Electromagnetic emergence in metamaterials

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This presentation focuses on the emergent electromagnetic properties in such heterogeneous media that are, in today's discussion, being more and more often called "metamaterials." More precisely, the very concept of metamaterial is under study as also are the preconditions under which such a term is appropriate.

The word "metamaterial" has become very common in the recent discussion of materials research in electromagnetics, and perhaps also in some other fields of applied and theoretical physics. At least such an impression is possible. If this is true, what is the reason for such a state of affairs? Why is "metamaterial" used increasingly in electromagnetics parlance, if not yet so much in literature? Indeed, what is the exact meaning of the term?

In this presentation, I would like to problematise the use of the term "metamaterial," at least in the extent to which it is used exclusively to new, especially nanoengineered, materials. The history of electromagnetics research contains a very rich collection of results for random, inhomogeneous, and composite materials. A closer look at the properties of these old-fashioned materials reveals that they could be certainly classified into the group of the modern metamaterials, even though they may be well known and familiar to many of us as "ordinary" materials.

That scientists name things such that they attract attention is understandable. One can think of the recent surge of interest in PBG (photonic band gap) materials, or photonic crystals, where artificially manufactured geometries create pass and stop bands for electromagnetic waves in microwave, millimetre wave, and optical regions. Physicist-driven research on PBG's has caused irritation within the microwave engineering community, and engineers point out (partially correctly) that periodical dielectric materials are nothing new. Who would not feel the desire of finding exciting and potentially money-attracting names for materials that are the subject of one's present studies? Certainly we also in the bi-anisotropics field have to admit this when talking about exotic, novel, or complex materials.

I think that it is important, therefore, to start the discussion with definitions.