# Anisotropic Representation for Spatially Dispersive Metamaterials

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Anisotropic permittivity and permeability relating generalized electric and magnetic polarization densities are shown to be sufficient to characterize the exact electric and magnetic macroscopic properties of the fundamental Floquet modes of 3D periodic arrays; that is, the macroscopic magnetoelectric dyadics of a bianisotropic formulation are not required, although a bianisotropic formulation may for some applications be more suitable and useful, especially for arrays with magnetoelectric coupling in the material of the inclusions. The generalized electric and magnetic polarization densities do not involve generalized multipole moments of higher order than generalized electric quadrupole moments. Moreover, as $\boldsymbol{\beta} \to 0$, the generalized electric and magnetic polarizations reduce to ordinary electric and magnetic dipole moments per unit volume with no contributions from higher order multipole moments required (unless the ordinary electric and magnetic dipole moments are zero as $\boldsymbol{\beta} \to 0$). Within the framework of this anisotropic formulation, it is significant that diamagnetism presents no unusual causality problems in that the resulting diamagnetic permeability with negative real part exhibits a zero time-domain response for time $t < 0$ and satisfies the Kramers-Kronig dispersion relations at each fixed $\boldsymbol{\beta}$. That is, the theory requires no special considerations or modifications for arrays with inclusions that produce macroscopic diamagnetic permeability.