Finite Element Modeling of a Microwave Cavity Under Resonant Conditions

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Abstract

A tapered cylindrical microwave resonant cavity, a frustum, also commonly known as an EM Drive, has been reported to produce thrust by the generation of EM radiation within a resonant cavity without using any propellants. In order to determine how a sealed microwave cavity can produce thrust under resonant conditions, research at the NASA Eagleworks laboratories had been initiated using both COMSOL modelling and physical experimentation. They were able to find thrust generated on the order of mN/kW under resonant conditions. We have replicated and built upon their results via COMSOL modelling.

As a result of the complexities of modeling the electromagnetic interactions within the frustum, a Finite Element Method (FEM) model was required. The FEM Model was made using COMSOL (version 5.3) with the RF module, by defining the microwave cavity as being excited with standing waves, generated at resonant conditions for the given geometry. These waves induce electric currents in the walls of the cavity that further maintain the electric and magnetic fields within the cavity as well as the current densities themselves. Classical electromagnetics and energy conservation theory in a closed cavity were examined in light of the Larmor formula for a magnetic dipole. In addition, an equivalent to the Abraham-Lorentz formula for the radiation reaction force between the magnetic dipole and its field is proposed.

Recent modeling results from the FEM analysis of the fields within the frustum reproduces the NASA model. Both the magnetic and electric fields match the direction and relative magnitudes throughout the cavity. This can be seen from the side view of the frustum in the attached figure. In addition, the surface current densities in the TM212 Mode at 1.93 GHz resonant frequency were obtained. It is significant to note that the TM212 mode actually refers to the equivalent cylindrical cavity shape, which it is derived from. The FEM model is used to obtain time dependent sidewall current density patterns, which are important for obtaining a better understanding of the underlying physics within the resonant cavity.

Figures used in the abstract

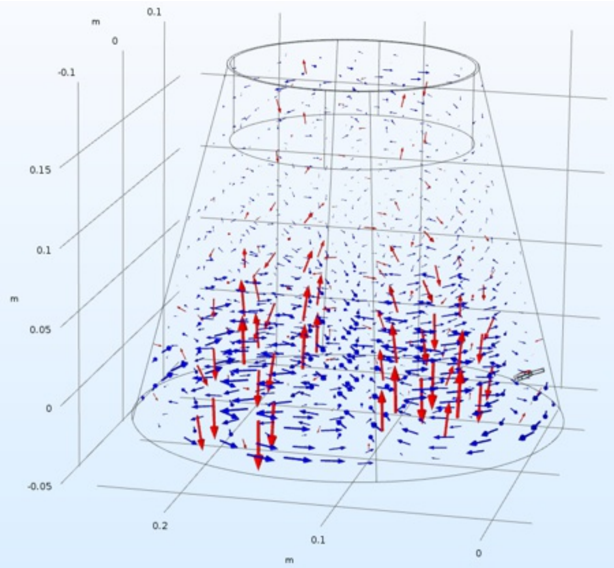

Figure 1: Side view of magnetic (blue) and electric (red) field lines in EM Drive (frustum) cavity