Non-Asymptotic Homogenization of Periodic Electromagnetic Structures and an Uncertainty Principle

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Igor Tsukerman

The University of Akron

Joint work with Prof Vadim Markel, University of Pennsylvania

Nontrivial magnetic response of periodic structures composed of intrinsically nonmagnetic constituents is now a well-established but still intriguing phenomenon; it plays a critical role in negative refraction, cloaking and other unusual effects. Much attention has been devoted to optimal (in some sense) design, whereby the magnetism would be enhanced and engineered to fall in a desirable range for specific applications – absorption, cloaking, lensing, etc. However, the speaker and his research group show both analytically and numerically that this artificial magnetism has principal limitations: the stronger the magnetic response (as measured by the deviation of the effective permeability tensor from identity), the less accurate ("certain") predictions of the effective medium theory are. The speaker and his research group view this as an *uncertainty principle* for the effective parameters of metamaterials.

This analysis is closely related to, but logically independent from, the recently developed non-asymptotic homogenization theory for periodic electromagnetic structures (*Proc. R. Soc. A, 2014.0245*). In that theory, no assumptions other than the intrinsic linearity of the constituent materials of the structure are made; in particular, anisotropy and magnetoelectric coupling may exist, and the lattice cell size does not need to be vanishingly small.

Numerical examples are given and a clear distinction between classical (asymptotic) and non-asymptotic homogenization theories is drawn.