Presentation - Dr. Romane Le Gal is a young and autonomous post-doctoral researcher hosted in the Pr K. Oberg's group in Harvard. As a modeler, she has developed many interesting aspects of astrochemical network, especially on Nitrogen chemistry and explicit spin state chemistry, both during her PhD thesis (University Grenoble-Alpes) and during her first post-doctoral position in Pr. E. Herbst's group (Virginia University, USA), founder of computational astrochemistry, and still a world leader of the discipline. Moving to Harvard, Dr Le Gal recently turned her interest towards Sulfur chemistry (Fuente et al. 2017, Vastel et al. 2018, Le Gal et al. 2019, Rivière-Marichalar et al. in prep, and work in progress). Collaborating with both the group that develops the NAUTILUS astrochemical code (Wakelam et al., LAB, Bordeaux) and the Paris-Meudon modeler group (Roueff et al., LERMA, Paris), she is at the state of the art of astrochemical modeling. Moreover, she is also an observer, which is another strong asset for the collaborative project started with Pr. F. Dulieu’s group. In particular, she was recently granted with an observational program focused on the investigation of Sulfur chemistry in protoplanetary disks with one of the most competitive astronomical interferometer, ALMA (observation project code 2018.1.01631).

Research project - During her visit at the IEA, Dr Romane Le Gal will work closely with Pr. Dulieu’s group, to investigate new chemical pathways for better understanding the formation of Sulfur-bearing species in star forming regions. Indeed, twenty-two different Sulfur-bearing species have now been observed in space, from diatomic (such as CS) up to 8 atom molecules (CH_3CH_2SH). They are observed in diverse star forming regions and thus constitute very powerful tracers of the specific physical conditions of these environments. As an example, the molecule SO traces shocked gas of these regions.

However, the Sulfur interstellar chemistry remains poorly understood. In the diffuse interstellar medium (ISM) and in photon-dominated regions (PDRs) the observed Sulfur abundance is close to the cosmic value (e.g. Howk et al. 2006, Neufeld et al. 2015, Goicoechea et al. 2006), whereas in dense molecular gas it is found highly depleted: only 0.1% of the Sulfur cosmic abundance is observed in the gas phase (Tieftrunk et al. 1994), implying a depletion factor of three orders of magnitude (e.g. Wakelam et al. 2004, Vastel et al. 2018). Where does the Sulfur go, from diffuse to dense interstellar gas? Since the late 90's, this long-standing issue is called “the Sulfur depletion enigma” (Ruffle et al 1999). A common explanation is that the Sulfur reservoir is probably locked into icy mantles coating interstellar dust grains. However, OCS and tentatively SO_2 are yet the sole molecules detected in icy grain mantles towards high-mass protostars (e.g. Palumbo et al. 1997, Zasowski et al. 2009) with abundances less than 4% of the Sulfur cosmic abundance. Icy H_2S, the most obvious Sulfur ice-chemistry product from successive hydrogenations of atomic Sulfur in solid phase, has not been detected yet (Smith 1991, Boogert et al. 2015). The coming launch of the James Webb Space Telescope promises new discovery in this area, and thus providing also a strong motivation to further investigate the Sulfur chemistry and in particular its surface processes.

While most of the Sulfur is hidden from us in star forming regions, recent observational spectral line surveys have increased the number of known interstellar Sulfur molecules to a dozen of species in prestellar cores (Vastel et al. 2018), protostellar envelopes (Drozdovskaya et al. 2018) and PDRs (Riviere-Marichalar et al. in prep). Together with new models, these new detections have advanced our understanding of the ISM gas-phase S-chemistry. In particular, we now know that a rich interstellar Sulfur chemistry is present in a range of ISM environments. However, the main S-reservoirs have not yet been identified, and there is still much theoretical work left to do to identify the chemical pathways that produce the observed distributions of Sulfur species.

In this context, and in synergy with the program initiated by Pr. Dulieu's group in collaboration with L. Kristensen from Copenhagen on the specific problem of S-bearing species in star forming regions, Dr. Romane Le Gal will bring both her observational and astrochemical modeling skills to guide laboratory experimentations aiming at identifying new Sulfur chemical pathways.

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