Travelling Plasma Wave Levitation of Objects supported by Coanda Effect

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Introduction: The idea on this subject was born during examination of plasma waves for surface sterilization purpose. Electrostatically excited plasma waves can induce a "plasma wind" in the surrounding media or air. See flow (Figure 1) and electric field scheme of the travelling wave (Figure 2). The lifted object has the shape of a flying saucer, just for better illustration. A travelling plasma wave propulsion requires a pre-ionized media around the surface and a travelling electrostatic field. The pre-ionization can be induced by DBD (dielectric barrier discharge) or by discharge electrode wire, for instance. There are also some other interesting recent developments, studies and prototypes with this technology, see references.

Results: Respecting the simplicity of this modelling, the results were impressive and show new scope of how to move or levitate objects in a silent and clean way without any moving parts. The travelling plasma wave in the media is shown as electric potential (Figure 3). The electric field on the object's surface is displayed in (Figure 4), pressure field in (Figure 5), volume force in (Figures 6,7,8). Support of the Coanda effect is clearly visible in (Figure 1), where no flow detachment can be observed on the object. The plasma wave induces and stabilizes the boundary layer flow, so it can become propulsive.

Travelling Plasma Wave

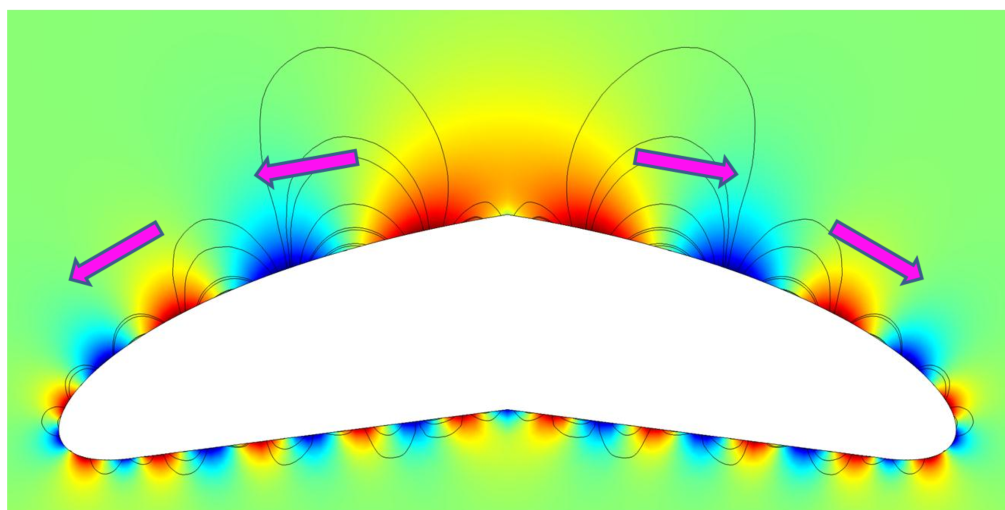

Figure 2. Travelling Plasma Wave -Scheme

Coanda Plasma Wave Levitation

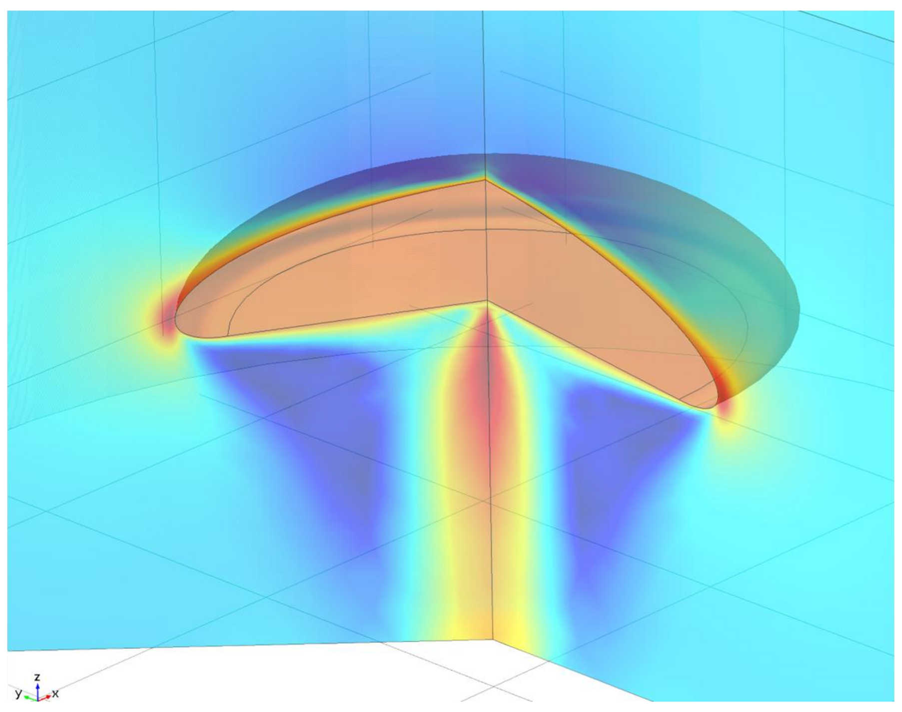

Figure 1. Lifting Body - fluid dynamics

Electric Field - Surface Potential

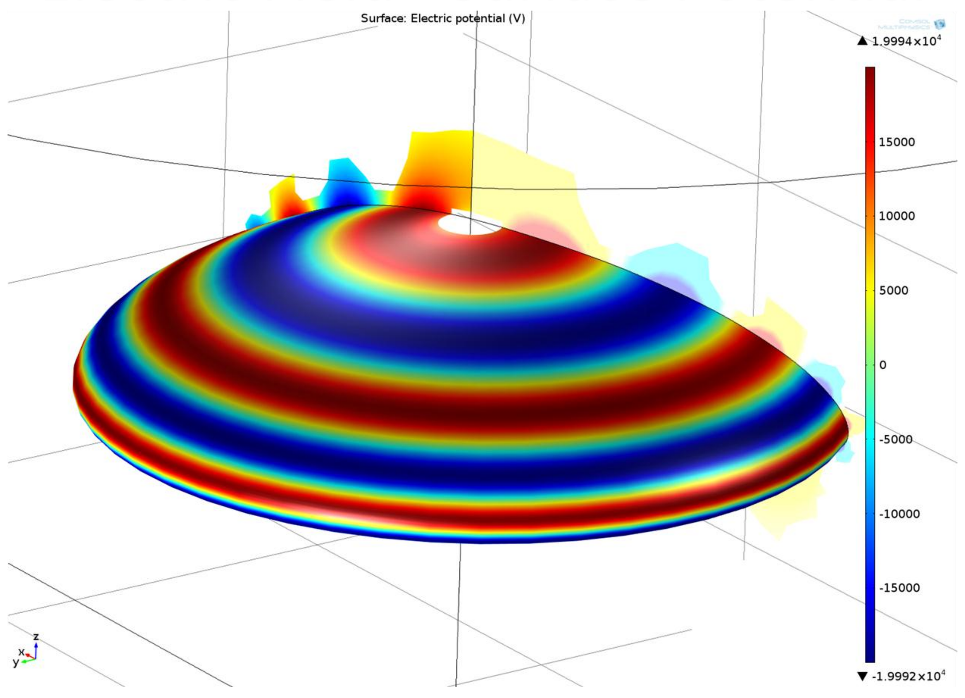

Figure 4. Plasma Wave's Electric Field - Surface Potential

Computational Methods: A simplified plasma model was used to set up an EFD (electro fluid dynamic) approach into a COMSOL Multiphysics® model. The pre-ionization of air and force on fluid was covered by just coupling the electric field [V/m] as a constant volume force (drag or lift) to the fluid dynamics equations, here laminar flow incompressible Navier-Stokes equations. Further studies will include a more enhanced approach to pre-ionization and space charge density of media.

$$\rho\frac{\partial \mathbf{u}}{\partial t} + \rho(\mathbf{u}\cdot\nabla)\mathbf{u} = \nabla\cdot[-p\mathbf{I} + \mu(\nabla\mathbf{u} + (\nabla\mathbf{u})^T)] + \mathbf{F}$$

$$\rho\nabla\cdot\mathbf{u} = 0$$

$$\mathbf{E} = -\nabla V$$

$$-\nabla\cdot(\varepsilon_0\nabla V - \mathbf{P}) = \rho$$

$$\mathbf{F} = \rho_q\,\mathbf{E}$$

EFD equations from Navier-Stokes and Electrostatics equations

Travelling Plasma Wave

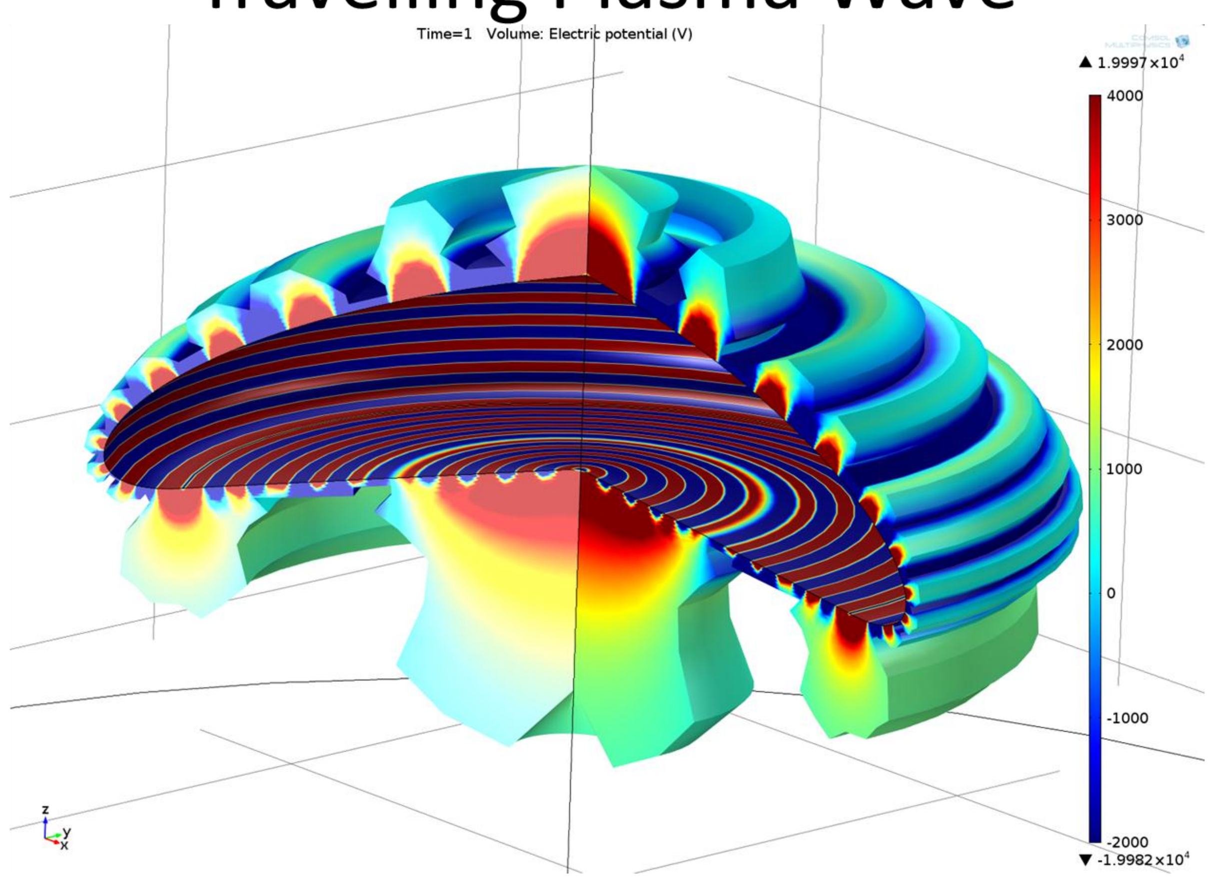

Figure 3. Travelling Plasma Wave 3D

Pressure Field, dimensionless

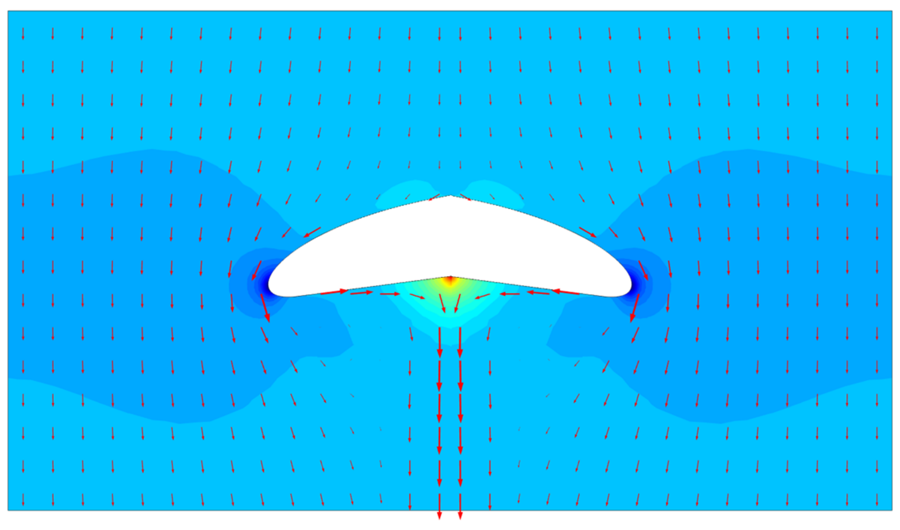

Figure 5. Pressure Field

Volume Force, Detail

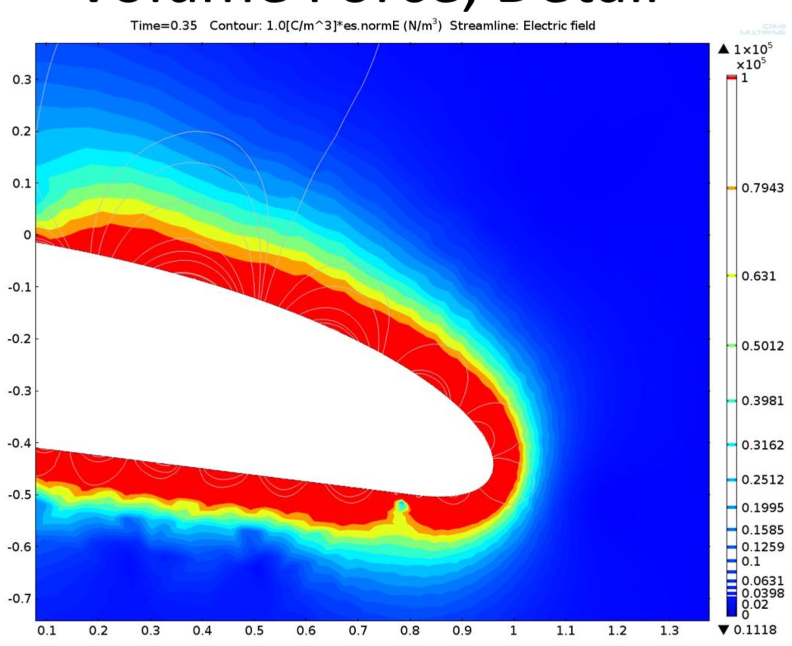

Figure 6. Volume Force

Volume Force 3D

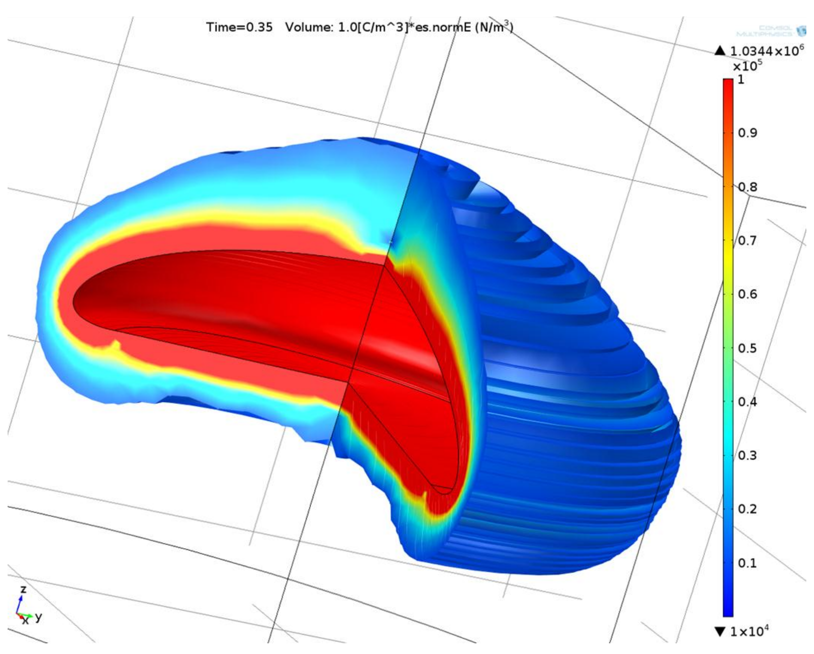

Figure 7. Volume Force

Volume Force, z-component

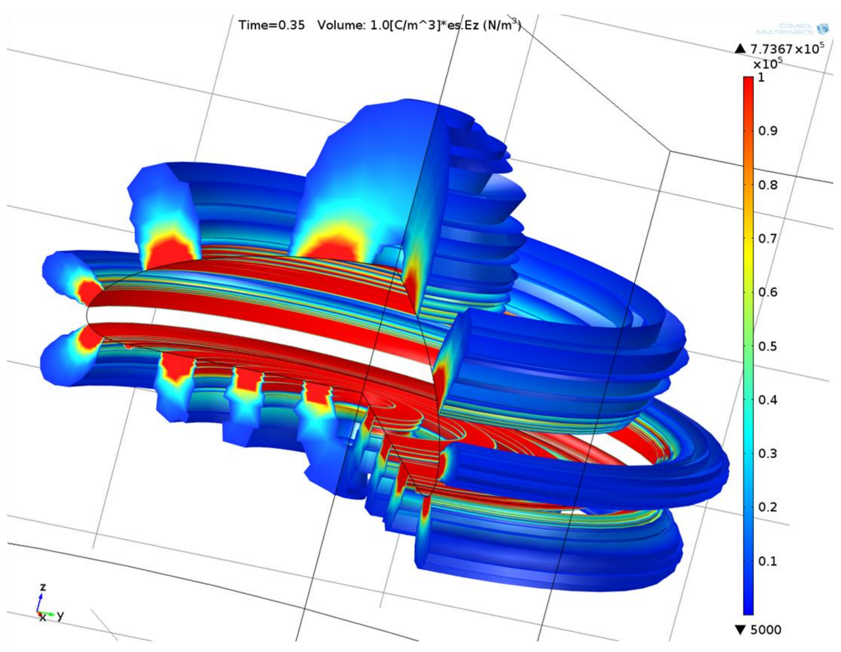

Figure 8. Volume Force

Conclusions: As shown above, this simple approach can help understanding "plasma wave manipulation of boundary layers" on aircraft, plasma wave driven air flow and particle separation without filters in clean rooms, and development of extraordinary flying or levitated vehicles.

References:

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