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Effective conductivity in regular periodic media with cuboid inclusions

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We derive a general solution for effective conductivity for an idealized, periodic heterogeneous media with cuboid inclusions. Comparison to effective conductivities derived for random heterogeneous media demonstrate similarities and differences in the behavior of the effective conductivity in regular periodic (low entropy) versus random (high entropy) media. The results define the low entropy bounds of effective conductivity in natural media, which is neither completely random nor completely periodic, over a large range of structural geometries. For isotropic inclusion and isoprobable conditions well below the percolation threshold, the results are in agreement with the self-consistent approach. For anisotropic cuboid inclusions, or at relatively close spacing in at least one direction (aniso-probable conditions), the effective conductivity of the periodic media is significantly different from that found in anisotropic random binary or Gaussian media. Transport properties in highly anisotropic systems with flow perpendicular to the anisotropy axis solute/particle transport in Markov Chain random fields is shown to be significantly different from Gaussian media, particularly near the percolation threshold.