Wave Analysis, Characterization, and Applications of Metamaterials

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Overview

1. What are Metamaterials?
   - History, refractive index, and $\mu-\varepsilon$ diagram
2. What is NIM?
   - NIM, LHM, NIR, DNG
   - Plane wave, phase and group velocities, Poynting vectors, Stored energy, dispersion
3. Subwavelength focusing and evanescent waves
   - Perfect lens, line source, $\varepsilon = -1+\Delta_1$, $\mu = -1+\Delta_2$
   - Drastic reduction of evanescent spectrum, spot size
4. New wave type on layers of Metamaterials and NIM
   - Poles, zeros, branch-cuts, Riemann surfaces
   - Forward and backward surface waves and lateral waves
   - Brewster's angle and Zenneck wave

Overview (cont.)

5. Dispersion and space-time wave packet in NIM
   - Phase velocity, group velocity, and wave front velocity
   - Incident angle < critical angle
   - Incident angle > critical angle
   - Backward lateral wave and Goos-Hanchen shift
   - Drude and Lorentz models of ε and μ
6. Surface plasmon on NIM
   - Surface plasmon resonance
   - Leaky wave and surface plasmon
7. Design and characterization of metamaterials
   - Generalized constitutive relation
   - Stacked Split Ring Resonator (SSRR), helices, tunable SSRR
8. Transmission line approach
   - Bulk medium (3-D)
   - Transmission lines (1-D, 2-D), low loss

Overview (cont.)

9. Realization of transmission line metamaterials and applications
   - Microwave application
   - Composite right-left handed (CRLH) TL
   - Leaky wave, scanned antennas
   - Guided waves
   - Mushroom structures
   - Focusing, and surface structure
10. Unusual characteristics and applications of NIM
   - Lens – subwavelength focusing
   - AMC, PMC, backward Goos-Hanchen, lateral waves
   - Small antennas, broadbanding, scanning, leaking wave
   - Nano particles, plasmonic nano-particles
   - Increase or decrease of crosssection
   - Polarization – separation
   - Resonance cone, surface impedance, mushroom EBG
   - Evanescent wave, Transmission through small hole