$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

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

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

$$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$$

Week 7

(Plasmonic Applications)

Stavros Athanasiou

Lausanne, 28 Oct 2025

Course Timeline

Week 1
- Introduction
- Ray Optics
- Wave Optics

Week 2
- EM Optics

Week 3
- Material Response
- Optical Constants

Week 4
- Light Scattering
- Mie Theory

Week 5
- Localized Surface Plasmons

Week 6
- Propagating Surface Plasmons

Week 7
- Plasmonic
- Applications

Week 8
- Gratings

Week 9
- Stratified Media
- Transfer Matrix

Week 10
- Photonic Crystals

Week 11
- Metamaterials

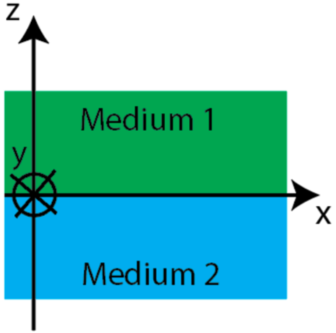
Week 12
- Metasurfaces

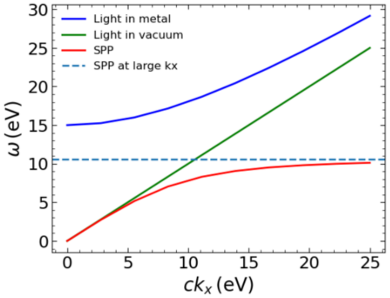
Week 13
- Applications of Metamaterials

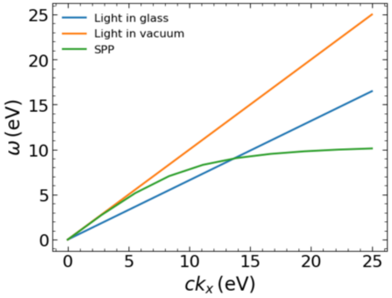
Week 14
- Lab Tour
- **No Exercise Session**

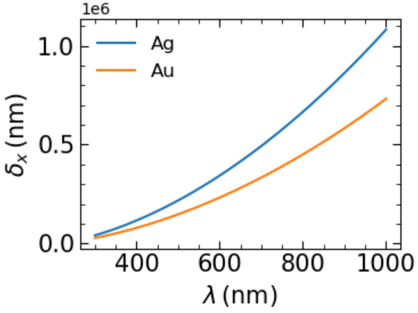
2 Weeks Ago: Propagating Surface Plasmons

1. Derivation of SPP relations
2. Dispersion Relations and SPP Excitation
3. Propagation and Penetration Depths
4. Surface Waves for TE Polarization for Magnetic Media





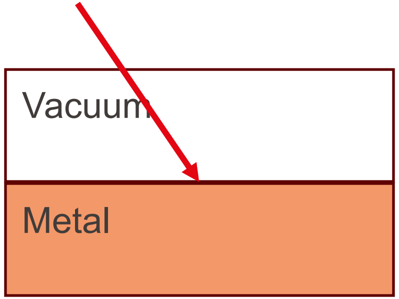




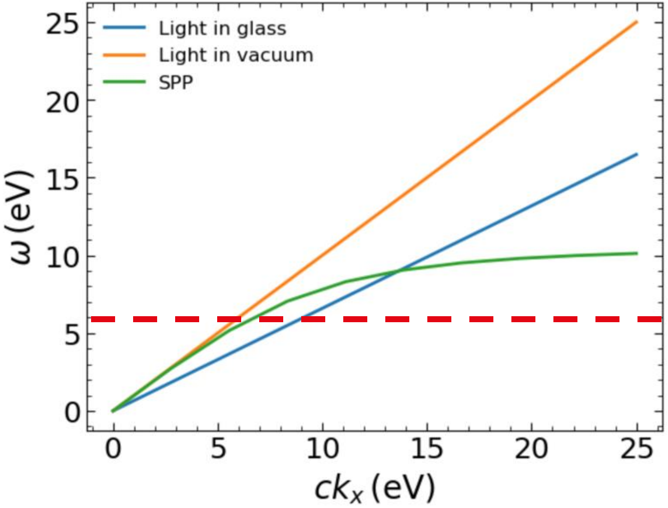
Comment on SPP Dispersion Relations

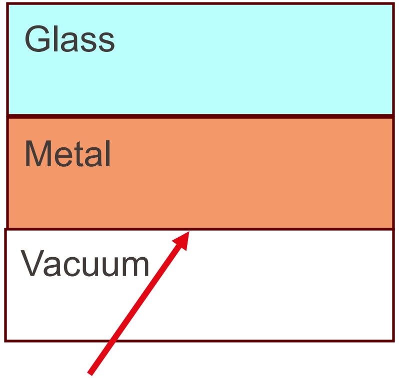
To understand the following dispersion diagram, consider the following scenario:

A monochromatic light is incident on the surface from vacuum.



No SPP on vacuum-metal interface.

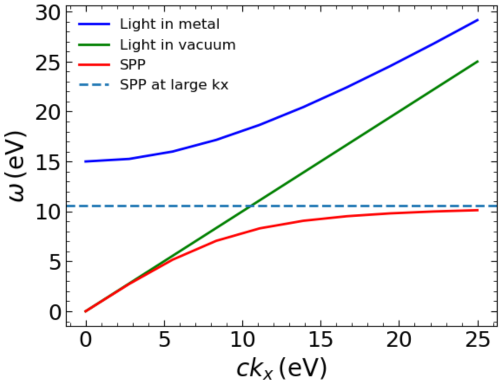


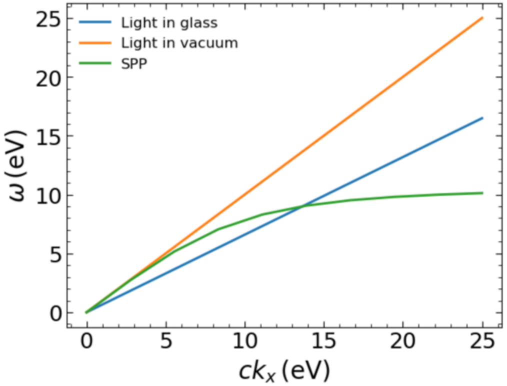


SPP on vacuum-metal interface.

SPP Excitation

SPP excitation requires to match the **SPP momentum**.





a) Otto Configuration

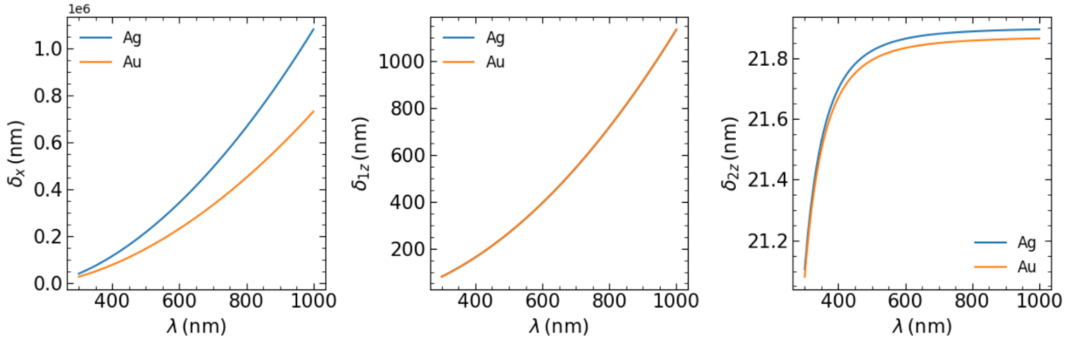
b) Kretschmann Configuration

c) Grating

Propagation of SPP

Length scales of SPP (propagation + penetration lengths)

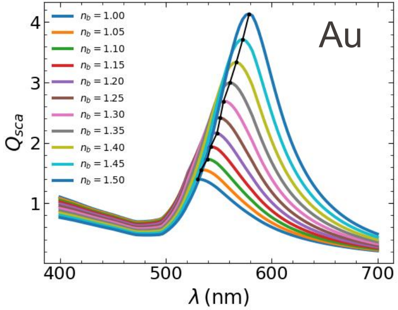
1. Crucially depends on the metal and losses
2. Dielectric environment can decrease lengths
3. Low frequency regime : larger propagation length -> SPP field extends further in the (lossless) dielectric rather than in the (lossy) metal

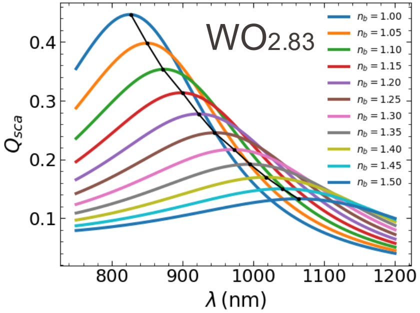


$\lambda\,(\mu m)$	$\delta_x\,(\mu m)$	$\delta_{1z}\,(\mu m)$	$\delta_{2z}\,(\mu m)$
0.633	9.8	0.165	0.014
1	91.6	0.51	0.012
10	38880	57.3	0.011
36	504243	702.67	0.013

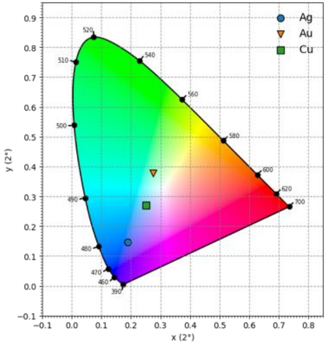
This Week: Plasmonic Applications / 1

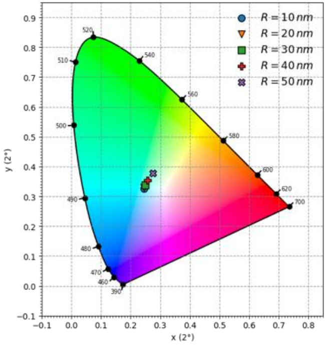
- Sensing with Plasmonic Particles





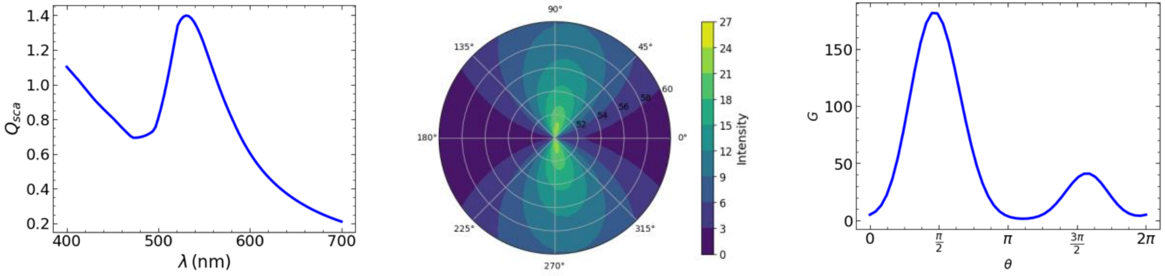
- Visualization of color with CIE Plot



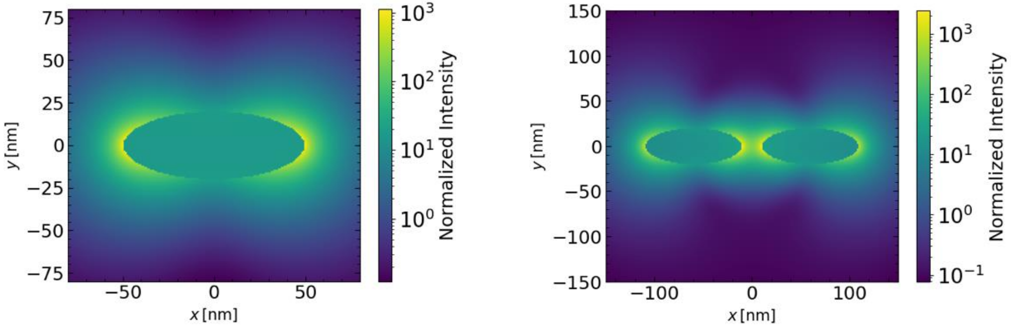


This Week: Plasmonic Applications / 2

- Plasmonic Enhancement of Raman Scattering



- Electromagnetic Response of Non-spherical particles



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