METHOD OF MANUFACTURED SOLUTION FOR NEAR FIELD RADIATION PROBLEMS

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Abstract

Near field is one of the regimes of thermal radiation where spatial separation between two bodies is small enough and comparable to the peak wavelength encountered in the radiation heat transfer(around $10\mu m$ at 300 K). The Planck's law (and related Stefan-Boltzmann's law) has a limitation as it is applicable only when "all spatial length scales are far more than the peak wavelength"[1]. In such a situation, the problem is solved using four Maxwell's equations along with the fluctuation dissipation theorem [2]. The Green's function method is generally used to solve such problems, where final electro-magnetic fields are expressed in terms of respective Green's dyads.

The method of manufactured solution(MMS) is a way to develop an artificial analytical solution for governing equations to validate the intermediate steps for the development of computer program. In this work, an manufactured analytical solution [3] has been developed along with artificial boundary conditions and used to validate intermediate steps of the numerical results of the near field thermal radiative heat transfer problem. The governing equations are discretized by finite volume method (FVM). A computer program is developed in the OpenFOAM® framework, an open source software to the compute electric and magnetic Green's dyads numerically. A test case has been taken as shown in figure 1, where two semi-infinite parallel SiC films are separated by a vacuum gap and the region is enclosed by a perfectly matched layer. The properties of SiC has been considered at a frequency of 1.55×10^{14} rad/s. At this frequency, the magnitude of real electric and magnetic dyads has been obtained numerically and compared with manufactured analytical manufactured solution as depicted in figure 2 and 3, respectively. The numerical results are almost exactly matching with the manufactured analytical solution. This verified the intermediate results for the final near field heat transfer solution, with assumed artificial boundary conditions.

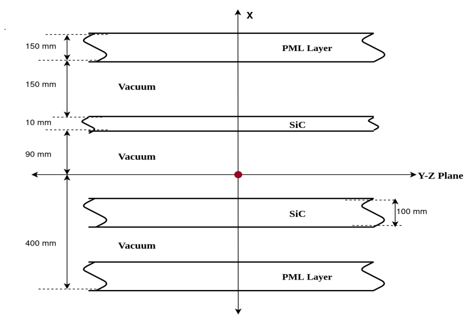

Figure 1: Problem geometry

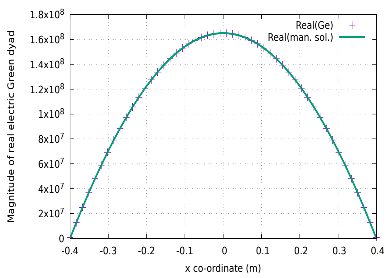

Figure 2: Magnitude real part of electric Green's dyad

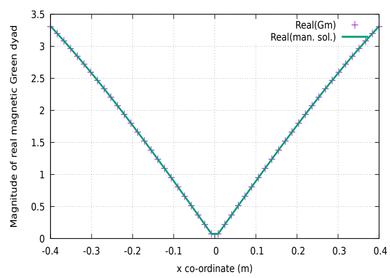

Figure 3: Magnitude of real part of magnetic Green's dyad

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