

New Aspects of Old Equations: Metamaterials and Beyond (Part 1)

신종화

KAIST 물리학과



James Clerk Maxwell
(1831-1879)

Maxwell's Equations

$$\nabla \cdot \mathbf{D} = \rho_f$$

Gauss's law

$$\nabla \cdot \mathbf{B} = 0$$

Gauss's law for magnetism

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

Faraday's law of induction

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

Ampere's circuital law with Maxwell's correction

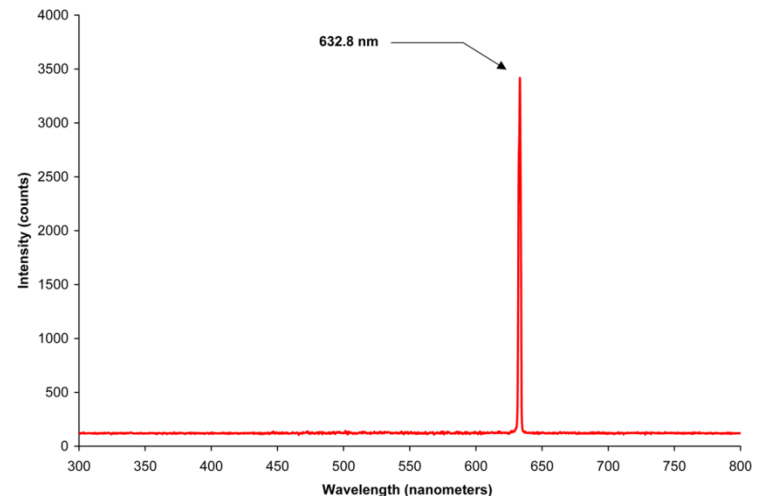
→ Unification of electromagnetic theory

But,

- That was almost 150 years ago.
(earlier than Edison, Marconi, etc.)
- Anything new from these equations?

Laser

- Light Amplification by Stimulated Emission of Radiation
- Applications: communications, data storage, medical imaging, surgery, defense, ...
- **Strong** fields with a **narrow** **spectral** width



Nanophotonics

- Nano-scale manipulation of light
- **Strong** fields with a **narrow** **spatial** width
 - Spatial width \ll wavelength in vacuum
 - Beyond the diffraction limit
- Potentials
 - **New physics**: e.g., greatly enhanced nonlinearity
 - **Integration**: photonic IC

Metamaterial

Near-field Configuration
in Periodic Structures
→ New “Material”

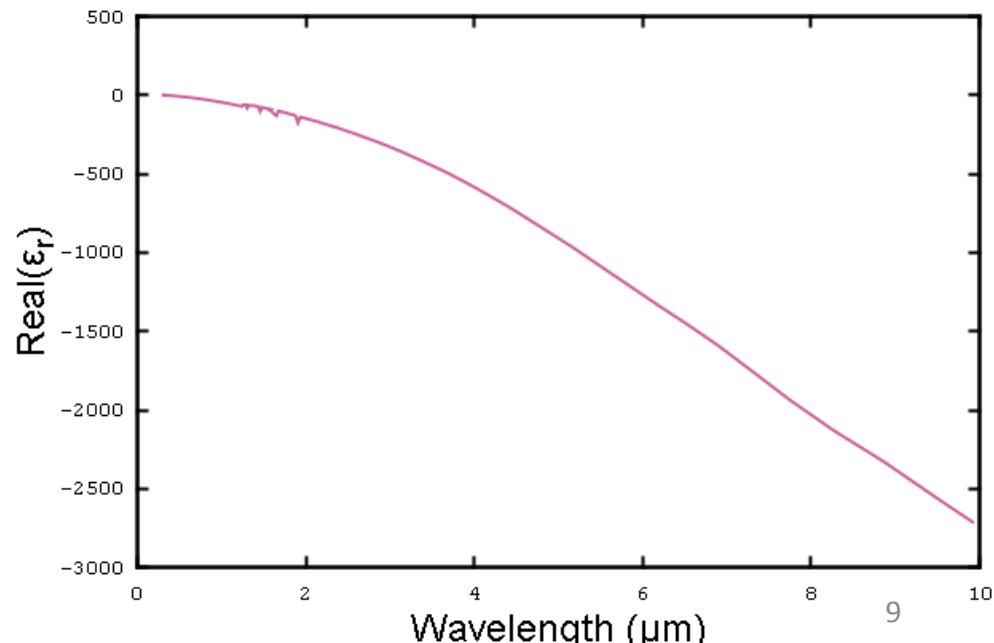
Invisibility Cloak



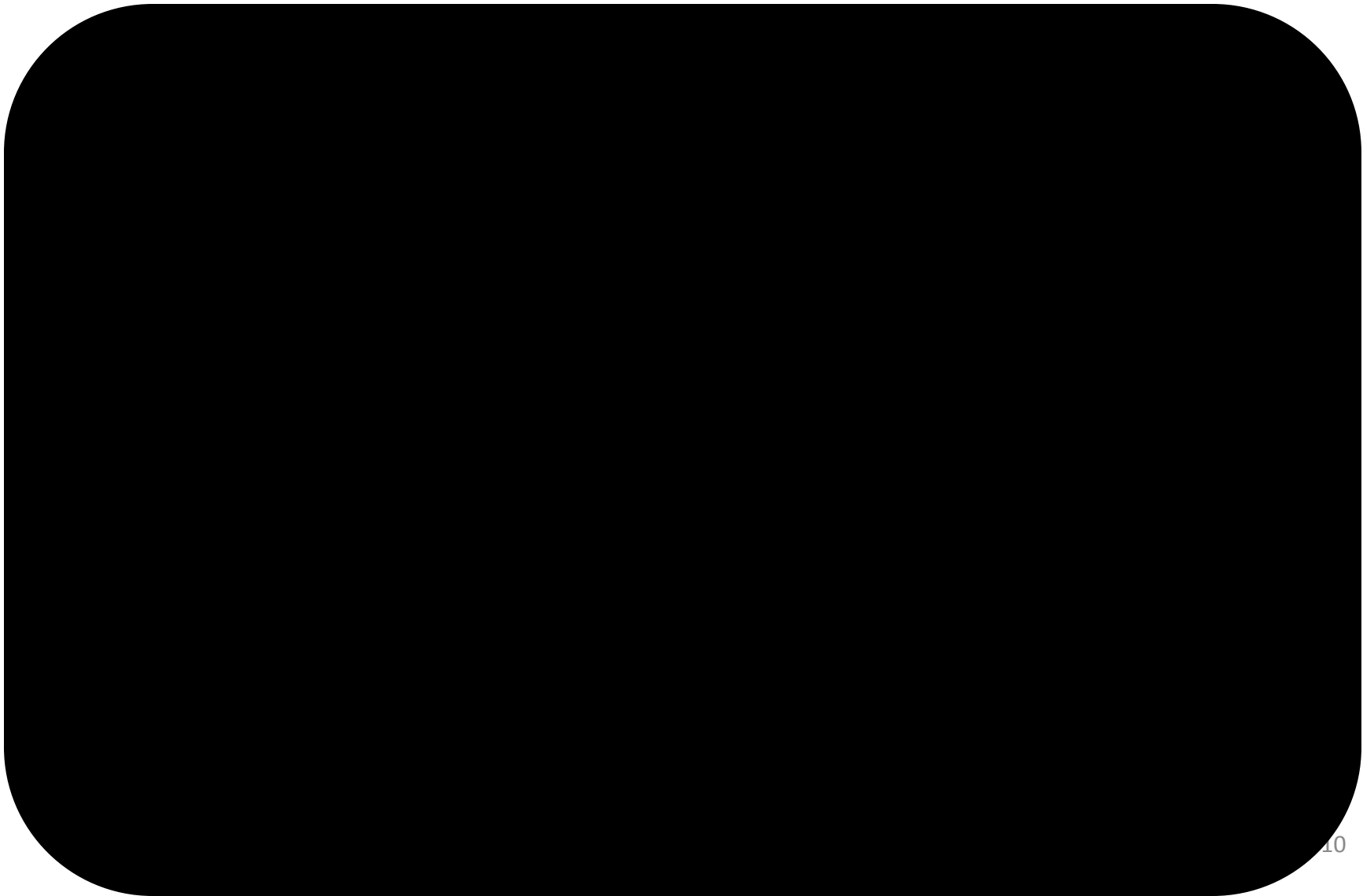
Cloak Video #1

Metal

- Indispensible material for nanophotonics
- Abundant charge carriers
 - Large absolute value of permittivity
 - Negative permittivity



Negative Permittivity?



Optical Properties of Metal

- Damped oscillator
- Drude model
- Low frequency regime
(Good conductor)
- Terahertz-Visible regime
(Negative permittivity)