COMPUTATIONAL RADIATIVE CHARACTERIZATION OF RANDOM FIBROUS MEDIA WITH OPTICALLY LARGE FIBERS

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Radiative heat transfer is analyzed in fibrous media with heterogeneous features in the limit of geometrical optics. The absorption and scattering coefficients and the scattering phase function of a model medium consisting of optically large homogeneous fibers (Figure 1) are determined based on the discrete-level medium geometry and the optical properties of the fibers. The fibers are assumed to be infinitely long, to have constant diameter, and to be randomly oriented and positioned inside the medium. Two combined analytical−numerical approaches are employed: a combined volume-averaging and Monte Carlo ray-tracing technique (method 1) [1−3], and a combined mean-free path and Monte Carlo ray-tracing technique (method 2) [4]. A new analytical approach recently developed for packed bed of spheres [5] and applied here to fibrous media is also examined (method 3). The radiative properties obtained by the three methods are then used to solve a radiative transfer equation in one-dimensional slabs by the collision-based Monte Carlo method to compute the overall transmittance and reflectance [6]. For the validation purpose, these three approaches are compared against the direct Monte Carlo simulation of radiative transfer within virtual fibrous samples of different thicknesses [7]. The effects of fiber diameter and volume fraction on the medium radiative properties and the overall slab radiative characteristics are investigated.

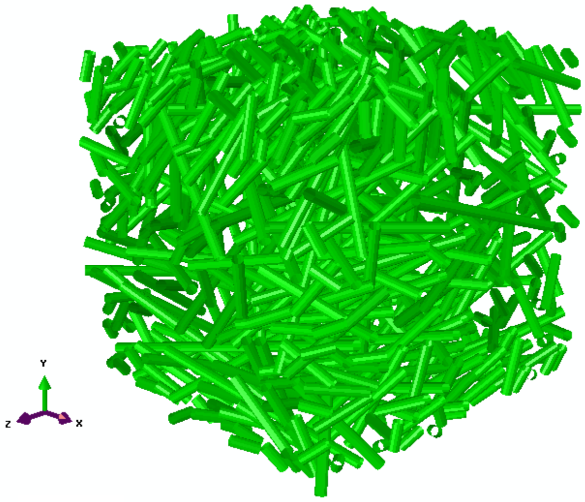

Figure 1: Model medium consisting of randomly oriented and positioned internally isotropic, infinitely long and optically large fibers of uniform diameter.

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