Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **78** Type: **Invited Speaker / Conférencier(ère) invité(e)**

Dust nucleation in very-low pressure plasmas

Tuesday 9 June 2020 10:45 (35 minutes)

The formation of soot particles in combustion, of cosmic dusts in the interstellar medium or of carbon nanoparticles in nonthermal plasmas, laser plumes, electric arcs or fusion devices is generally described by successive steps of nucleation, coagulation, processing and surface growth.

Nucleation is the crucial stage. Nevertheless, it is not well defined except in flames where polycyclic aromatic hydrocarbons (PAHs), evidenced as the precursors of soot particles, are formed through successive reactions of hydrogen abstraction and carbon addition.

Based on these models, PAHs have been suspected as precursors of dust particles in nonthermal plasmas. However, only aromatic molecules smaller than naphthalene (C10H8) were identified in acetylene RF capacitively-coupled plasmas. Indeed, though the numerous species (radicals, cations and anions) formed in the plasma through acetylene-electron collisions yields to really efficient dust particle growth, the thermodynamic parameters (pressure, temperature) was considered unsuitable to efficiently produce large PAHs.

Hence, nucleation pathways in nonthermal dusty plasmas still remain open issues, especially at very low pressure as in the case of plasmas excited at electron cyclotron resonance (ECR), where nucleation was generally considered negligible before we reported dust particles formation in pure acetylene. By combining transmission electron microscopy with the analytical experimental setup AROMA, we observed that those dust particles are with a really rich molecular composition. Notably, PAHs such as pyrene (C16H10) or coronene (C24H12) are found in abundance. It also includes carbon clusters (Cn, n < 30) and, more surprisingly in nonthermal plasmas, buckyballs such as C60. The presentation will report some of these results obtained in the ERC Synergy project Nanocosmos.

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Session Classification: DPP-1 : Plasma Physics Symposium

Track Classification: Symposia Day (DPP) - Plasma Physics