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Coupled Radiation-Conduction Heat Transfer in Complex Semitransparent Macroporous Media

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ABSTRACT Porous media are used and studied in many different fields due to their interesting and versatile morphological characteristics and transport properties. Often the structure of porous media is complex and it is impossible to resolve all scales when investigating practical applications. Volume averaging methods are instead used, giving rise to closure problems which are resolved by introducing effective transport properties. If various modes of heat transfer are considered, coupling terms will appear in the volume-averaged equations, introducing additional effective properties that are not present when each mode is treated separately. We developed a numerical method to simulate coupled radiative and conductive heat transfer in morphologically complex macroporous media composed of two thermally conducting and (semi)transparent phases in order to allow for an accurate determination of the effective properties. The exact morphology was obtained by X-ray computed tomography providing the discretized modelling domain. The radiative heat exchange, taking place in the geometrical optics regime, is simulated using a Monte Carlo ray tracing method. A finite volume method is used for solving the transient energy conservation equation. The results of the direct simulation allowed investigating the effect of radiative-conductive heat transfer coupling and deriving the corresponding effective properties.