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ELECTRICAL CONDUCTIVITY OF ANISOTROPIC DISPERSIONS: AN EFFECTIVE-MEDIUM THEORY VERSUS FULL-FIELD SIMULATIONS

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Abstract. The electrical conductivity of dispersions depends on the constitutive and morphological properties of the pure phases in an intricate manner. To estimate such dependency, several effective-medium theories have been proposed (Banisi, Finch and Laplante, Minerals Engineering 6, pp. 369–385). Ponte Castañeda and Willis (Journal of the Mechanics and Physics of Solids 43, pp. 1919–1951) proposed an effective-medium theory of the Hashin-Shtrikman type that incorporates the influence of inclusion shape and distribution on the electrical anisotropy of the dispersion. The theory provides particularly simple estimates for the effective conductivity of ellipsoidal distributions of ellipsoidal inclusions, which have hitherto been employed in a variety of applications. The purpose of this work is to generate full-field simulations to assess the accuracy of those estimates. A rigorous assessment calls for simulations based on microgeometries complying with the ellipsoidal symmetries assumed by the estimates. In this work we consider Hashin sphere assemblages of ellipsoidal inclusions. The effective conductivity of an assemblage is bounded from above and below by solving the field equations within a single sphere subject to affine boundary conditions via the finite element method. Results are reported for a wide range of conductivity contrasts, volume fractions and aspect ratios. Estimates are found to lie within the bounds for the entire range of material parameters considered, including the limiting cases of needles and discs.