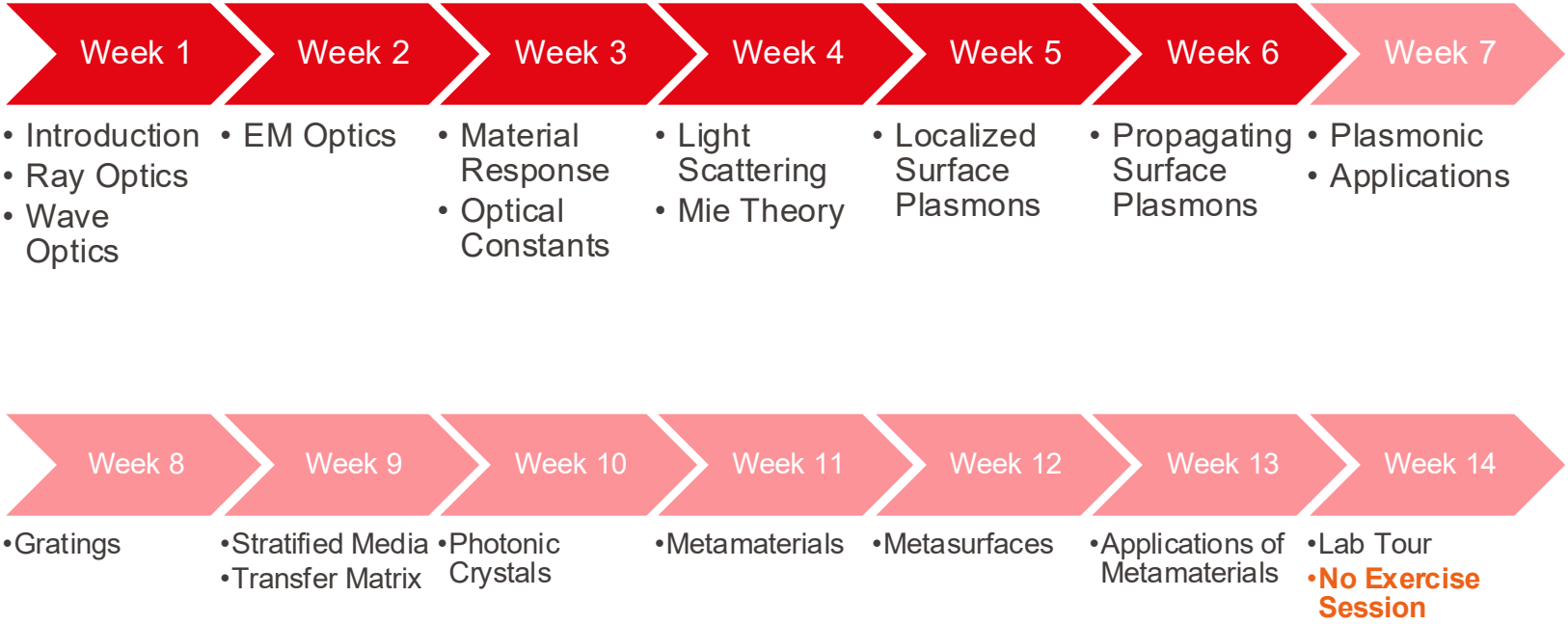
Week 6

(Propagating Surface Plasmons)

Stavros Athanasiou

Lausanne, 14 Oct 2025

Course Timeline



Last Week: Localized Surface Plasmons / 1

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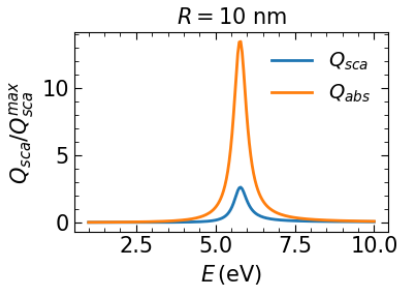
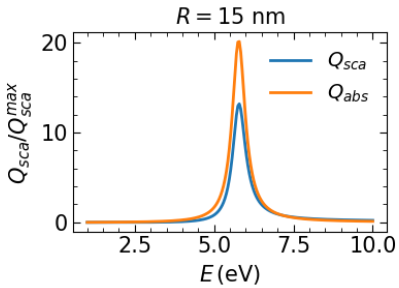
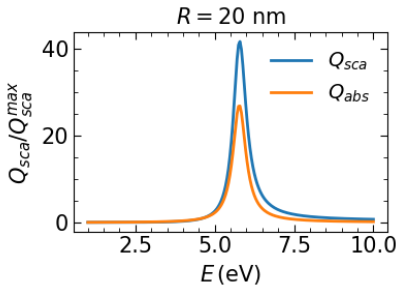
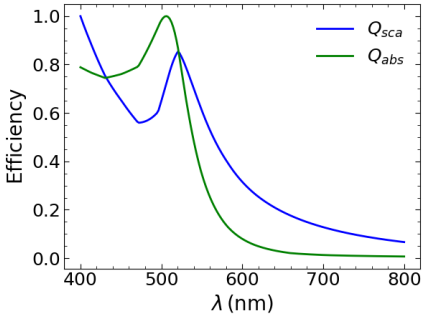
1. Scattering from Small Particles and the Drude Model
2. Comparing Scattering and Absorption in Small Particles
3. Small Gold and Silver Particles

$$\tilde{\omega}_{sp} = \frac{\omega_p}{\sqrt{1+2\varepsilon_b}}\sqrt{1-\frac{(2\varepsilon_b+1)\gamma^2}{4\omega_p^2}} - i\frac{\gamma}{2}.$$









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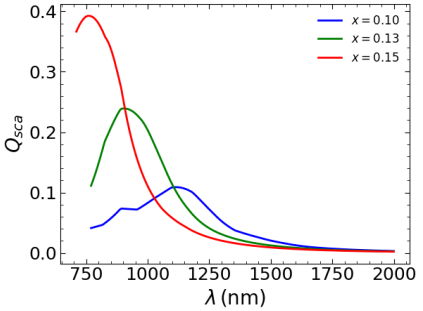
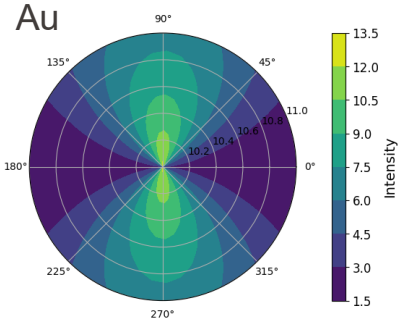
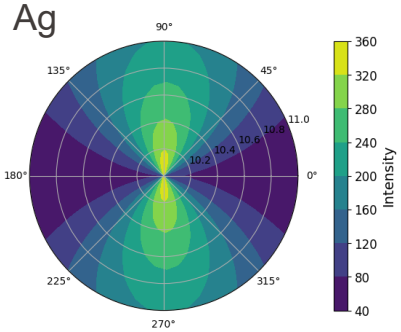
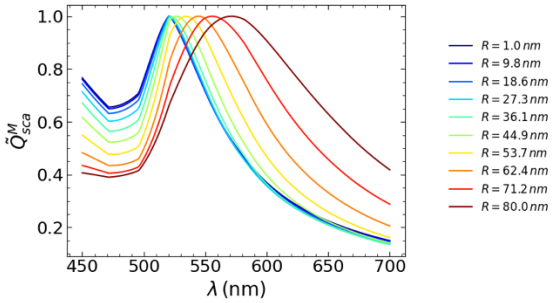
Last Week: Localized Surface Plasmons / 2

4. Near-Field Enhancement of Metallic Particles
5. Breakdown of the Small-Particle Approximation
6. Tuning Plasmon Resonance with Doping









Insights from last week

1. Electrostatic approximation for small particle size.
2. Determine the LSPR frequency from the root of the response function.
3. Factors that impact LSPR frequency:
   - Particle size
   - Material (special attention to representation of dielectric function)
   - Dielectric constant of the host
   - Doping (for semiconductors)
4. Breakdown of electrostatic approximation (comparison with Mie theory)

Additionally : metal NPs seem to scatter light more efficiently than their semiconductor counterparts

Breakdown of electrostatic approximation

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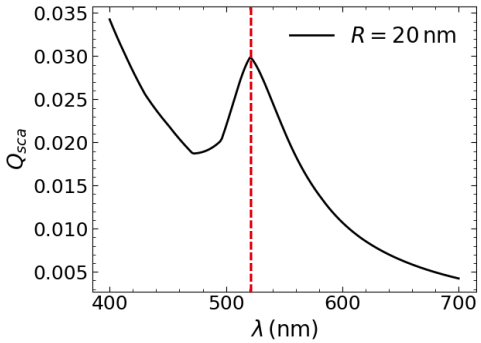
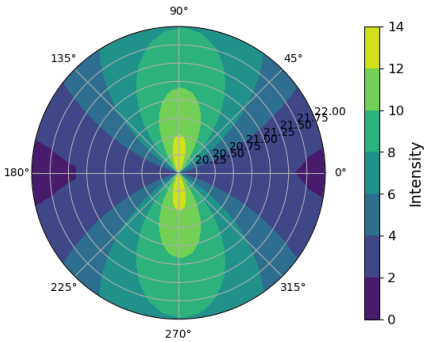
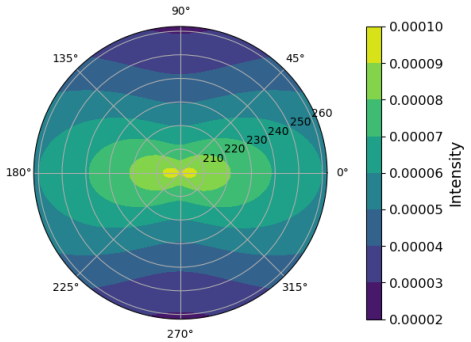
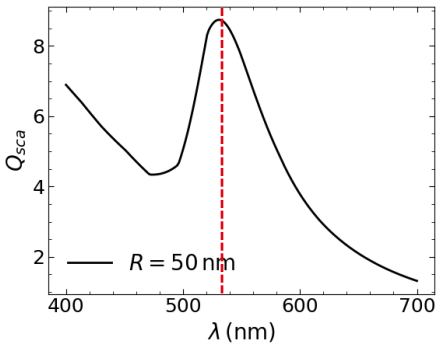
Near-field

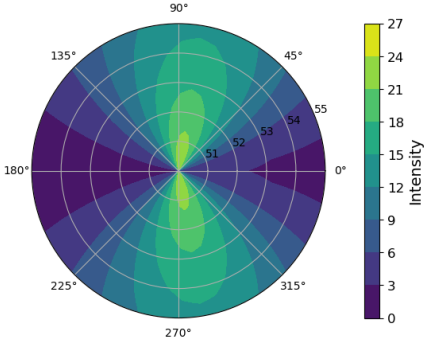
Far-field

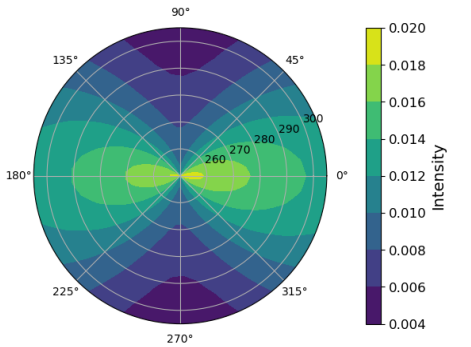












This Week: Propagating Surface Plasmons / 1

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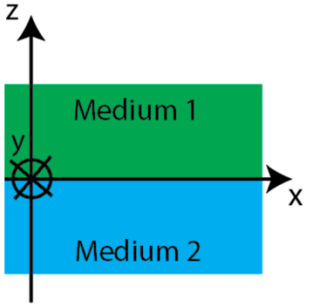
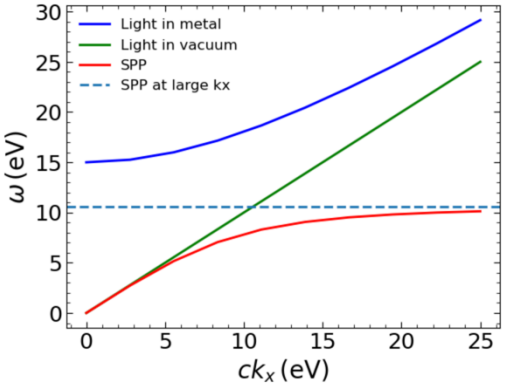
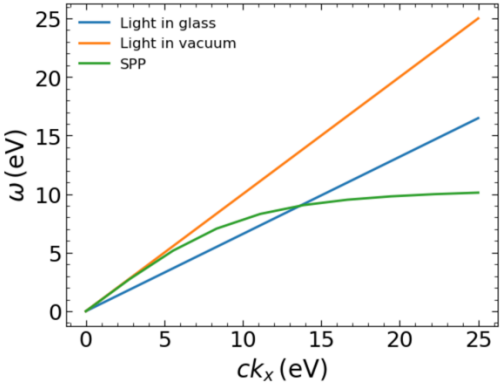
- Derivation of SPP relations



$$k_{sp} = \frac{\omega}{c}\left(\frac{\varepsilon_1\varepsilon_2}{\varepsilon_1+\varepsilon_2}\right)^{1/2}$$

- Dispersion Relations and SPP Excitation





This Week: Propagating Surface Plasmons / 2

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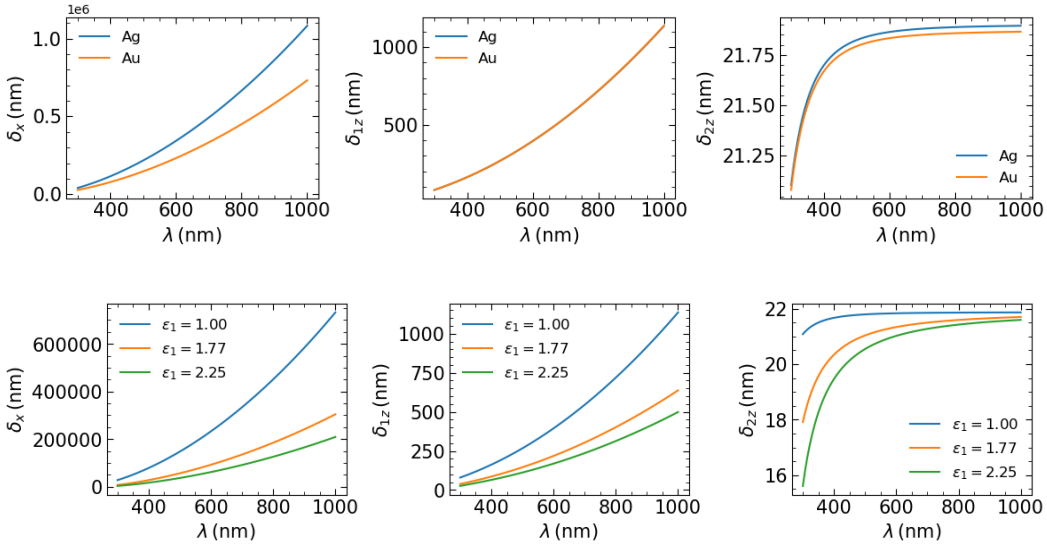
- Propagation and Penetration Depths



- Surface Waves for TE Polarization for Magnetic Media