# 4

# Heat Conduction in Porous Media

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## I. INTRODUCTION

Heat conduction in materials consisting of substances of different thermal properties has been encountered frequently in many engineering applications. One such example is the manufacture of composite materials where one substance with a distinct material property is added to a matrix substance to enhance the overall property performance. Other examples, involving substances of solid and fluid phases, commonly referred to as porous materials, are the extraction of oil from reservoirs, energy production in geothermal engineering, the disposal of nuclear waste, and the confinement of heat in thermal insulation, to name a few. In this chapter, we will restrict our discussion to heat conduction in porous materials saturated with fluids. It is noted that the results of the present discussion are generally applicable to two-component composite materials and can be extended easily to multi-component materials.

Heat conduction in porous materials is usually described macroscopically by averaging the microscopic heat transfer processes over a representative elementary volume (REV). Traditional treatment of heat conduction in porous materials is based largely on the mixture theory, assuming local thermal equilibrium within the solid and fluid phases, so that the heat transfer processes in the two phases can be lumped into a process described by a single heat conduction equation. The problem then becomes the construction of an appropriate composite model for the effective stagnant thermal conductivity of the mixture. This type of approach can be traced back to the works of Maxwell (1873) and Rayleigh (1892). Continuing efforts in
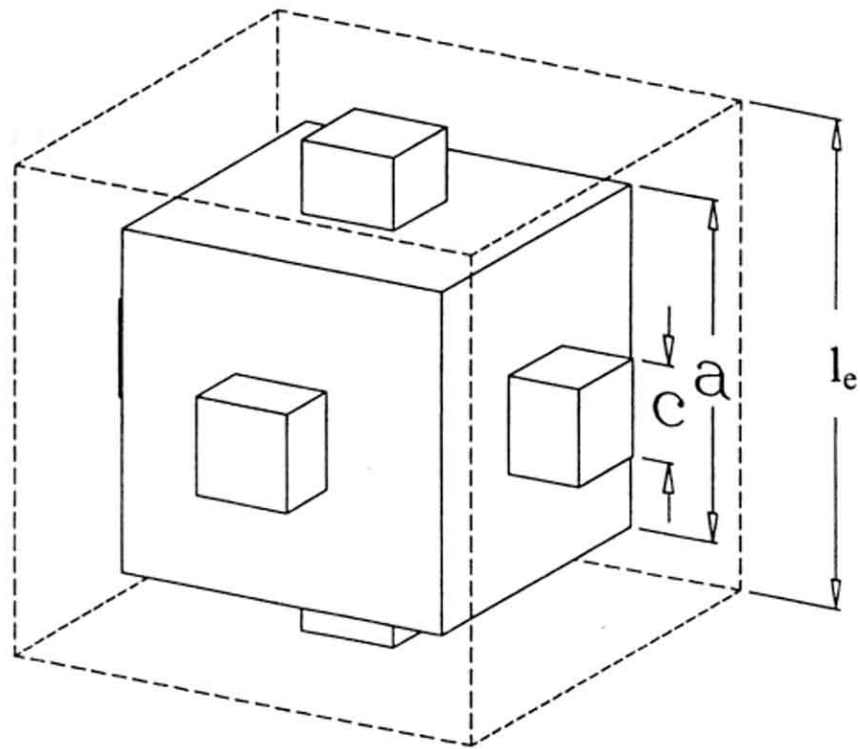
**Figure 4.** Unit cell of 3D in-line arrays of cubes used by Hsu et al. (1995).