Begin 01-16-2025

Light-Matter Interaction

Hierarchy of Sophistication:

- Classical — Classical light, classical matter
- Semiclassical — Classical light, quantum matter
- Quantum — Quantum light, quantum matter

Possible attitudes:

- Purist — Most complete description possible
- Minimalist — Quantum only when necessary
- Pragmatic — Quantum or classical, based on what is simplest and still works

OPTI 544: All of the above in turn

Classical Theory of Light-Matter Interaction

Self-consistent, fully classical description

Motivation: We will

- Develop Concepts $\alpha(\omega), n, \chi$
- Develop Intuition
- Classical is often adequate, sometimes accurate
- A Quantum Theory has classical limits
  Identify/understand regime of validity
- The Classical description is a useful starting point for Nonlinear and Quantum Optics

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Light-Matter Interaction

Classical Theory of Light-Matter Interaction

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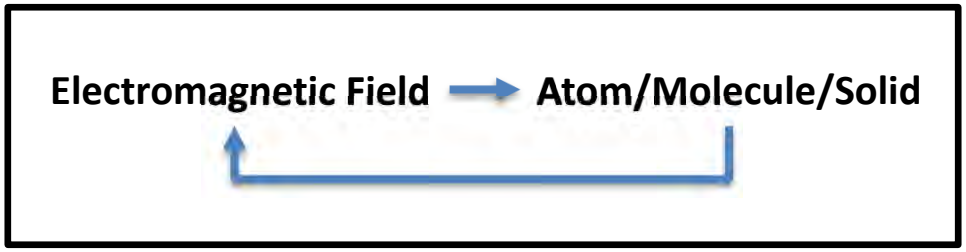

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The Electromagnetic Field: Basic Eqs. in SI Units

Maxwell's eqs.

(no free charges, currents ➡ dielectrics)

(i) $\nabla \cdot \vec{D} = \rho = 0$ $\quad \vec{D}$: Dielectric displacement

(ii) $\nabla \cdot \vec{B} = 0$ $\quad \vec{B}$: Magnetic induction

(iii) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ $\quad \vec{E}$: Electric field

(iv) $\nabla \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$ $\quad \vec{H}$: Magnetic field

Material Response:

(v) $\vec{B} = \mu_0 \vec{H} + \vec{M}$ ⬅ Non-magnetic ➡ $\vec{M} = 0$

(vi) $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$ ⬅ Info about response in dipole moment density (polarization density)