Hidden plasmonic modes revealing via angle resolved optical characterization.

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Dark field spectroscopy

- Advantages
  - Single nano-object scattering measurements
  - Broadening of the spectrum linewidth

- Drawbacks
  - Noisy spectrum
  - Complexity to model and simulate accurately due to multi-angle excitation

Figure 1. Dark field (DF) reflection scattering setup schematic: a centrally blocked and linearly polarized beam is focused through the 50X dark field objective. The collected light is filtered confocally using an optical fiber coupled to a spectrometer through a lens.

Far-field 2d map

Figure 4. Far-field two geometry (reflection and transmission) radiation maps in air for wavelengths: 520 nm, 594 nm and 750 nm. P-polarized illumination angle is 50 degree.

Far-field multi-wavelength maps

Figure 5. Schematic of 50° p-polarized gold nanodisk excitation and collection geometries. The green dash line semicircle shows the reflection collection geometry and the red one corresponds to the transmission geometry.

Figure 6. Simulated far field multi-wavelength maps of 50° p-polarized gold nanodisk excitation for two geometries.

Angle Resolved Extinction

- Advantages
  - Easy operation
  - All excited mode detection

- Drawbacks
  - Nano-objects ensemble measurements
  - Possible coupling LSPR and Diffractive orders

Observation

- Coupling minimization between LSPR and Diffractive order
- New plasmonic modes detection
- Analogy between single particle extinction and ensemble of them

Figure 2. DF reflection scattering spectrum of single 170nm diameter and 50 height gold nanodisk. Illumination NA=0.8 in air (a), corresponding numerical simulation (b).

Figure 3. (a) Angle resolved experimental extinction spectrum of a gold nanodisk 2D array (1µm spacing). P-polarized illumination angle is 50°. (b) Simulated extinction spectrum of a single gold nanodisk. P-polarized illumination angle is 50°.

Near-field and charge distribution maps

Figure 8. Simulated electric near-field maps

Figure 9. Simulated surface charge distribution