

Electroaerodynamic phenomena in atmospheric corona discharges – Applications to airflow control and electric propulsion

Eric MOREAU, Nicolas BENARD

PPRIME Institute, University of Poitiers, UPR 3346 CNRS, Poitiers, FRANCE

Corona discharges have been the subject of intensive studies that started at the end of the 19th century. Since then, throughout the 20th century, much progress has been realized, leading to a better understanding of the extremely complex phenomena related to these discharges. A corona discharge is usually generated in air at or near atmospheric pressure when a high voltage is applied to a sharp edge, a point or a small diameter wire electrode. On the one hand, in most engineering applications, the capability of corona discharges can be used to modify the gas chemistry, for ozone production, reduction of gaseous pollutants, surface treatment or assisted-combustion to name a few examples. On the other hand, it can be used for its electrohydrodynamic (EHD) properties, either for manipulating the trajectory of particles in electrostatic precipitators, or to induce a thrust or an airflow called *ionic wind*. For about twenty years, this last EHD (also called AED for *electro-aerodynamic*) phenomenon has been the subject of a lot of research because of its numerous applications, mainly for airflow control by plasma actuators and more recently for electric propulsion.

For the first application, the ionic wind produced within a surface discharge is generally used to manipulate the boundary layer of airflow. There are different types of plasma actuators, but the most commonly used is the Dielectric Barrier Discharge (DBD) actuator. With this actuator, the produced velocity can reach 7 m/s for an electrical power consumption of 1 W per cm of electrode, and an average force of about 1 mN/W. By optimizing the electrical and geometrical parameters of the plasma actuator, velocities of 12 m/s and an EAD force of about 400 mN/m were obtained. The second application concerns the idea of using ionic wind as a propulsive phenomenon. There is indeed a significant challenge to explore this new "all-electric" aircraft propulsion system. This idea is not new but a team of MIT recently succeeded in flying a 2.4 kg drone with a wingspan of 5 meters with this type of propulsion (published in *Nature* in November 2018), bringing this research theme to the forefront.

In this presentation, we will present the experimental work which has been conducted at University of Poitiers on the EHD phenomena occurring inside corona discharges in atmospheric air and their applications in airflow control and electric propulsion. It will be divided in several parts:

- Electrical, optical and mechanical properties of volume corona discharges,
- Electrical, optical and mechanical properties of surface dielectric barrier discharges,
- Applications to airflow control and electric propulsion.