Strong field magneto-transport in a disordered composite conductor: Exact asymptotics and some new critical points

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Abstract:

In the limit where the Hall-to-Ohmic resistivity ratio H is much greater than 1, the local electric field and current density in a composite medium simplify, becoming much simpler than even in the absence of any magnetic field. As a consequence of this, simple closed form asymptotic expressions are found for some of the elements of the macroscopic or bulk-effective resistivity tensor. These expressions provide a reasonable approximation for the exact values as soon as $|H|>10$. In the case of a disordered microstructure, those expressions have singular points which indicate the existence of critical points and an associated critical behavior. These points have nothing to do with the geometric percolation phenomenon: They occur even when all the constituents have finite, nonzero resistivities with comparable but different magnitudes. While some of these points were identified previously using the self-consistent effective-medium approximation (SEMA), the new treatment endows them with a more convincing theoretical basis: Whereas SEMA is an uncontrolled approximation that is known to yield erroneous results for the critical behavior near a percolation conductivity threshold, the current treatment is based upon an exact asymptotic expansion of the relevant equations governing the magneto-transport phenomena in a composite medium. Thus there can be no doubt regarding the existence of these critical points, and they ought to be looked for in appropriately designed experiments.

In a related presentation by Yakov M. Strelniker at this conference some consequences of the above described exact asymptotic treatment for the case of periodic microstructures are described and discussed and compared with numerical solutions.