TW Hya as a Chemical Rosetta Stone

The case of H_2CO

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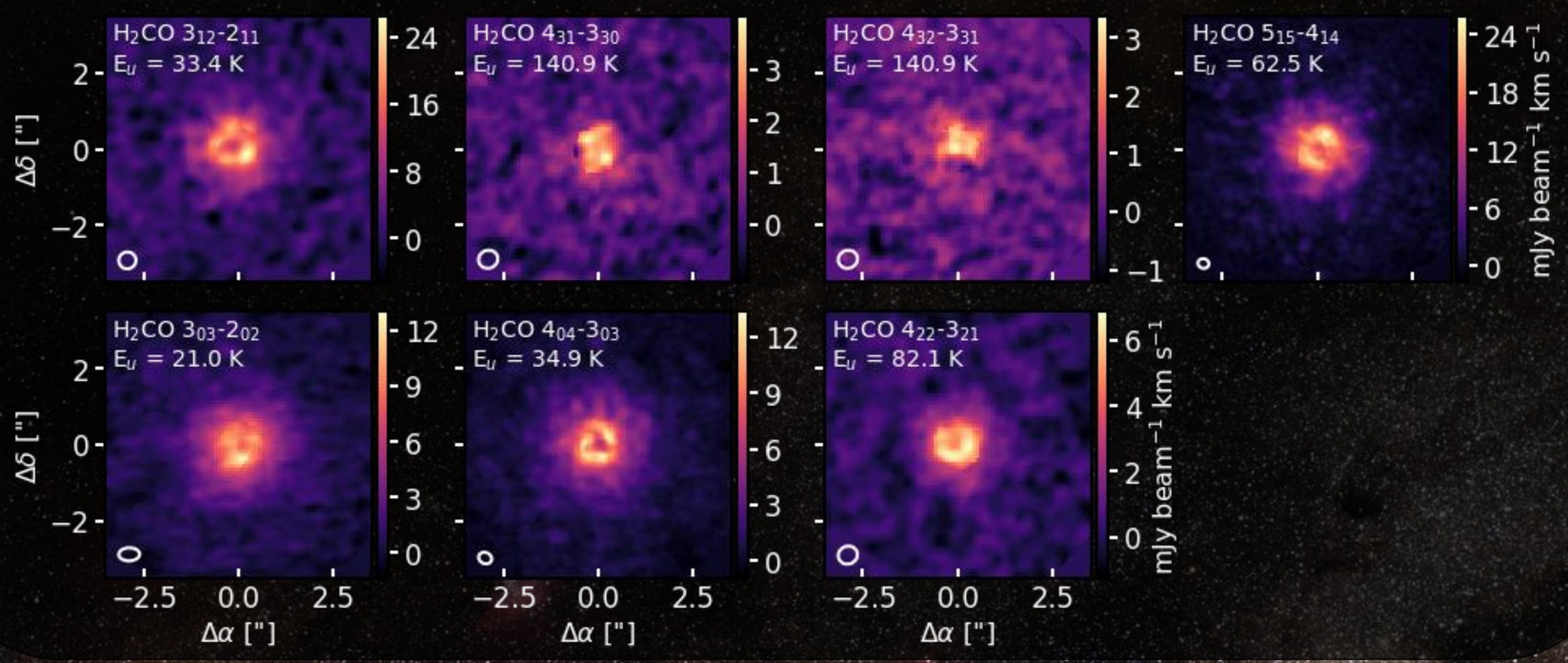
Introduction

We present ALMA observations of seven formaldehyde (H_2CO) transitions of the planet forming disk around TW Hya, obtained as part of the project 'TW Hya as a chemical Rosetta Stone'. H_2CO is a precursor of the simplest complex organic molecule methanol (CH_3OH) and thus understanding its formation history and the link to the physical structure is of great importance. Formation of H_2CO is possible in the gas-phase at increased temperature but also in the solid-state in the cold midplane and outer regions. Evidence for both chemical pathways was seen in work by Loomis et al. 2015 and Öberg et al. 2017, however the resolution of the data and limited number of transitions hindered conclusive interpretation of which is dominant. To investigate this, seven transitions with different excitation temperatures have been measured and analyzed toward the disk of TW Hya covering both ortho and para transitions. The relatively high spatial resolution of the Rosetta program gives insight into the origin of the gas-phase H_2CO abundances in TW Hya. Comparison to detailed model calculations provides further constraints on which formation route of H_2CO dominates and its relation to CH_3OH also observed toward this disk (Walsh et al. 2016).

Why TW Hya?

TW Hya is the nearest (60 pc; GAIA) sun-like star with a protoplanetary disk. Its proximity allows ALMA to probe smaller physical scales then other sun-like stars at larger distances, which is why it was targeted for a chemical mapping survey with ALMA in Cycles 4 and 5 (Project Code: 2016.1.00311.S, PI: Cleeves). Furthermore, TW Hya has been well studied supplying a wealth of knowledge on the physical and chemical structure. This will allow us to put constraints on the origin of H_2CO.

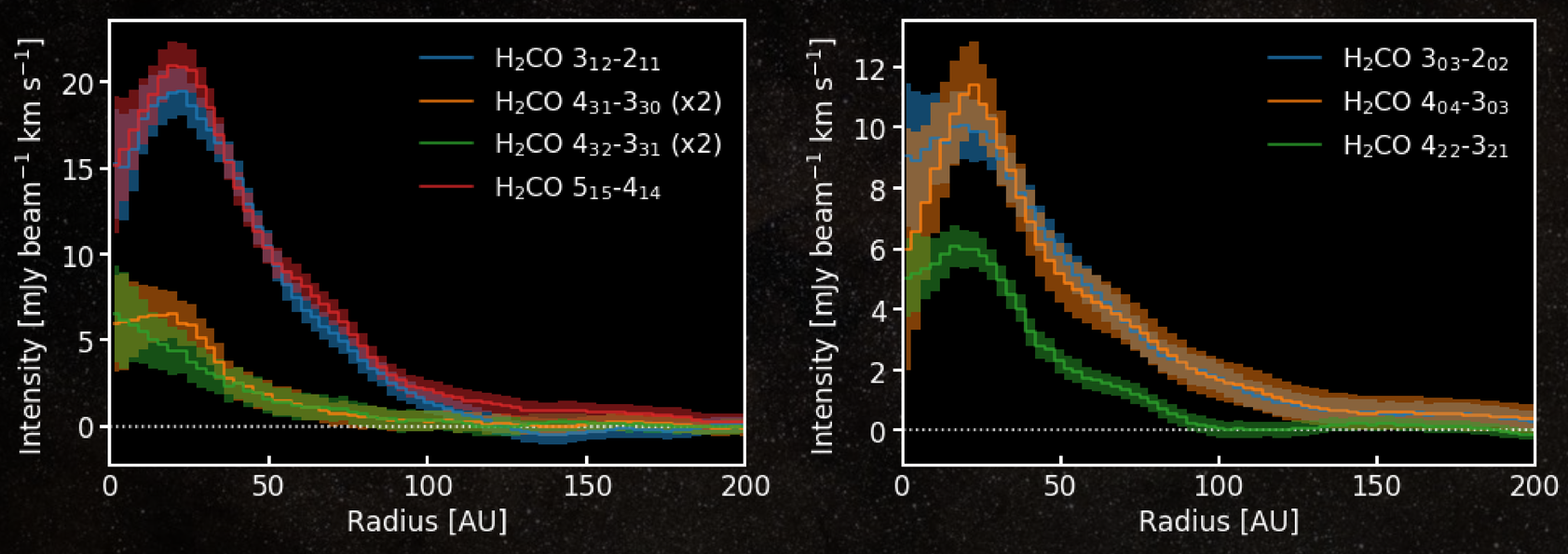
H_2CO Moment 0 maps



Chemistry

There are two competing chemical pathways to form H_2CO in the gas and ice. The gas-phase pathway favors warmer temperatures. While H_2CO is also formed efficiently from CO ice in the colder regions of the disk. The radial distribution of H_2CO can help shed light between these pathways. Alternatively, H_2CO may form in the cloud and be partially inherited (Loomis et al. 2016). Beyond constraining the column density distribution, we plan on constraining the radial ortho/para ratios as these different pathways are expected to imprint differently on the o/p ratio of H_2CO.

Radial Profiles



What's next

Rotational diagrams of the H_2CO ortho and para spin isomer lines will provide us with the disk-averaged and radially resolved excitation temperatures and column densities for each isomer. The transitions will be modeled in DALI with the derived physical structure of TW Hya (Kama et al. 2016b). However, abundance profiles will be supplied to DALI in a parametric way, i.e. no chemistry is run by the code. We will start with the abundance profiles derived by Öberg et al. (2017) and match these with the seven observed transitions and adjust from there. These profiles will constrain the origin of H_2CO and it role in the formation of complex organic molecules. A follow-up project is to run a full chemical model to reproduce the derived abundance profiles.

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