its deuterated species form mostly on grain surfaces although some gas-phase contribution is expected at the warm HMPO stage (Zahorecz *et al.* 2017). Resolving the emitting region of a molecule is fundamental to

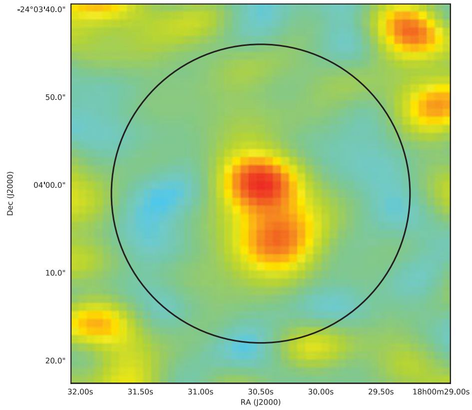

Figure 1. Integrated intensity map of $H_2^{13}CO$ $3_{1,2}$-$2_{1,1}$ emission based on ALMA ACA observations toward G5.89+0.39. Two cores are revealed according to the two velocity components found in our previous APEX observations. Black circle indicates the single dish beam size of our previous observations.

understand its chemistry. Only higher angular resolution observations allow us to shed light on the physical conditions of the region traced by the selected molecule, and based on them the molecules can finally be grouped in families depending on their emission morphology and chemical paths can be found by simply correlating their distribution.

2. ALMA observations of formaldehyde in G5.89+0.39

G5.89-0.39 is a shell-like ultra-compact H II region (diameter of ∼4”) found at 3 kpc (Sato *et al.* 2014). Sub-arcsecond observations revealed at least five dust condensations (Su *et al.* 2009). Our single dish APEX (Atacama Pathfinder EXperiment) SEPIA receiver (Swedish-ESO PI receiver for APEX; Billade *et al.* 2012) observations were centred on the SMA-N dust condensation. Two velocity components were detected within the APEX beam of 34”, see details in (Zahorecz *et al.* 2017).

We performed ALMA (Atacama Large Millimeter/submillimeter Array) ACA (Atacama Compact Array) observations as part of the 2017.1.01157.S. project. Two cores corresponding to the two velocity components are resolved, see on Figure 1. Detailed analysis will help us to better understand the deuteration process of formaldehyde and the chemical properties of these high-mass star-forming cores (Zahorecz *et al.* in prep).

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