

PhD position in Astrochemistry (Fall 2022)

Title: Detailed study of the formation of methanol and its return to the gas phase: coupled experimental, modelling and observational approach.

Thesis supervisors: Francois Dulieu and Emanuele Congiu (LERMA CY, FR) and Paola Caselli (MPE-Garching, DE)

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Proposed topic:

Each phase of the formation of stars and planets is accompanied by a particular combination of molecular signatures, which indicates the physical conditions, but also the chemical evolution of the astrophysical environments (Caselli and Ceccarelli 2012). Methanol (CH_3OH) is the emblematic Complex Organic Molecule (COMs). It is an easily detectable molecule with a rich spectrum. It is relatively abundant so that it is the only COM detected in the ice (Boogert, Gerakines, and Whittet 2015). In radio-millimetric observations of molecular clouds and star-forming regions, the abundances of other COMs are often compared to methanol.

In the pre-stellar phase, the conditions of high density ($>10^4 \text{ cm}^{-3}$) and low temperature ($<12\text{K}$) mean that methanol should accrete completely onto the grains, especially since it is likely to be formed directly on their surface. In the Center for Astrochemical Studies (MPE Garching), observations and modelling of methanol have been performed (Punanova et al. 2018)(Harju et al. 2020)(Vasyunin et al. 2017). In Cergy, the formation (Minissale, Moudens, et al. 2016), sticking (Gadallah et al. 2020) and the return to the gas phase by chemical desorption have been measured (Minissale, Dulieu, et al. 2016). Nevertheless, there is still progress to be made because not all the experimental conditions have been studied, and not all the observational constraints are perfectly reproduced by the models. Among the possible developments we can note the following question: what fraction of atomic oxygen still available reduces the formation of methanol (CO would be transformed into CO_2)? Can this explain the $\text{CH}_3\text{OH}/\text{CO}_2$ abundance ratios measured in the ice? How can we evaluate the impact of environmental dynamics (e.g. slow shocks due to accreting material onto molecular cloud cores) in the desorption of methanol? Is the visual extinction range in which methanol is observed in the gas phase (away from a young stellar object) significant for the role of UV, or are there other explanations? ...

A detailed study of the formation and desorption processes in the laboratory (<https://lerma.obspm.fr/spip.php?article48>), the implementation of astrochemical models, and their comparison with the new observations would advance our understanding of the star formation processes for which methanol is an important molecular tracer. The first part could be realized in Cergy and the second and third in Garching (<https://www.mpe.mpg.de/CAS>).

Practical details:

The PhD student will follow the rules and courses of Doctoral School of Sciences and Engineering of the CY Cergy Paris Université. The working language is English. The final manuscript and the defence will be done in English. The first 18 months will be mostly spent in Cergy and the last 18 months in Garching, although some short venues (few weeks) in the other location. Professional travel expenses

as well as any cost of the scientific working environment will be at the charge of the labs. The salary will be the standard French and German PhD grant.

Application:

Applicant must have a master degree in Science, especially in Astrophysics, Physics or Chemistry. An experience (Internship, master diploma...) in radioastronomy or experimental physics would be an effective positive aspect of the application.

Applicant must have excellent communication skills in English (oral and written), which will be the working language, although student will follow French language training (part of Doctoral School educational program), and may learn German, Italian and few other languages with the team crews if motivated.

Applications should be constituted of a detailed CV and a letter of motivation. The candidate should furthermore arrange for a recommendation letter from a professor familiar with the applicant to be sent to Pr Dulieu. Applications received before 1st June 2022 will receive full consideration. Remote interviews will be organized for shortlisted students for a decision around 20th of June 2022.

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<https://cylerma.cyu.fr/> <https://www.mpe.mpg.de/CAS>

Bibliography

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