A three-phase tessellation: solution and effective properties

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Two-dimensional, doubly periodic, three-phase structures are considered in the situation where mean fluxes are applied across the structure. The approach is to use complex variables, and to use a mapping that reduces the doubly periodic problem to a much simpler one involving joined sectors.
This is a model composite structure in electrostatics (and mathematically analogous areas such as porous media, anti-plane elasticity, heat conduction), and we find various effective parameters and investigate limiting cases. The structure is also amenable to asymptotic methods in the case of highly varying composition and we provide these solutions, partly as a check upon our analysis, and partly as they are useful in their own right.