A New Homogenization Method For Radiative Heat Transfer Within COMSOL Multiphysics®

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Abstract

In various industries (nuclear power plants, furnaces, …), heat transfer by radiation can occur between many geometrically ordered tubes. Such configurations are challenging and heavy to solve numerically, because of both the nonlinearities of the radiant exitance, and the fact that surface-to-surface radiation may generate dense matrices.

This article proposes a new homogenization method to reduce the numerical complexity of solving such configurations without losing the accuracy of the results. Our method is empirical and based on major principles of classical periodic homogenization: define a unit cell and solve the physics under a unitary load at microscale, deduce homogenized properties, and solve the homogenized physics at macroscale. The method has nevertheless been customized for surface-to-surface radiation: nonlinearities are treated by constraining the unit cell to multiple mean temperature values, while interactions between distant nodes are tackled by studying the homogenized properties obtained as function of the size of the unit cell. Once implemented within COMSOL Multiphysics, our method provides a law of thermal conductivity depending on temperature, ready to be used at macroscale.

We validated our approach by performing numerical experiments in various geometrical configurations. The results show the accuracy of the method in predicting both temperatures and thermal fluxes, confirming the relevance of our approach and its ability to be used for industrial applications.

Figures used in the abstract

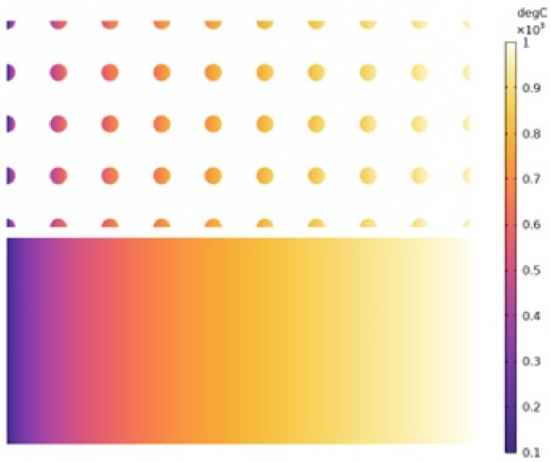

Figure 1 : Temperature field before (top) and after (bottom) homogenization