Cosmic dust analogues in plasmas

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Generation of plasmas containing nano-sized particles, or more generally, dusty plasmas, can be achieved through different plasma sources; the most frequently ones rely on growth of dust in a reactive plasma from the working gas mixture and sputtering of a target. Motivations for the study of dust growth dynamics in reactive plasmas are multiples, starting from the fundamental level of description of this complex phenomenon and spanning to the controlled deposition of nanocomposite layers and the elaboration of laboratory cosmic dust analogues. Although the astrophysical environment cannot be entirely reproduced, the application of plasmas for elaboration of cosmic dust analogues offers many advantages. One is the number of reactive gases used as precursors. Silane (SiH_4), acetylene (C_2H_2) and methane (CH_4) have already been used in the study of dust growth in reactive plasmas aiming at elaboration of laboratory cosmic dust analogues [1, 2].

Here, we investigate an original method for dust formation in reactive plasma based on pulsed injection of hexamethyldisiloxane (HMDSO, $Si_2O(CH_3)_6$, mass 162.38 g/mol) in an Ar-discharge [3, 4]. The HMDSO contains key cosmic dust-forming elements: carbon, oxygen, and silicon. For some cases, the HMDSO-injection is accompanied by gradual addition of oxygen (O_2). Thus the aim is to explore the transition between carbon-rich and oxide particles by investigating a range of plasma operating conditions including RF power, HMDSO pulsed injection, and oxygen concentration. The carbon to oxygen ratio (C/O) in the atmospheres of evolved stars is known to determine the type of cosmic dust that is formed (carbon-rich if $C/O > 1$ or silicates and oxides if $C/O < 1$).

Moreover, introduction of metallic atoms in the plasma during dust formation is achieved by sputtering of a metallic target. One has to keep in mind that “good” cosmic dust analogues may considerably deviate in stoichiometry and crystallinity from materials which are easily available for laboratory analysis. Given that the plasma is a non-equilibrium medium, we can produce non-stochiometric materials. Our study is limited for the moment to the use of silver as metallic component.

In this presentation, we will provide an overview of our recent achievements.

Acknowledgments: This work has the support from the European Research Council under the European Union's Seventh Framework Programme ERC-2013-SyG, Grant Agreement n. 610256 NANOCOSMOS.

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