

Left-Handed Devices

Physical Review Letters, vol. 92, no. 5, pp. 053901-1, -4, 6 Feb., 2004.

- **Basics of left-handed media**

- permittivity and permeability are located in the third quadrant of the $\mu\epsilon$ chart
- phase propagation constant and Poynting vector are in opposite directions
- refractive indices are negative
- rays diverge and converge opposite to ordinary (right-handed) media

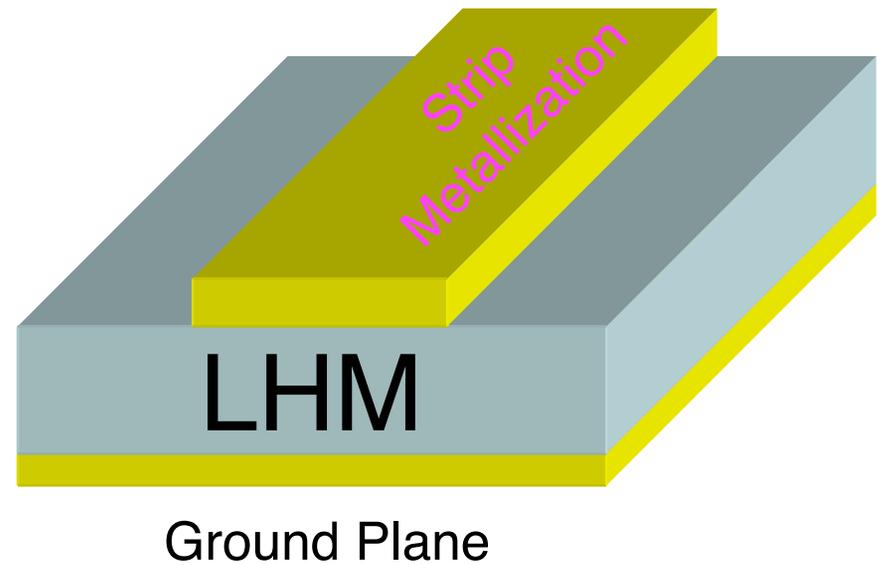
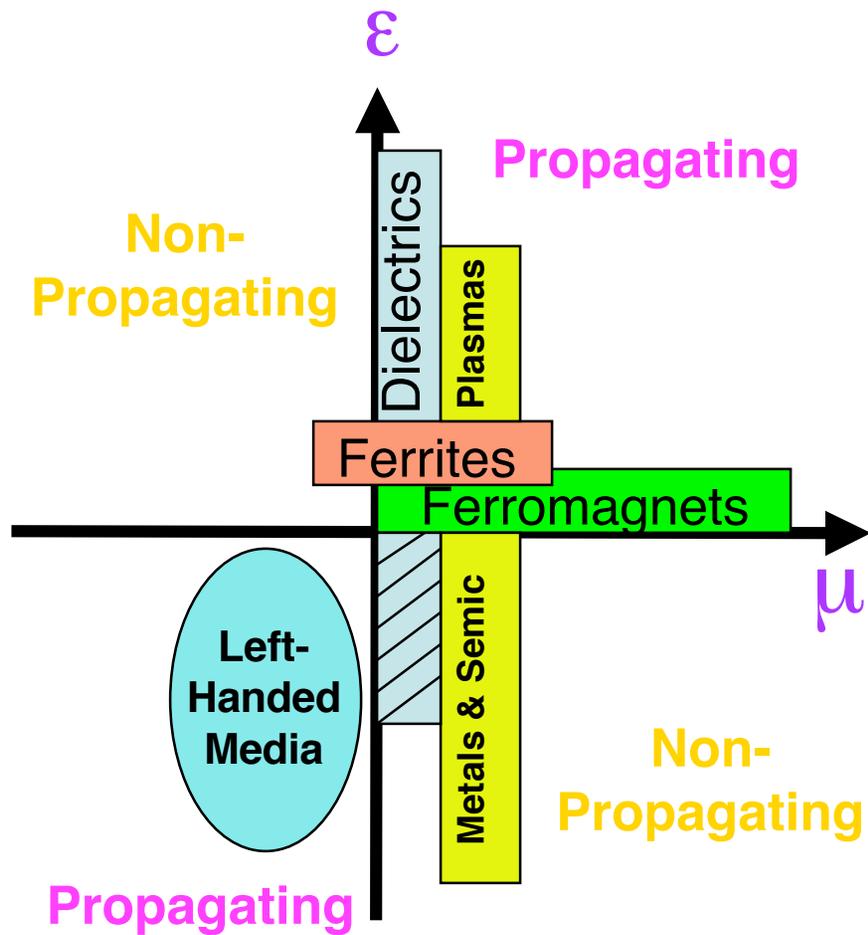
- **Potential techniques for realizing a left-handed substrate**

- metamaterials
- layered negative permittivity and permeability

- **Candidate guided wave left-handed-media-based devices**

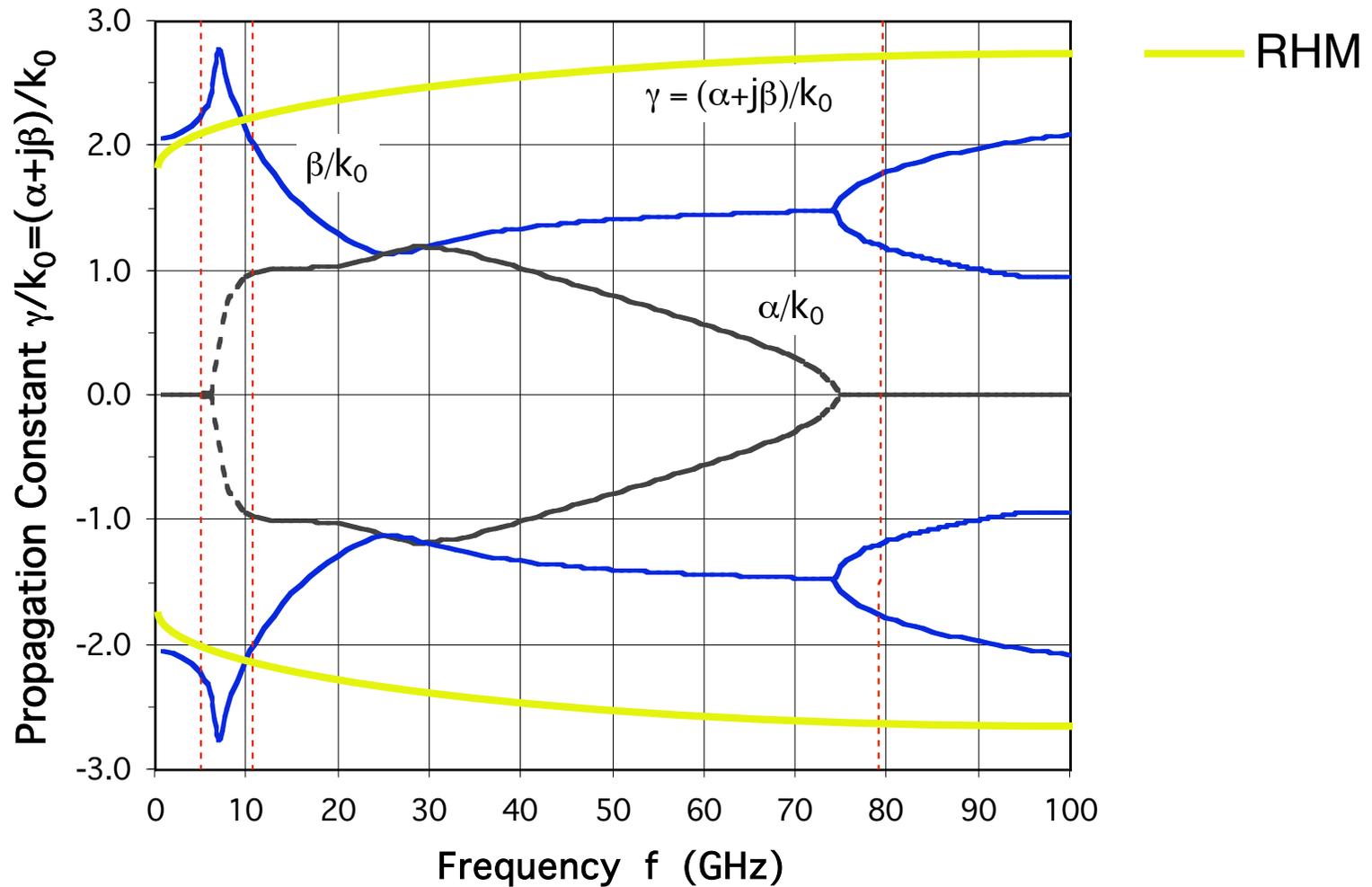
- new filters with frequency response determined by material rather than circuit
- compact variable delay lines and phase shifters (low group velocity)
- ultra-compact circulators and isolators (novel lumped element geometries)

Properties of Media and Canonical Device



Dispersion Curves for Left-Handed-Media Microstrip

- Complex propagation constant of the fundamental microstrip modes



Cross-sectional Magnetic Field Distribution at 5 GHz

- Magnetic-field strength and direction of a simulated 5-GHz EM wave, guided by a metal microstrip on a left-handed substrate (below the yellow bands).

