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Aerodynamic Effects in Weakly Ionized Gas: Phenomenology and Applications[1]

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Successful application of gas discharges in aerodynamics requires their efficient generation, sustaining and control at supersonic or hypersonic flow conditions. Wall-free plasma formations that meet the requirements may then act as time-controlled and space-localized actuators to modify the flow. Potential candidates for this challenging task are plasmas contained in open or linear-cavity microwave field structures. We present and discuss direct observations of aerodynamic effects activated or modified by wall-free discharges. Further, we compare two generic types of wall-free discharges. First group, applicable for inlet-type structures, consists of a periodic series of microwave-induced plasmoids generated in a linear cavity, using the outgoing wave from a microwave antenna and the reflected wave from a nearby on-axis concave reflector. The plasmoids are spaced at half-wavelength separations according to the standing-wave pattern. The plasmoids are enhanced by an "effective focusing" in the near field of the antenna (Fresnel region) as a result of diffraction effects and mode structure. Second group, applicable to supersonic and hypersonic boundary layers, are the surface microwave discharges enhanced by a structure of Hertz dipoles. Standard microwave discharge phenomenology, such as microwave breakdown, mode structure and plasma parameters, is revisited to present a quantitative interpretation of the observed effects. Special attention is given to complex phenomena specific to flow-plasma interaction (double electric layers, ionization waves, instabilities), which provide the physical basis for localized heating in the aerodynamic flow.

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