Aero-Electro-Dynamic (AED) propulsion modeling and data assimilation for ionic wind generation

18 month post-doctoral position starting any-time 2021.
period : 2021 - 2023

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Context : (AED) propulsion possesses some intrinsic and specific appealing features : silent, without mobile mechanical parts, distributed, easy to control. The first interests in the area started in the late fifties, but the poor efficiency obtained by various teams has discouraged further investigations for aerodynamic propulsion developments. The subject has regained interest during the last years from recent advances realizing that this propulsion possesses some intrinsic propulsive performances outperforming classical ones, (Masuyama & Barrett 2013) that could propel distributed gliders such as Solar Impulse II (Monrolin et al 2017). The recent flight of an autonomous, 2.4kg drone embarking a small battery and sustaining a stationary flight with AED propulsion during 90s (Yu et al. Nature) has boosted the field for potential applications in silent drone or high-altitude photo-voltaic self-sufficient propelled gliders. This recent regain of interest calls for new experimental and numerical efforts in order to provides a better understanding about the AED mechanisms. An improved knowledge on the physics behind its limitations can possibly lead to strategies for future improvements. This is the goal of the on-going ANR project PROPUL-ION (associating three laboratories, i.e PPRIME in Poitiers, IMFT and DEAP @ ISAE-Sup-Aéro in Toulouse) into which this post-doc takes place.

Topic: The goal of the post-doc position at IMFT is to achieve various challenging footsteps. (i) To handle the 2D numerical modeling of AED at moderate Mach numbers (incompressible flows) with an original two-way coupling between the fluid and the ionic wind described into the drift region. This first issue will be pursued with the help of an existing in-house code developed with the Free-FEM++ finite elements library. This code needs to be improved by taking into account some additional coupling terms to implement into the existing Newton iteration solver. Some parametric exploration will conclude this first step, using the user-friendly in-house StabFEM code-driver (https://stabfem.gitlab.io/StabFem/). The forcing Coulomb term will also be provided to our partner ISAE-Sup-Aéro in various configurations (ii) to develop a data assimilation strategy based on a variational approach, associated with the identification of the ionic flux emitted from the emitter region feeding the charges into the domain. The adjoint formulation of the 'one-way' coupling problem will first be implemented on the 'one-way' direct solver onto tailored, numerically generated, incomplete data so as to test the assimilation strategy. Later-on, the adjoint problem for the two-way coupling problem will be developed and validated. The data assimilation performance and robustness will then be measured on the numerically generated and artificially noised data. Finally the both 'one way' coupling and 'two-way' coupling assimilation strategies will be applied to assimilate the ionic flux near emitter from experimental measurements involving current/Voltage laws, and 2D PIV measurements (Monrolin et al 2018).

Key words : Data assimilation, CFD, aerodynamics, ionic wind, adjoint method
Expected Skills : Experience in CFD formulations, modeling, programming (C++, Matlab, Python) and possibly data assimilation. Scientific publications editing & writing. No EHD prerequisites needed.

Salary : depending of the experience it will be within 40-45 k€/year (medical care insurance included).

Références :

K. Masuyama, et al., , *Proceedings of the Royal Society A:* **50,** 6,1480-1486, 2013.
C.K. Gilmore and S.R.H. Barrett, *Proceedings of the Royal Society A:* **471**(2175), 2015.
H. Xu, Haofeng et al, Nature, **563** 7732, 532,2018.
N. Monrolin, et al. , *AIAA*, 55, 12, 4296-4305, 2017.
N. Monrolin, et al. , *Phys. Rev. Fluid.*, 3, 063701, 2018.