ENZ materials: Optimal designs for low-loss composites and near-field antennas

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Abstract – **Surprising phenomena for many applications can be enabled at wavelengths where the real part of a material's permittivity is near zero. A key hurdle for many of these phenomena at optical frequencies is material loss, with typical material quality factors of 5 or smaller. We use the theory of composites to identify a pathway, using typical materials, to design ENZ metamaterials with substantially smaller losses, offering order-of-magnitude improvements in material quality factors at the ENZ point. We also identify a new application for ENZ materials: near-field antennas. "Dual-polarizability" designs enable dramatic enhancements of Purcell factors, at a fixed quality factor, increasing the exponent that dictates enhancement rate as a function of minimum feature size. Materials with dielectric and ENZ materials can provably outperform *any* dielectric-only designs.**