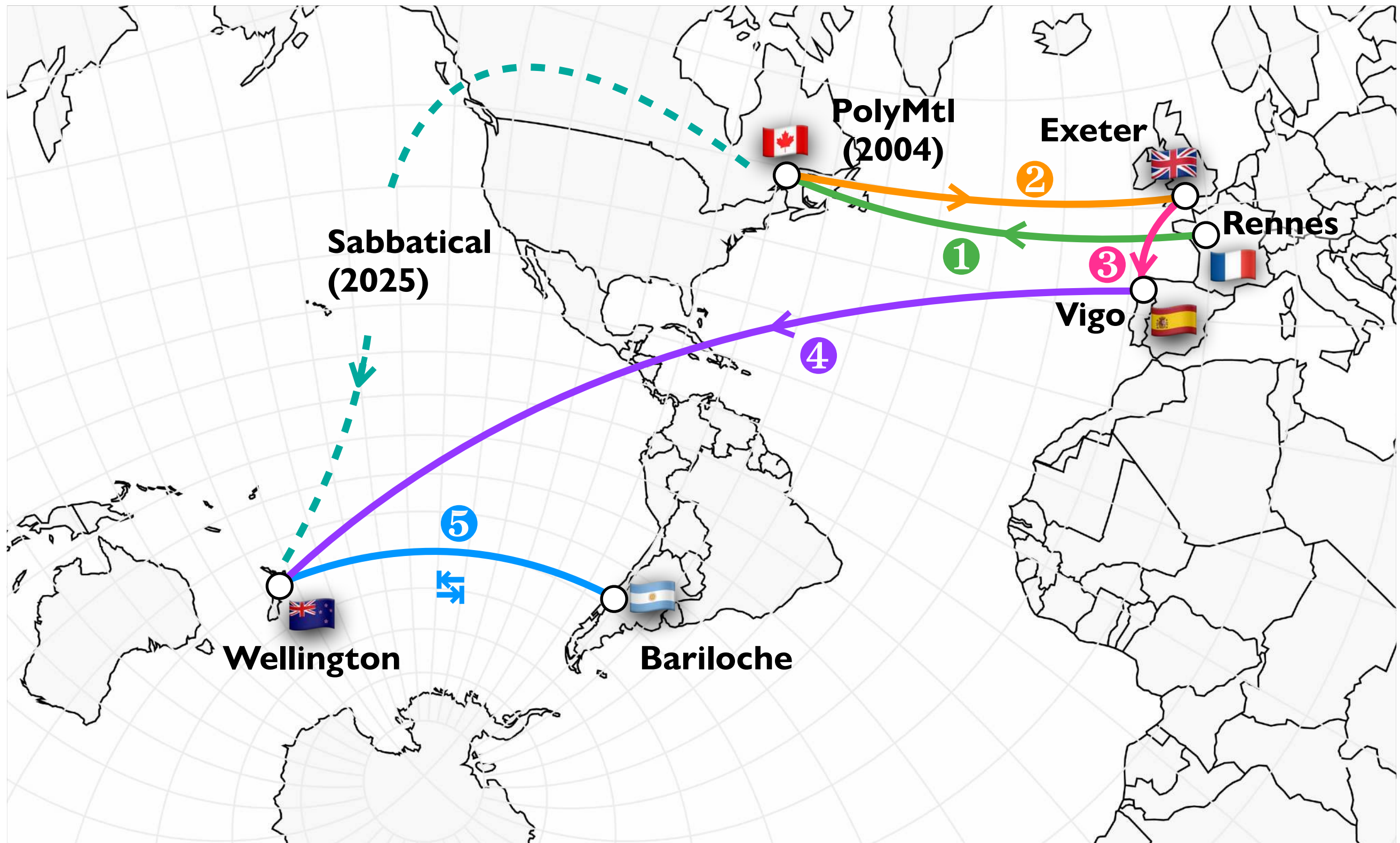




QUANTITATIVE SPECTROSCOPY OF TURBID SOLUTIONS

& overview of our activities in nano-optics

Baptiste Auguié • Victoria University of Wellington, New Zealand



PHOTONIC
CRYSTALS



TWEEZERS

FAR-FIELD



LASER

QUANTUM
OPTICS

CHIRALITY

OPTICAL
FIBRES

METASURFACES

INVISIBILITY CLOAK

SCANNING TIP
MICROSCOPY

DEAD
BRANCH

NEAR-FIELD



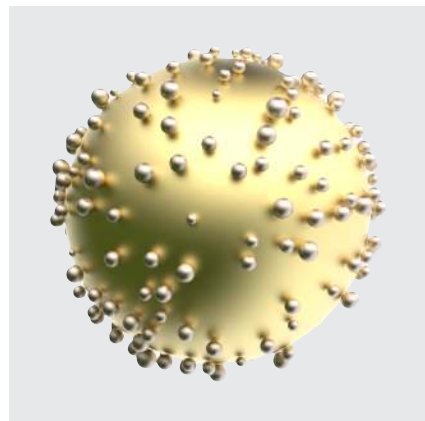
~ Modern Optics ~
(Hobbit's Perspective)



NANO-OPTICS AND SPECTROSCOPY

NANO-OPTICS.AC.NZ

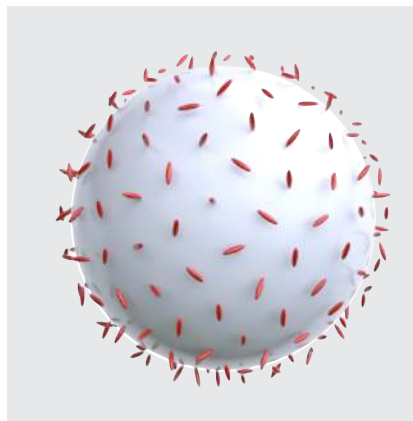
RESEARCH INTERESTS



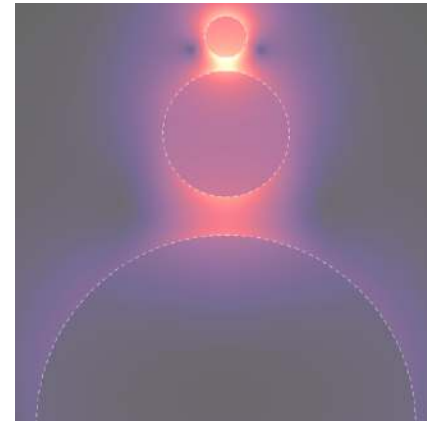
CORE-SATELLITES



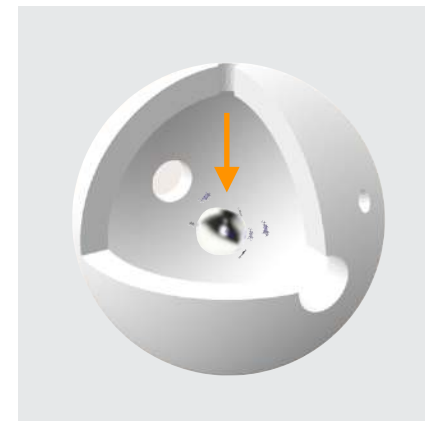
PARTICLE CLUSTERS



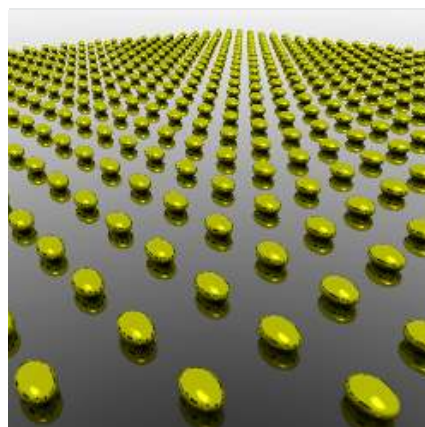
COUPLED DIPOLES



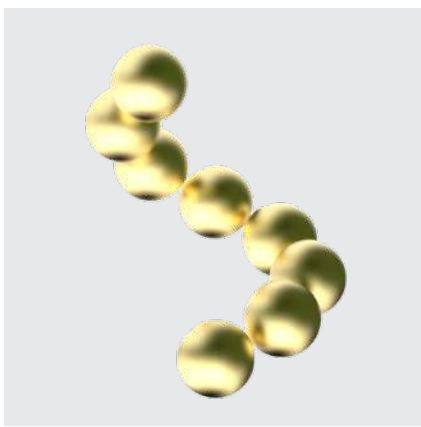
T-MATRIX



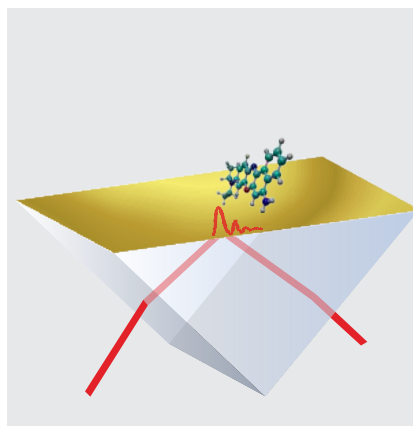
INTEGRATING SPHERE
UV-VIS SPECTROSCOPY



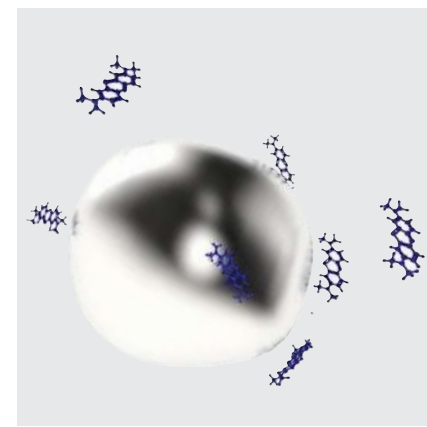
LATTICE RESONANCES



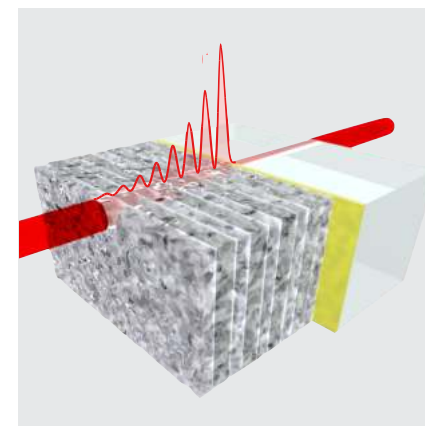
PLASMONIC CHIRALITY



SPR



SERS

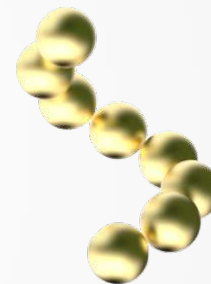


TAMM PLASMONS

OUTLINE

1. INTRODUCTION

Misc. projects on *plasmonic nano-antennas*
T-matrix modelling of light scattering

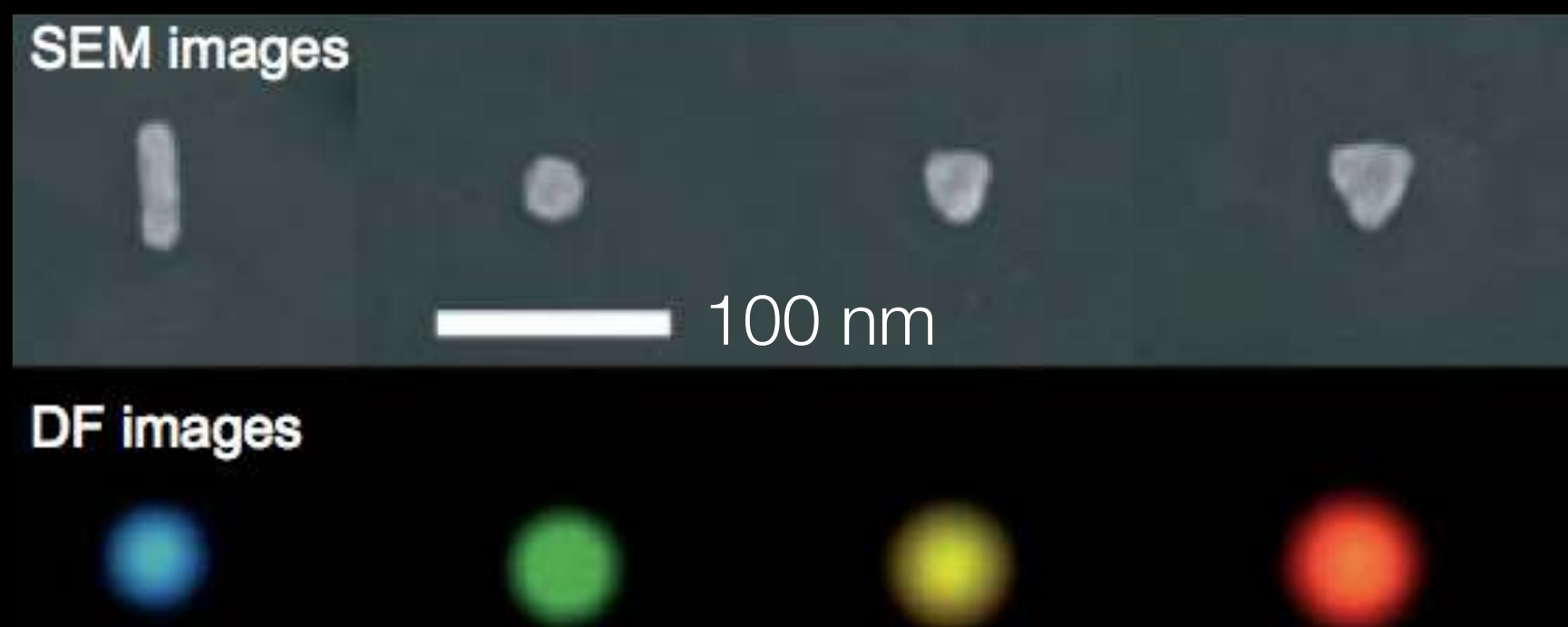
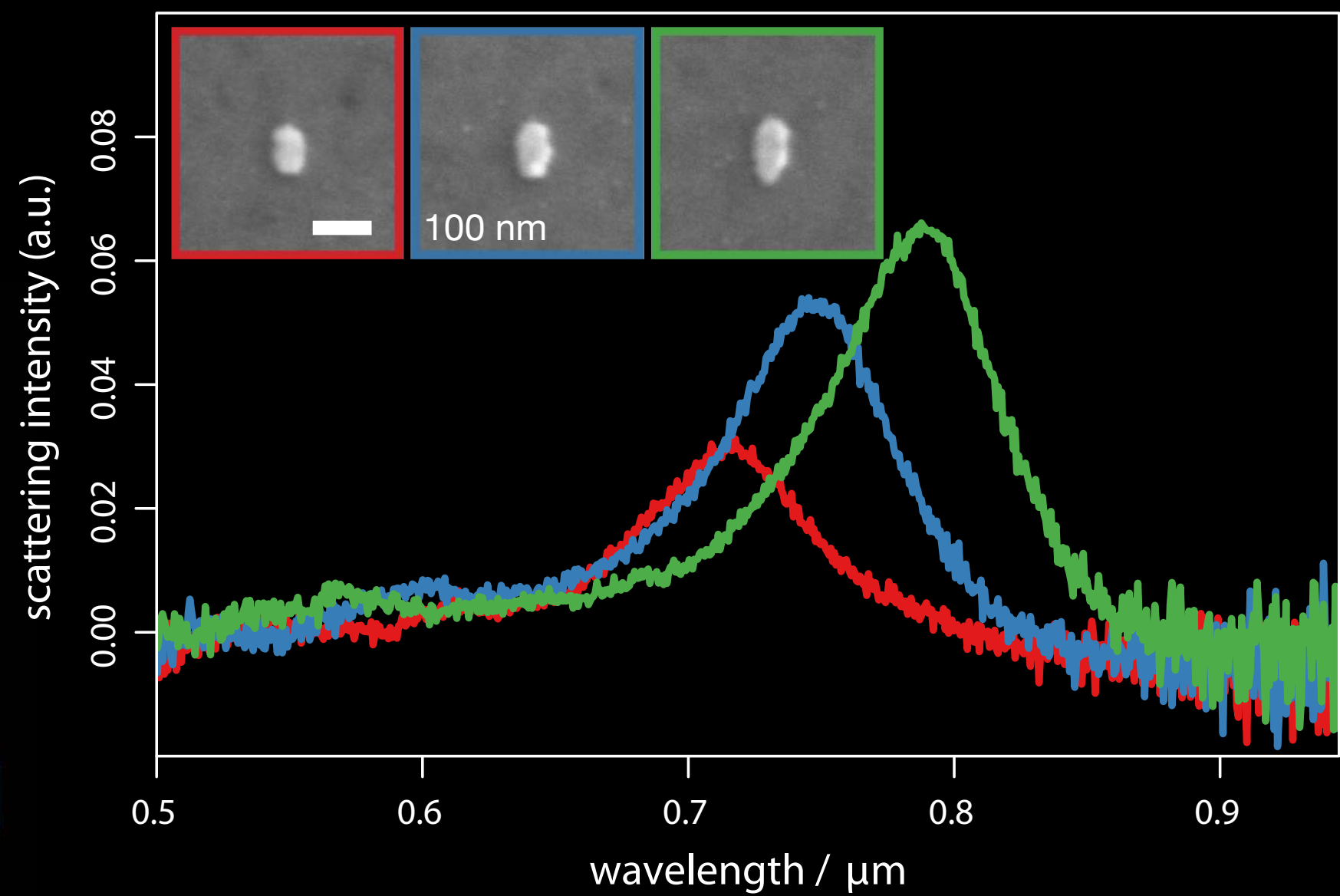
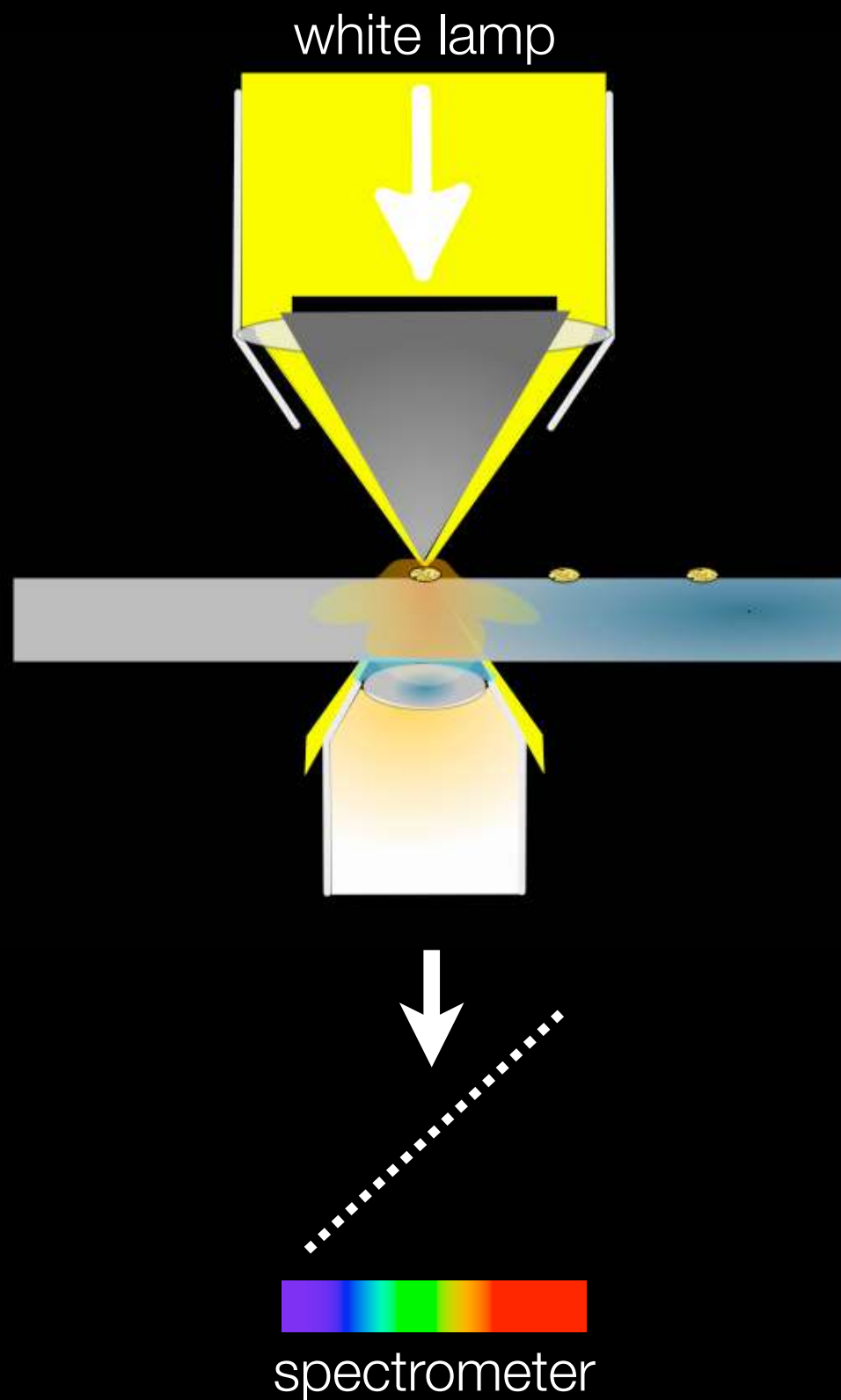


2. INTEGRATING SPHERE SPECTROSCOPY

Differential absorbance of dye–NP and photocatalysts
Current project: microfluidics & miniaturisation



“NANO ANTENNAS”



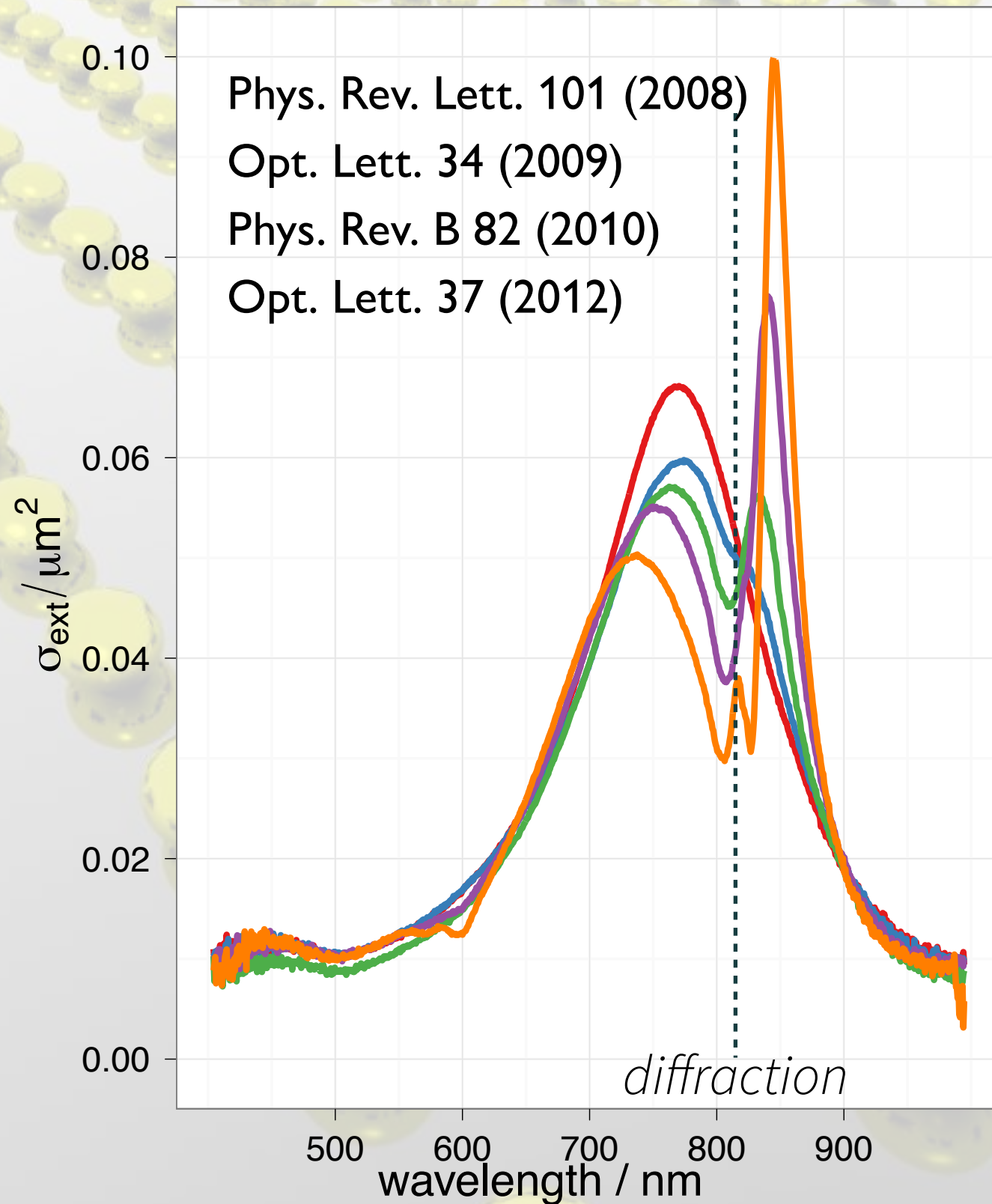
2D ARRAY: LATTICE RESONANCES

Phys. Rev. Lett. 101 (2008)

Opt. Lett. 34 (2009)

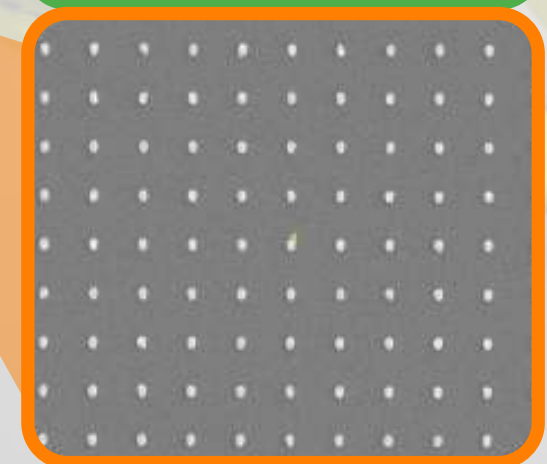
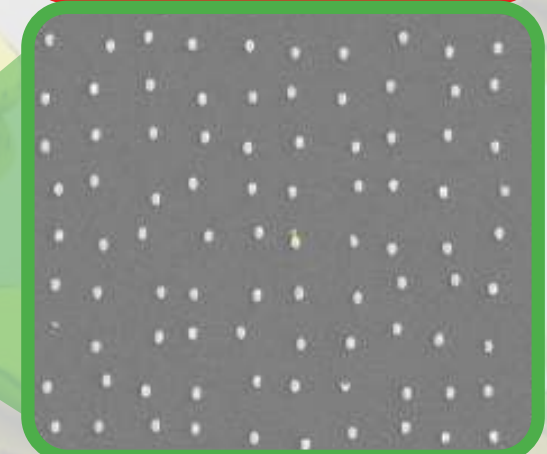
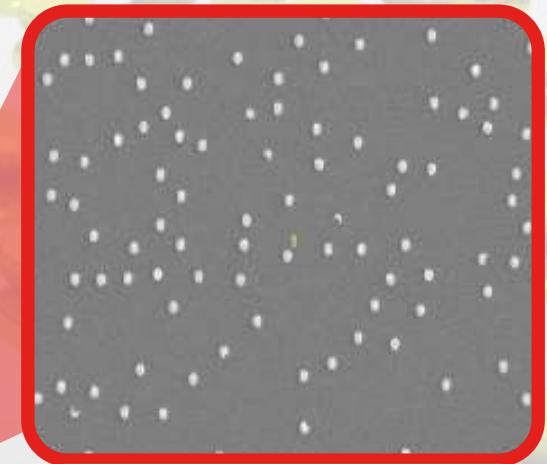
Phys. Rev. B 82 (2010)

Opt. Lett. 37 (2012)



disorder

pseudo-
random
40%
30%
20%
ordered

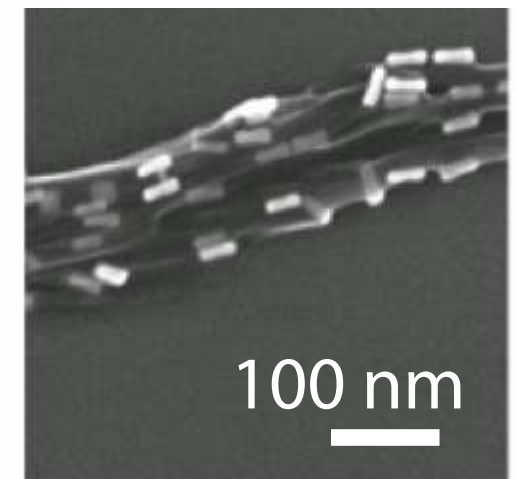
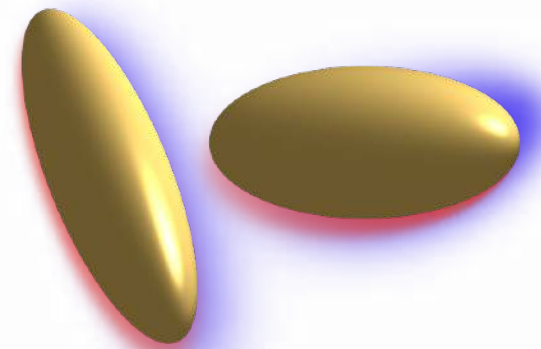
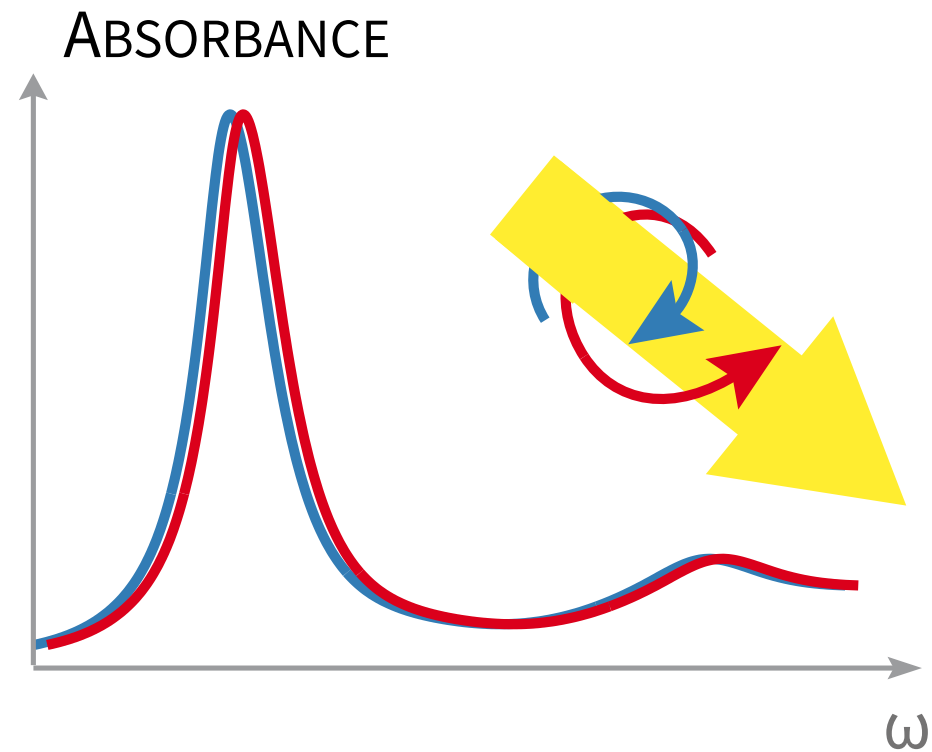


3D: PLASMONIC CHIRALITY

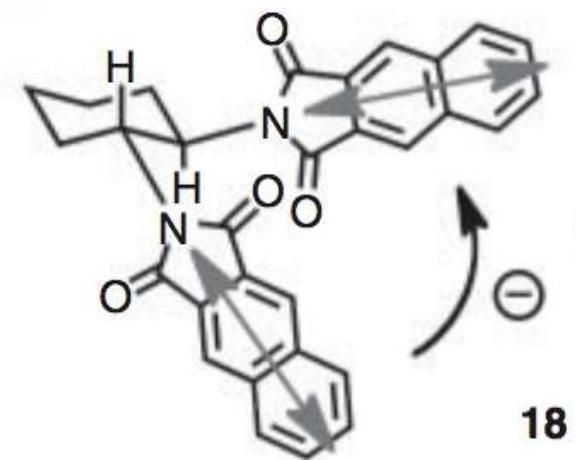
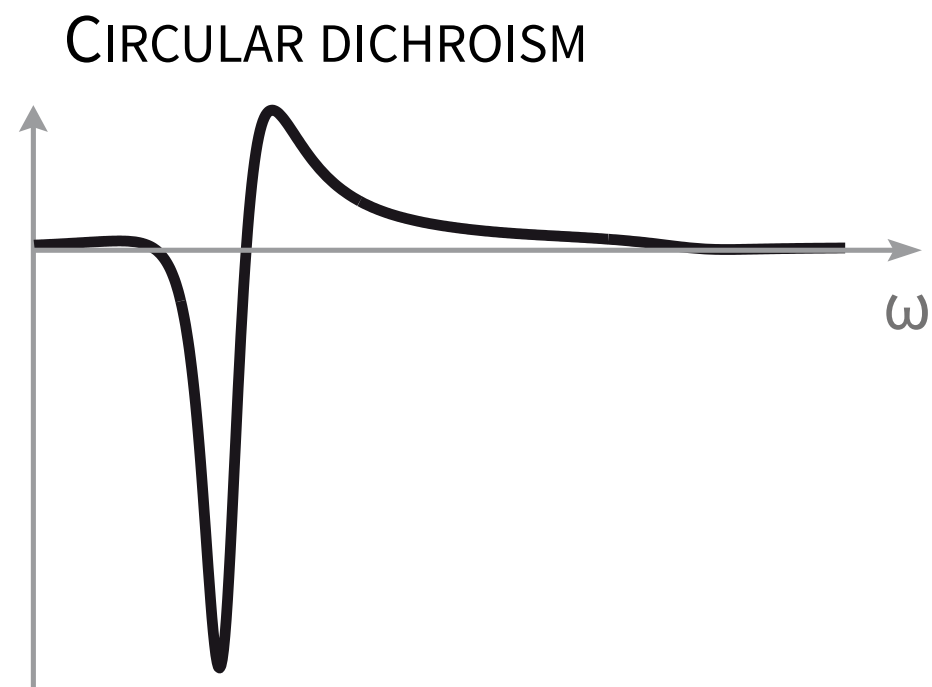
Angew. Chem. Int. Ed. 50 (2011)

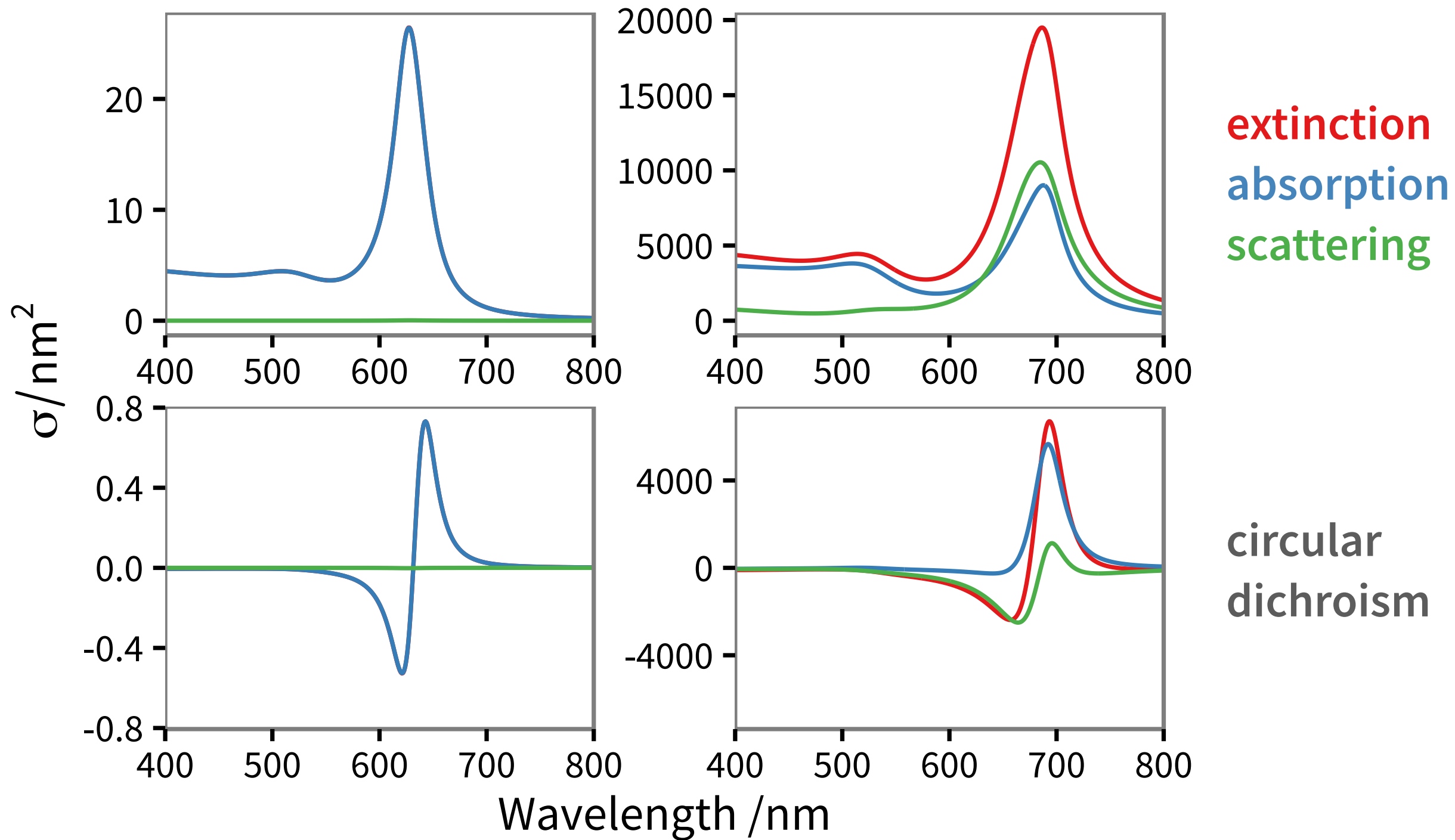
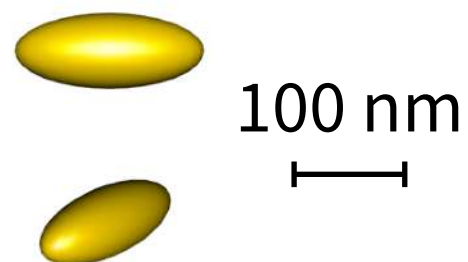
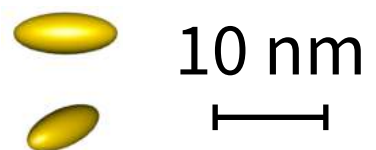
J. Phys. Chem. Lett. 2 (2011)

Nano Today 6 (2011)

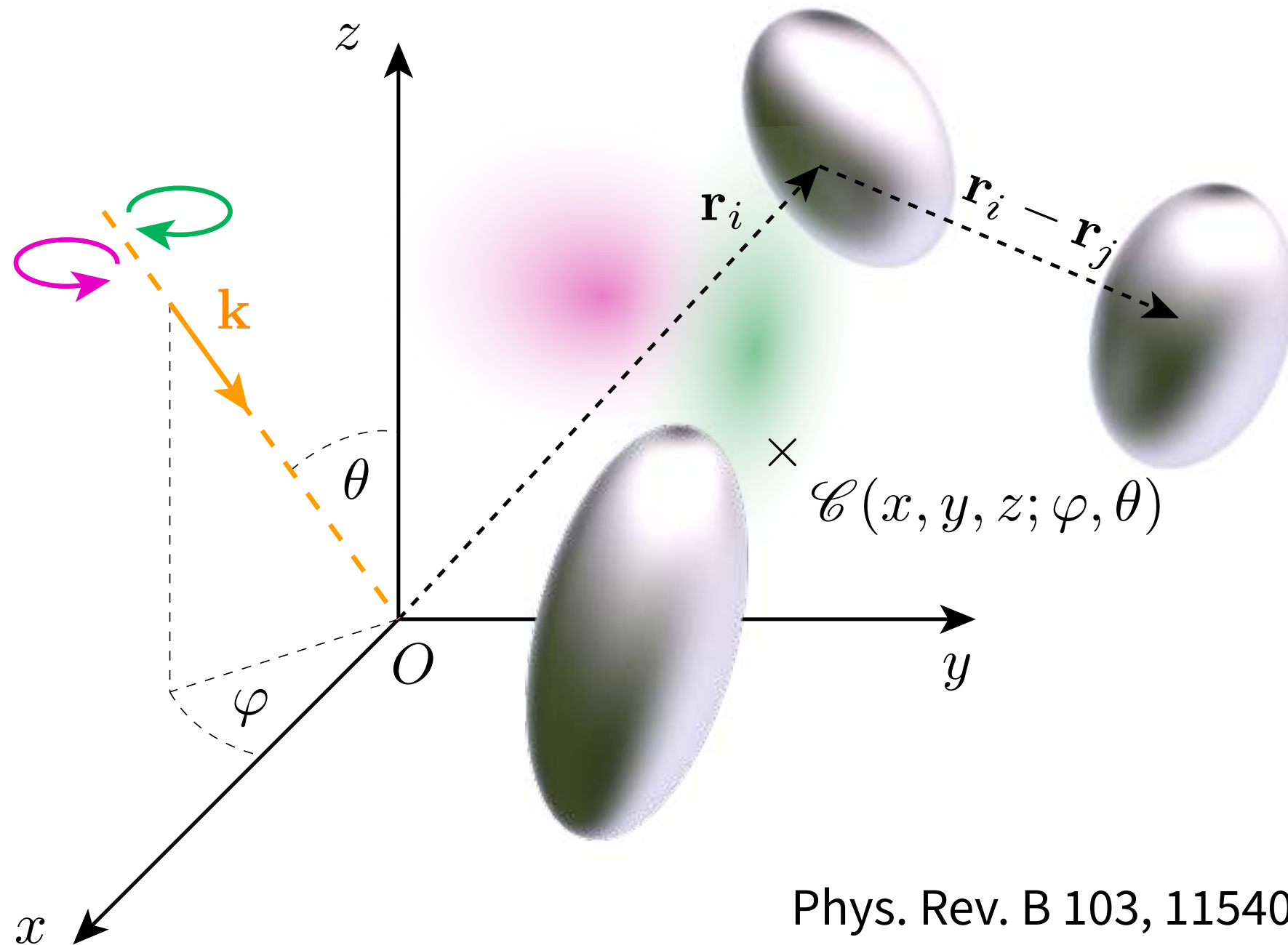


mimicking “*exciton coupling*”



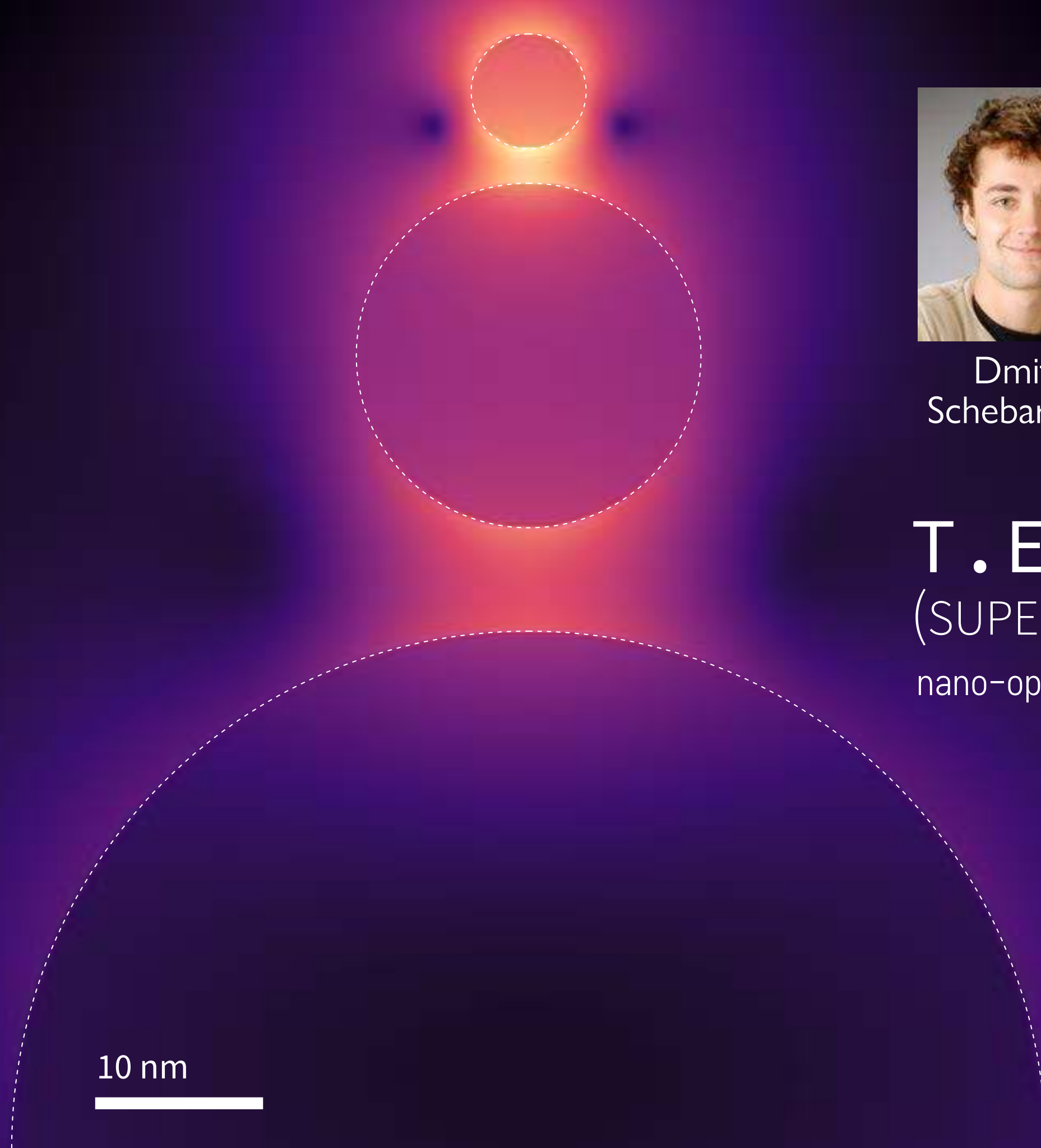


LOCAL DEGREE OF OPTICAL CHIRALITY $\mathcal{C} \propto \Im(\mathbf{E}^* \cdot \mathbf{B})$



Phys. Rev. B 103, 115405 (2021)

J. Quant. Spectrosc. Radiat. Transf. (2022)



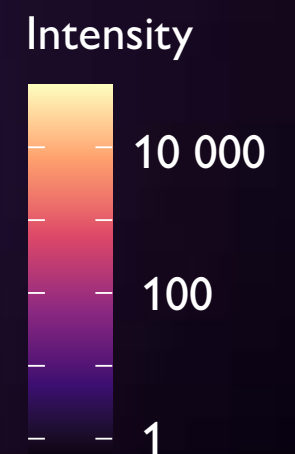
Dmitri
Schebarchov

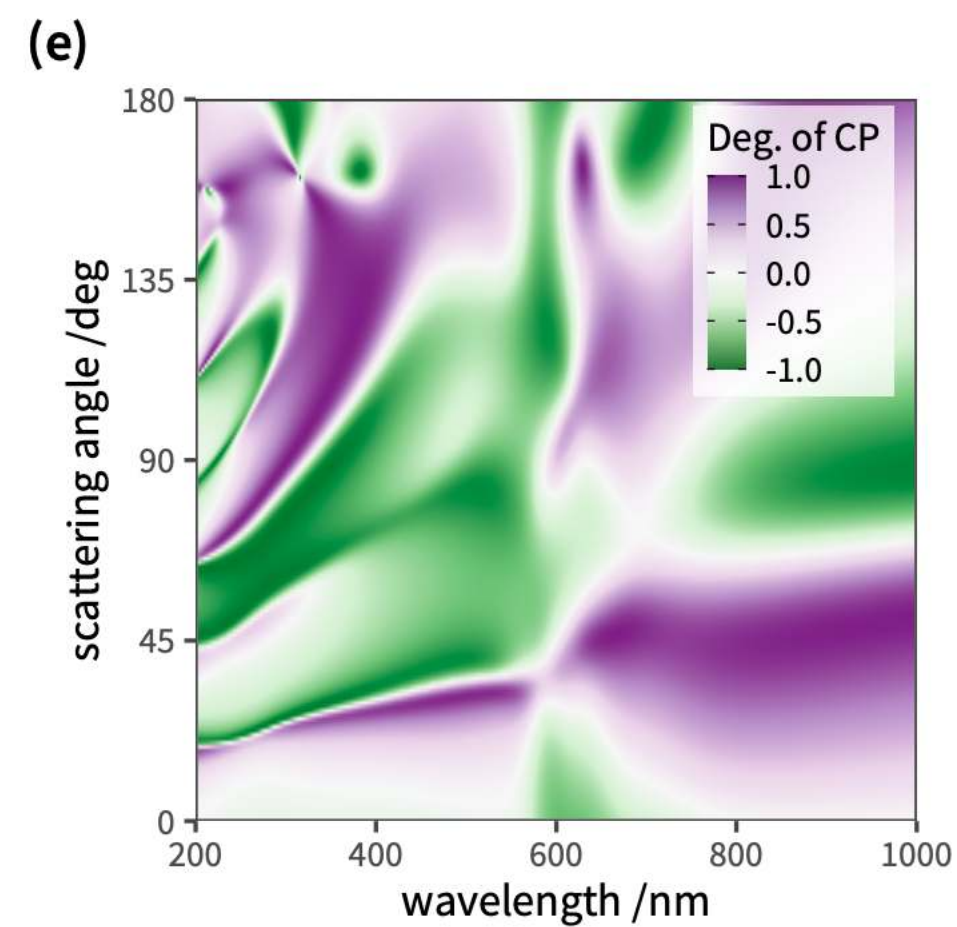
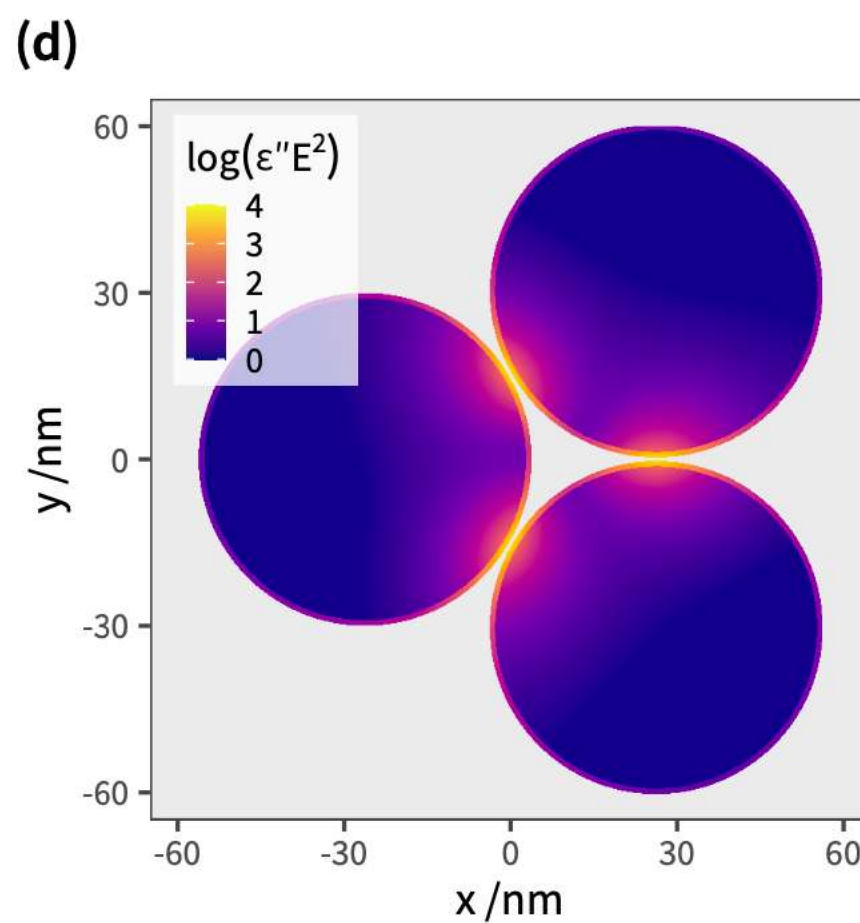
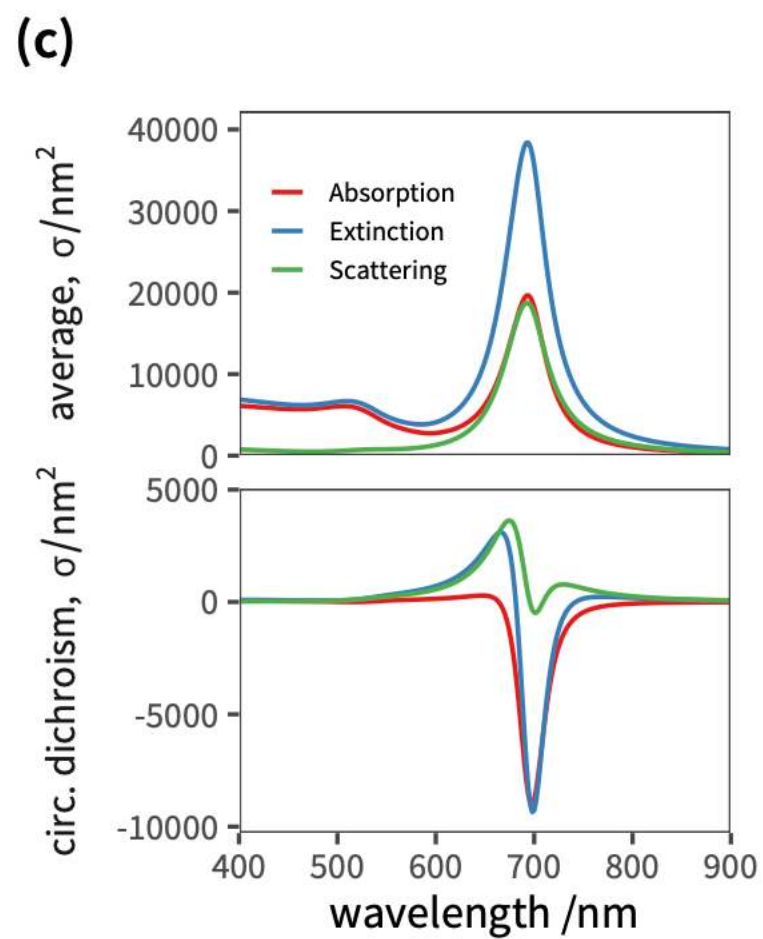
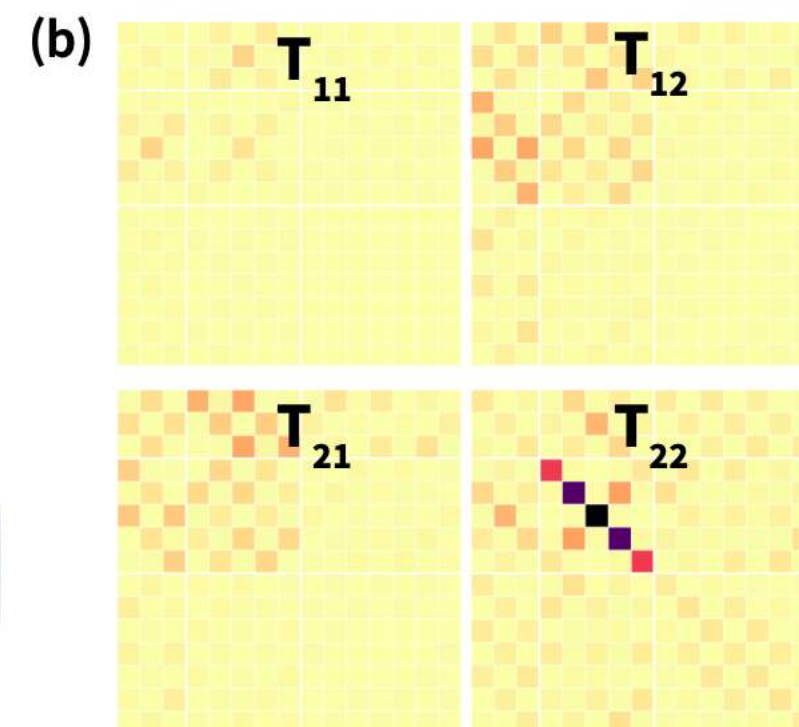
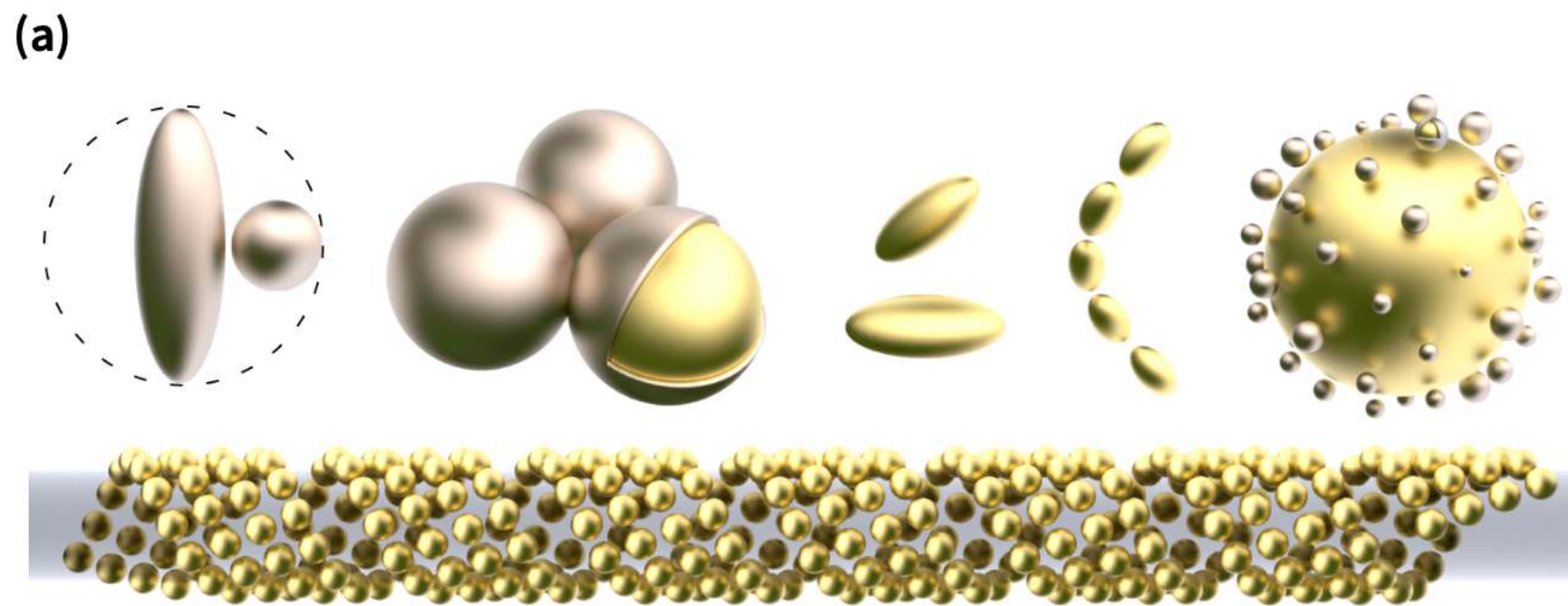


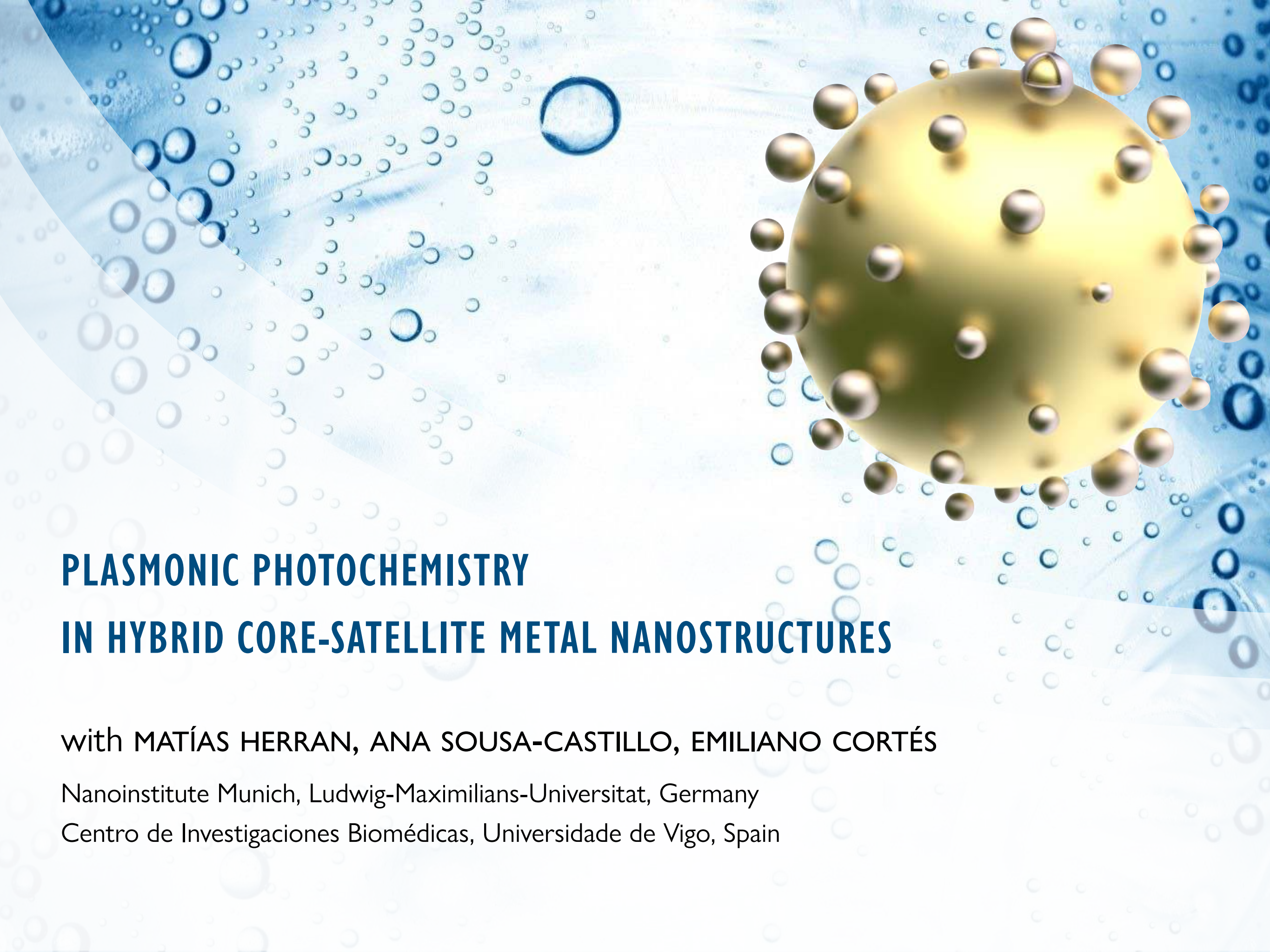
Atefeh
Fazel-Najafabadi

T.E.R.M.S. (SUPERPOSITION T-MATRIX)

nano-optics.ac.nz/terms







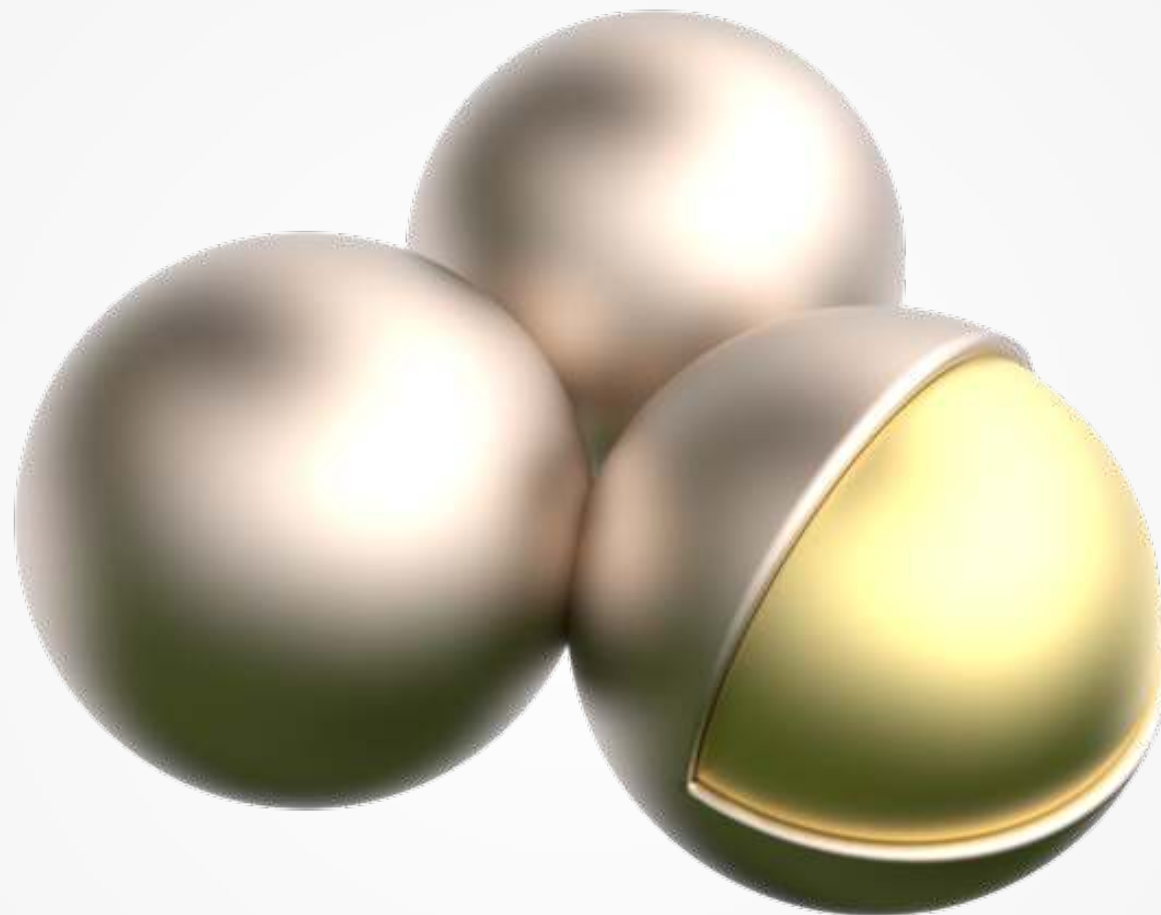
PLASMONIC PHOTOCHEMISTRY IN HYBRID CORE-SATELLITE METAL NANOSTRUCTURES

with MATÍAS HERRAN, ANA SOUSA-CASTILLO, EMILIANO CORTÉS

Nanoinstitute Munich, Ludwig-Maximilians-Universitat, Germany

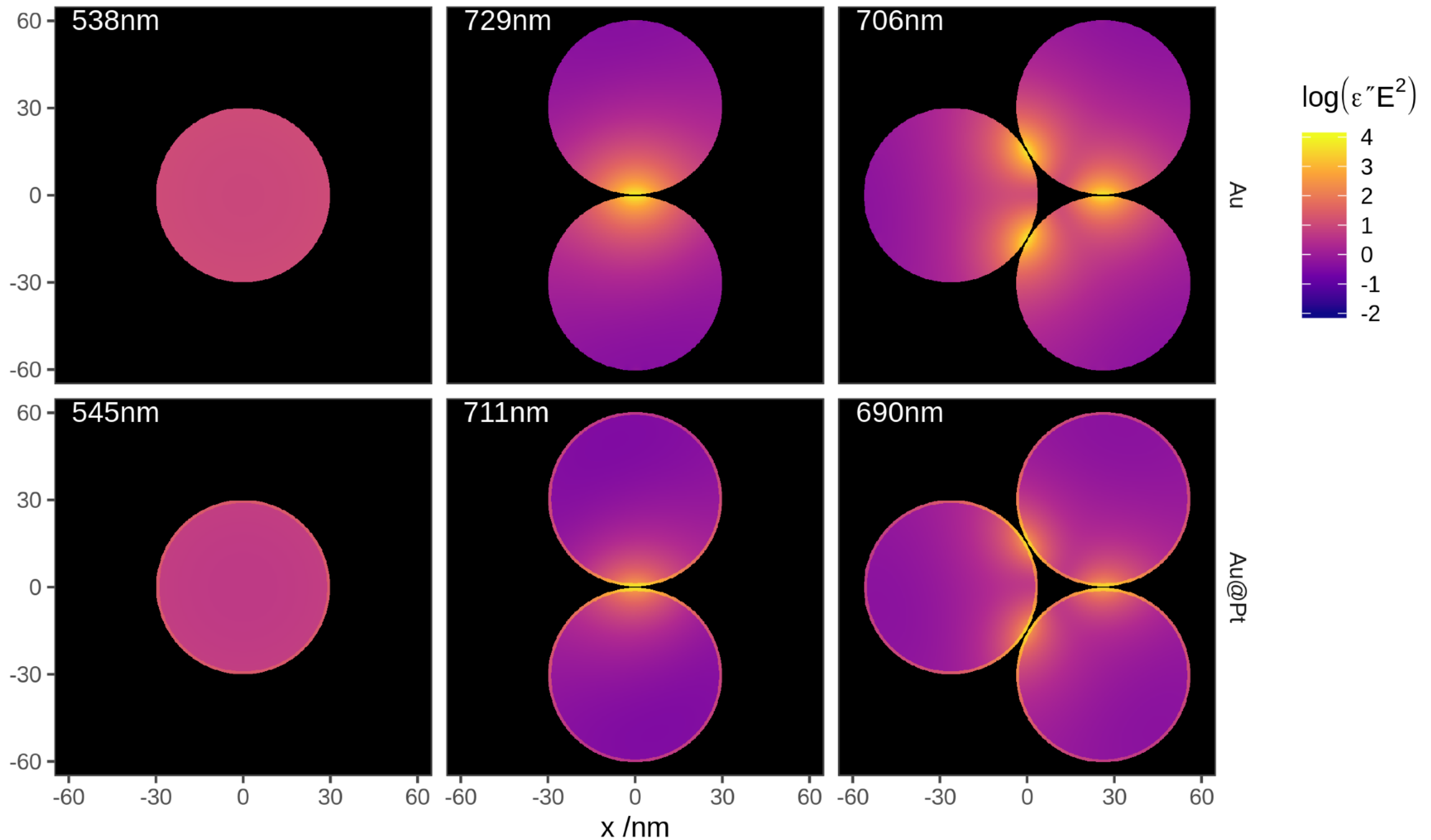
Centro de Investigaciones Biomédicas, Universidade de Vigo, Spain

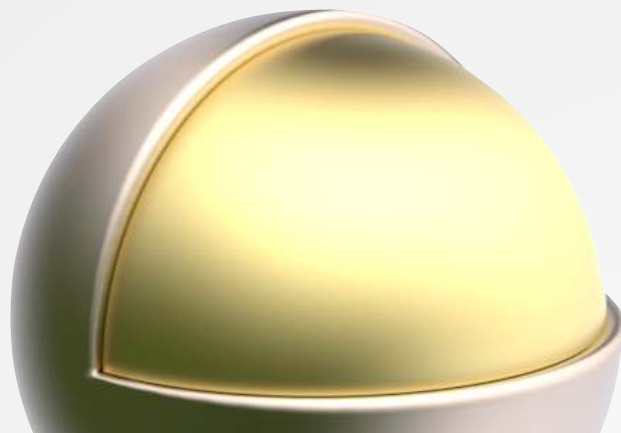
ABSORPTION OF Au@Pd PHOTOCATALYSTS



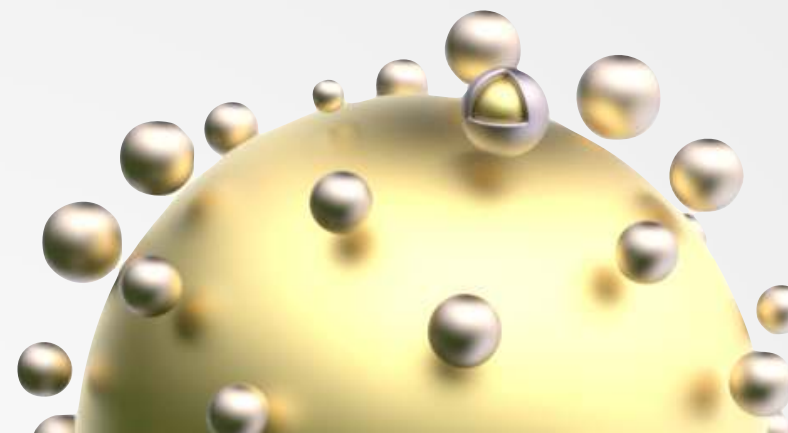
ACS Energy Lett. 5, 12, 3881–3890 (2020)

LOCAL ABSORPTION IN Au@Pd NANO-TRIMERS





Au@Pd

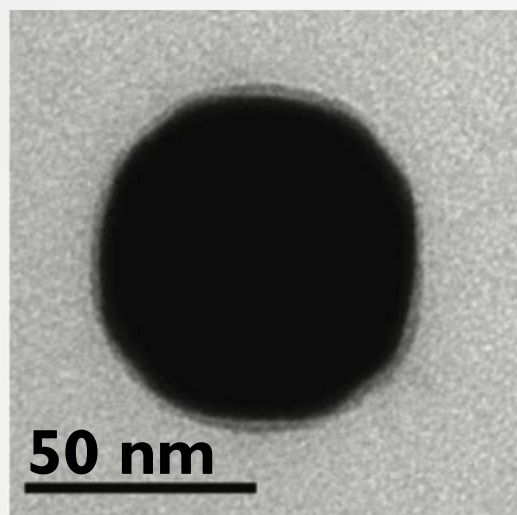


Au@AuPd

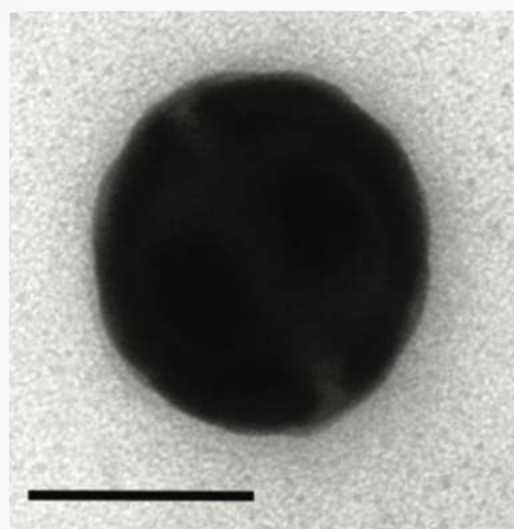
Au-Pd

Au-Au@Pd

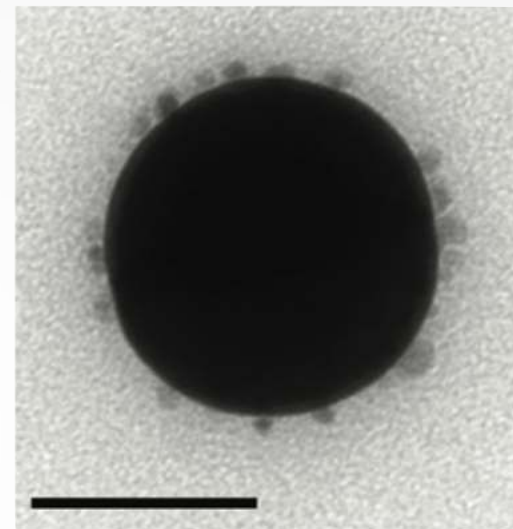
e



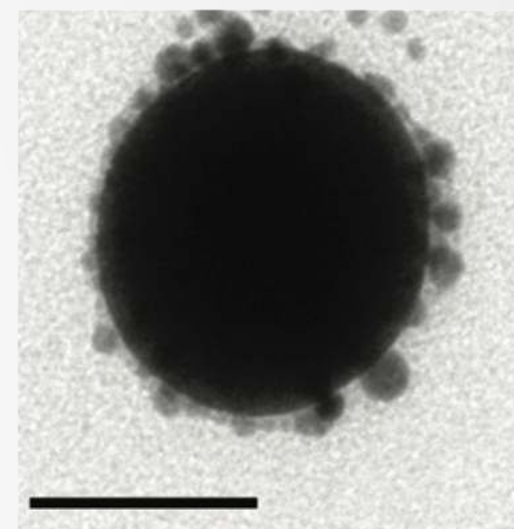
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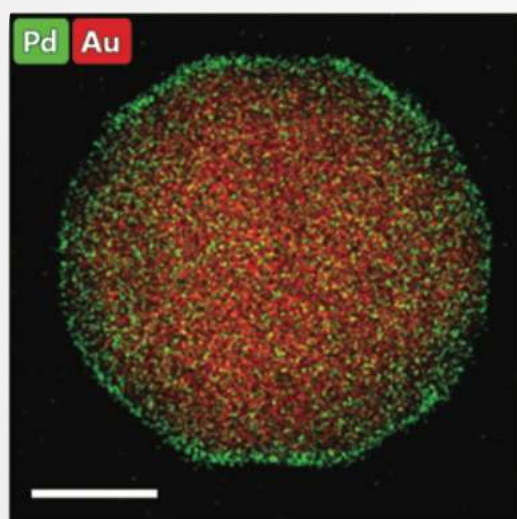
g



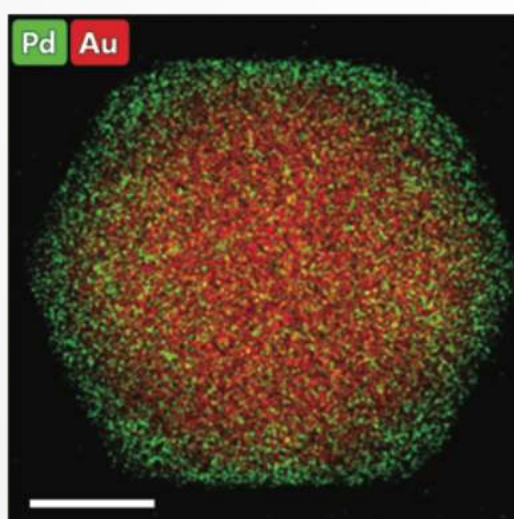
h



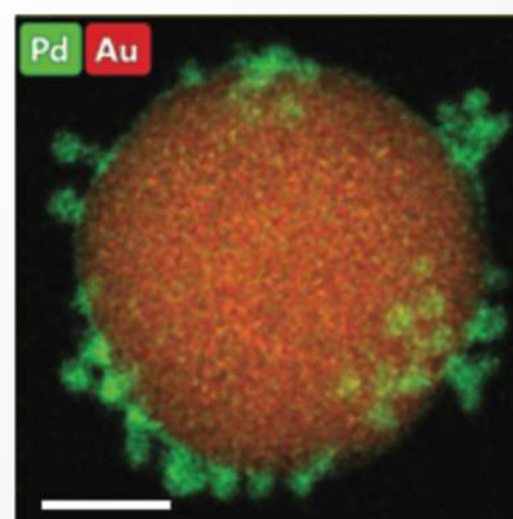
i



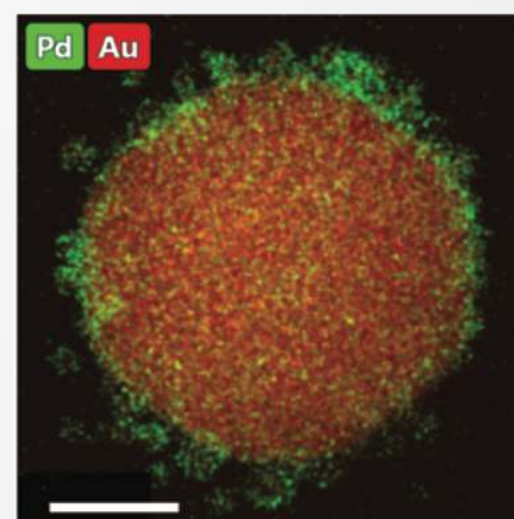
j



k



l

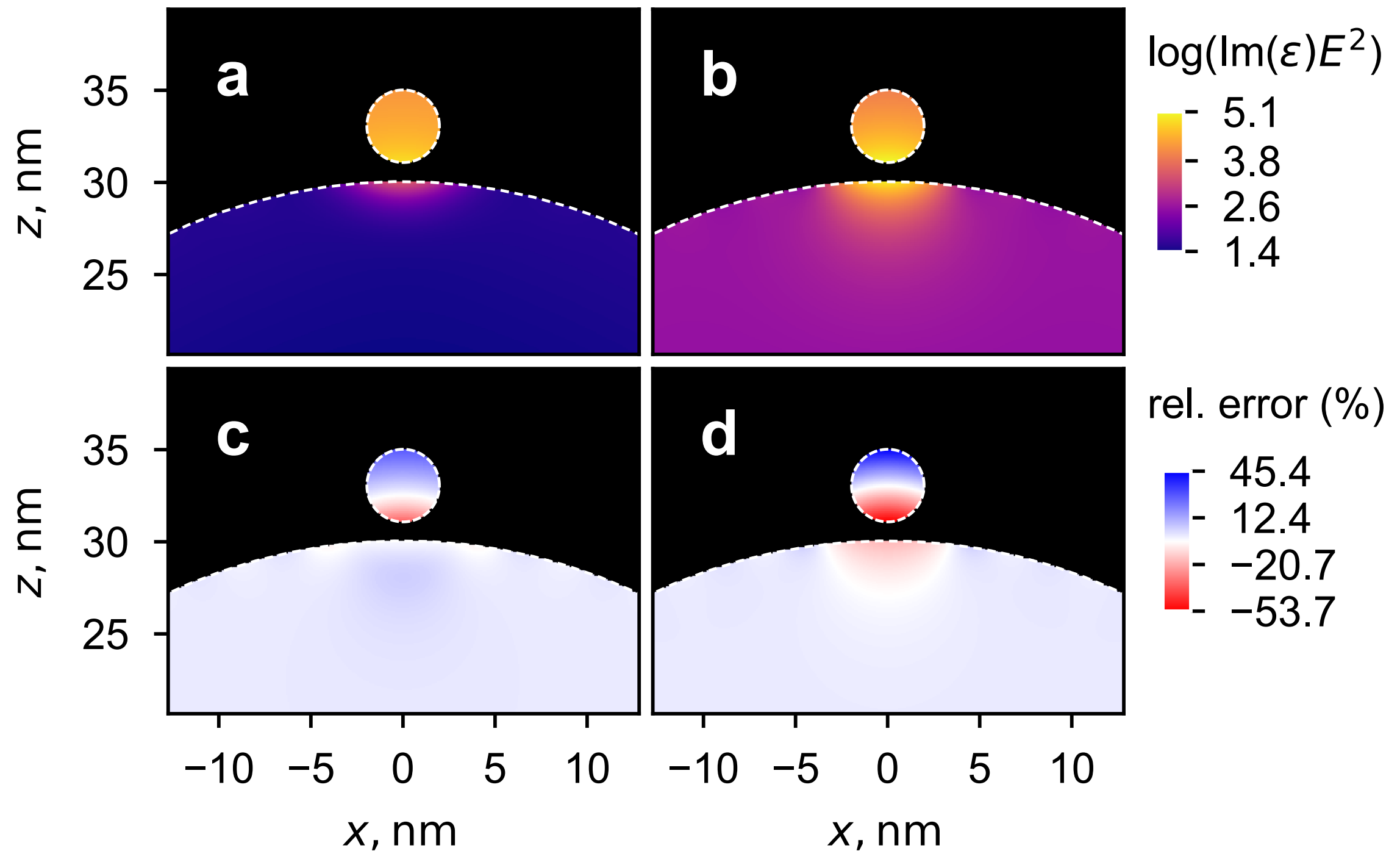


M. Herran, A. Sousa-Castillo, C. Fan, S. Lee, Wei Xie, M. Döblinger, B. Auguie and E. Cortés · *Adv. Func. Mat.* 32, 2203418 (2022)

DIPOLE APPROXIMATION VS EXACT RESULTS

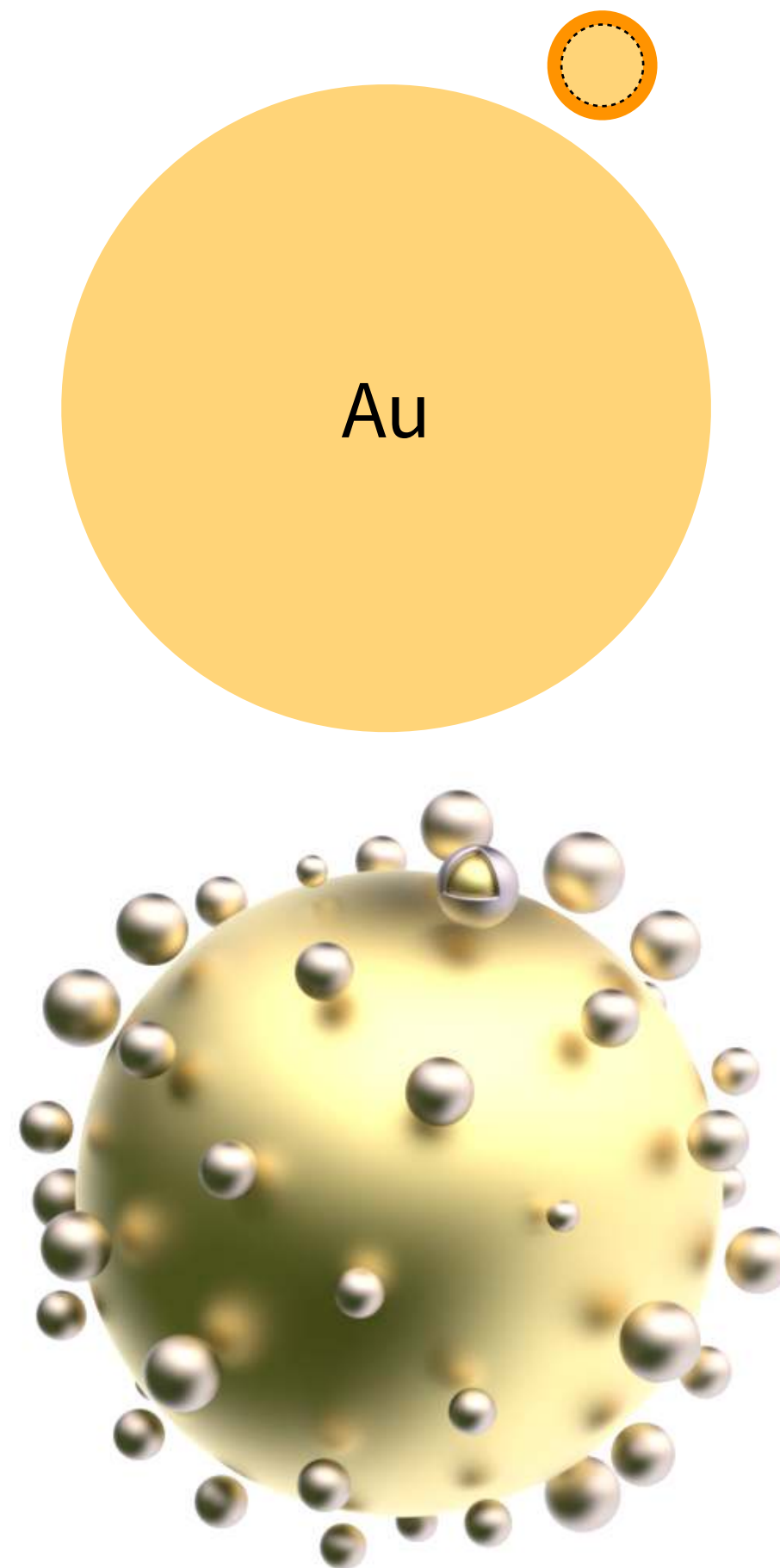
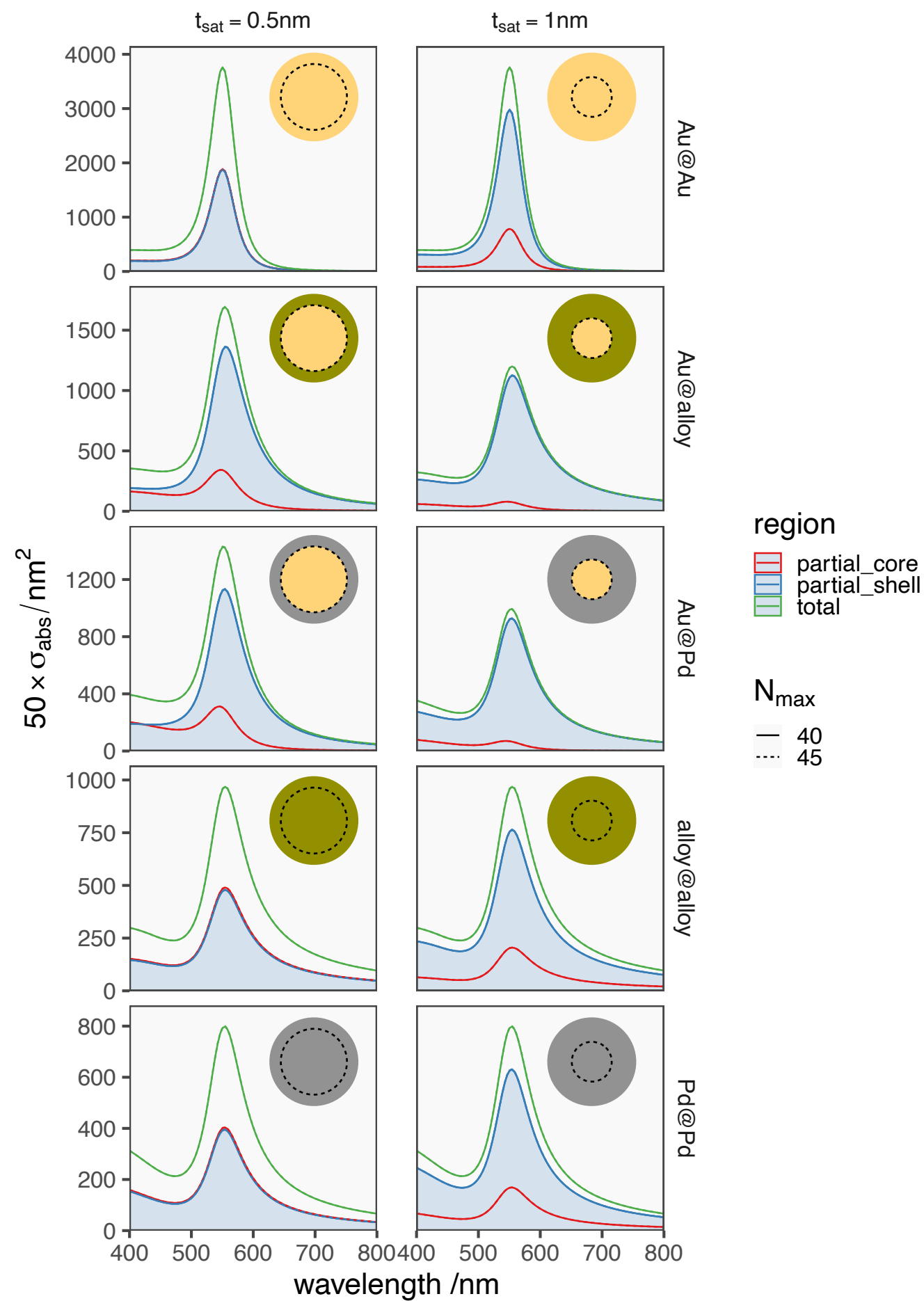
$\lambda = 394\text{nm}$

$\lambda = 534\text{nm}$



Partial absorption in core-shell satellites

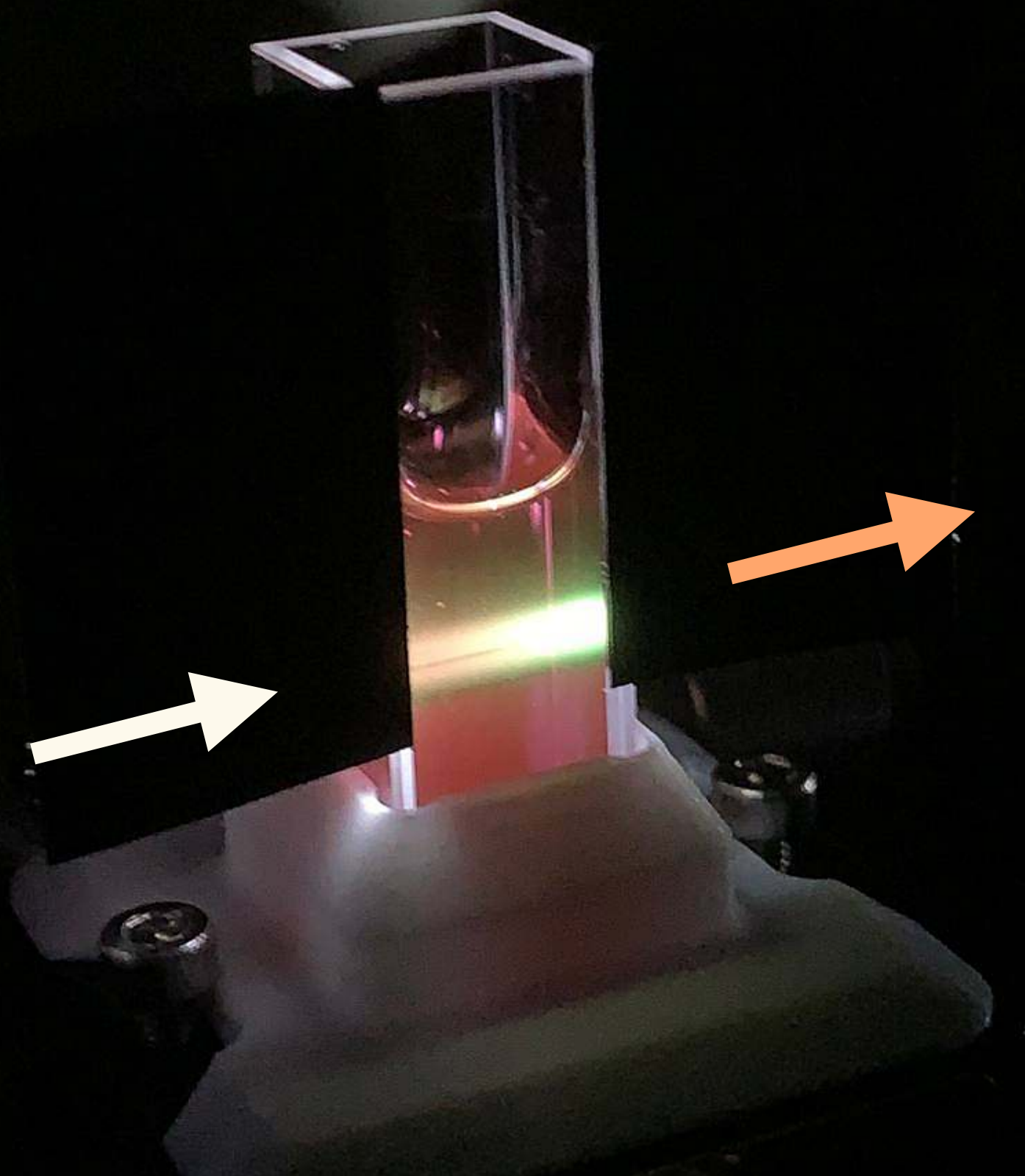
1 satellite, $R_{\text{core}}=30\text{nm}$, $\text{gap}=1\text{nm}$, $R_{\text{sat}}=2.5\text{nm}$

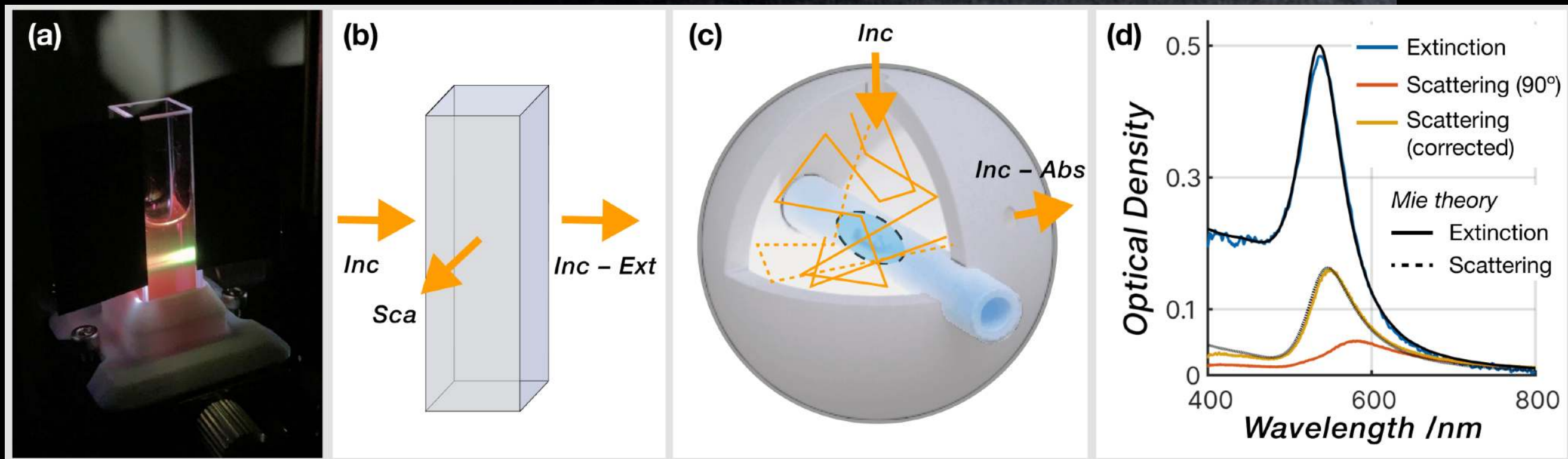
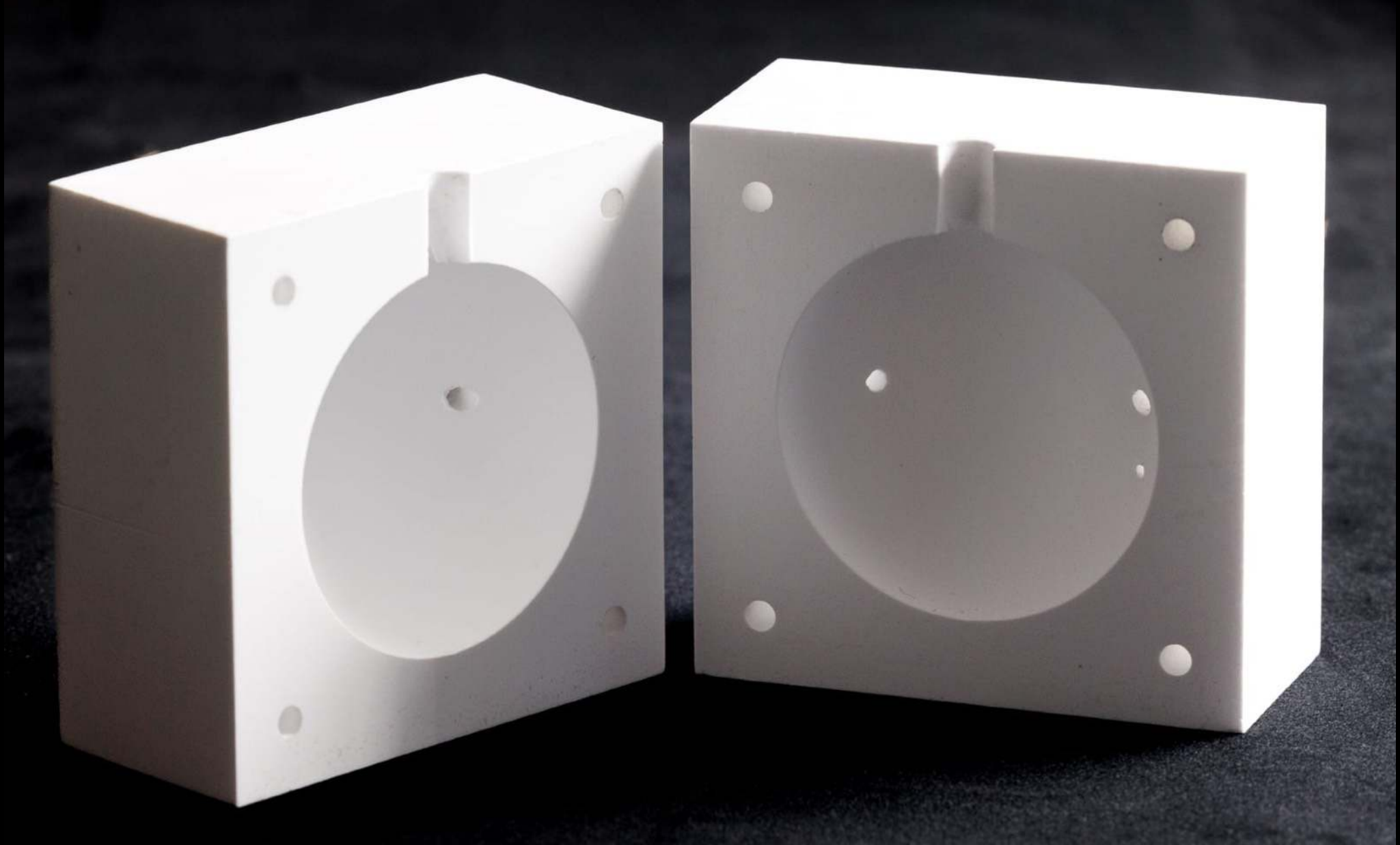




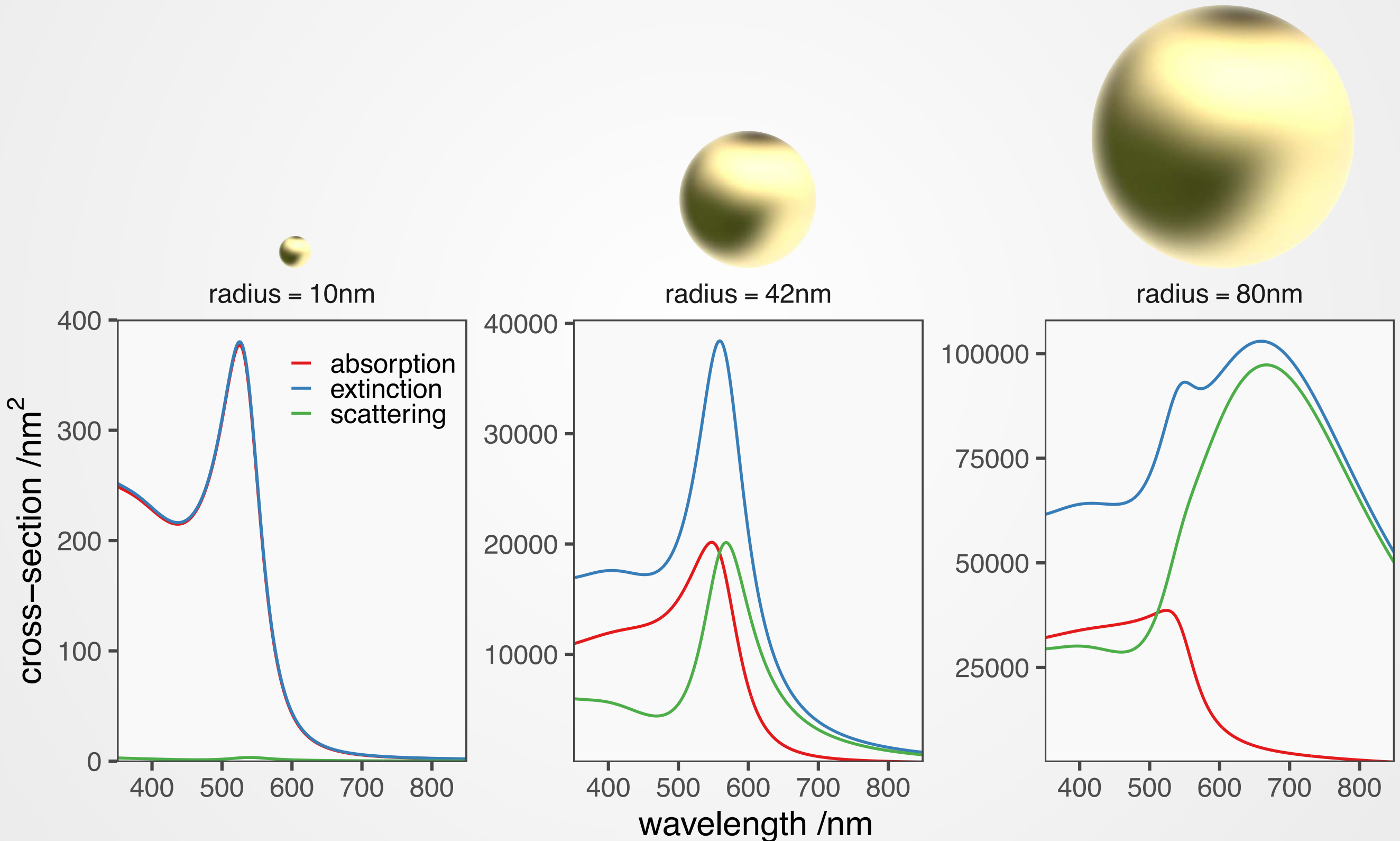
QUANTITATIVE SPECTROSCOPY OF TURBID SOLUTIONS

60nm GOLD NANOSPHERES

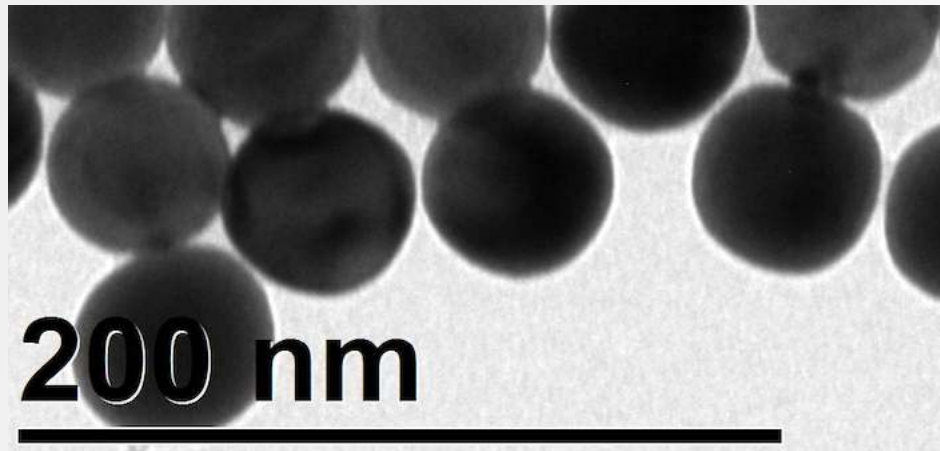




DIFFERENT INFORMATION IN $EXT = ABS + SCA$



RATIO EXTINCTION/ABSORPTION $\rightarrow$ EPSILON

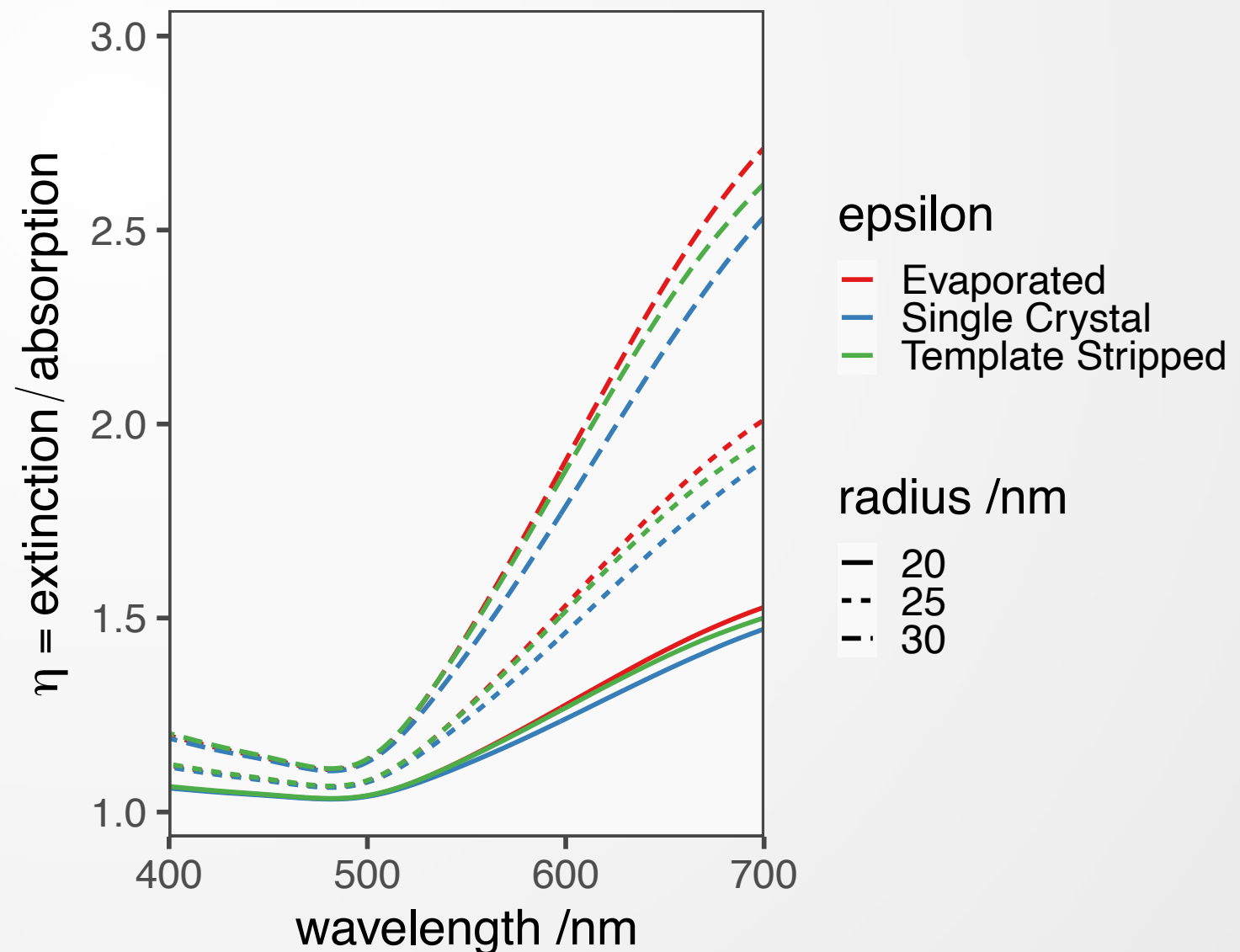
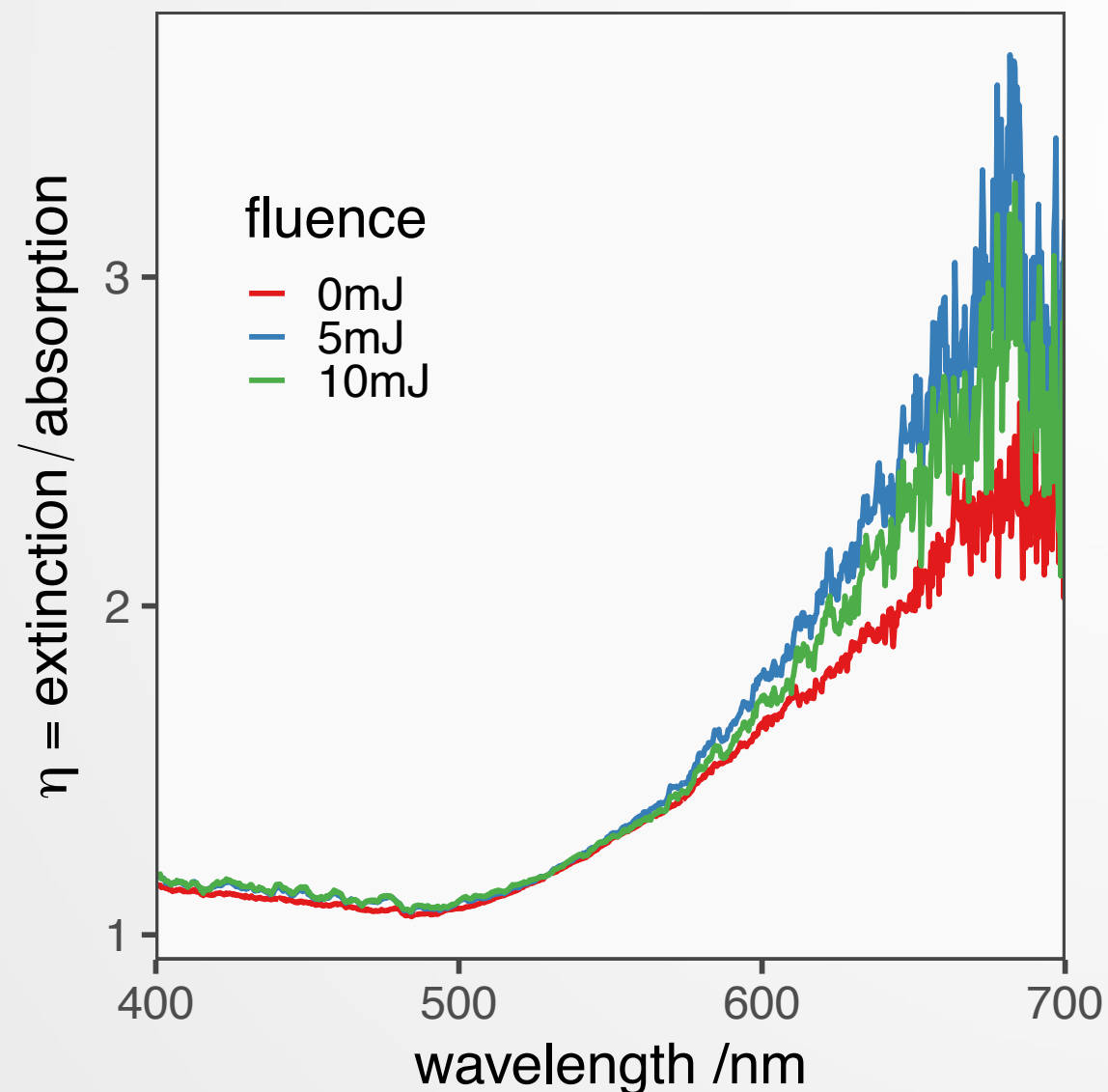


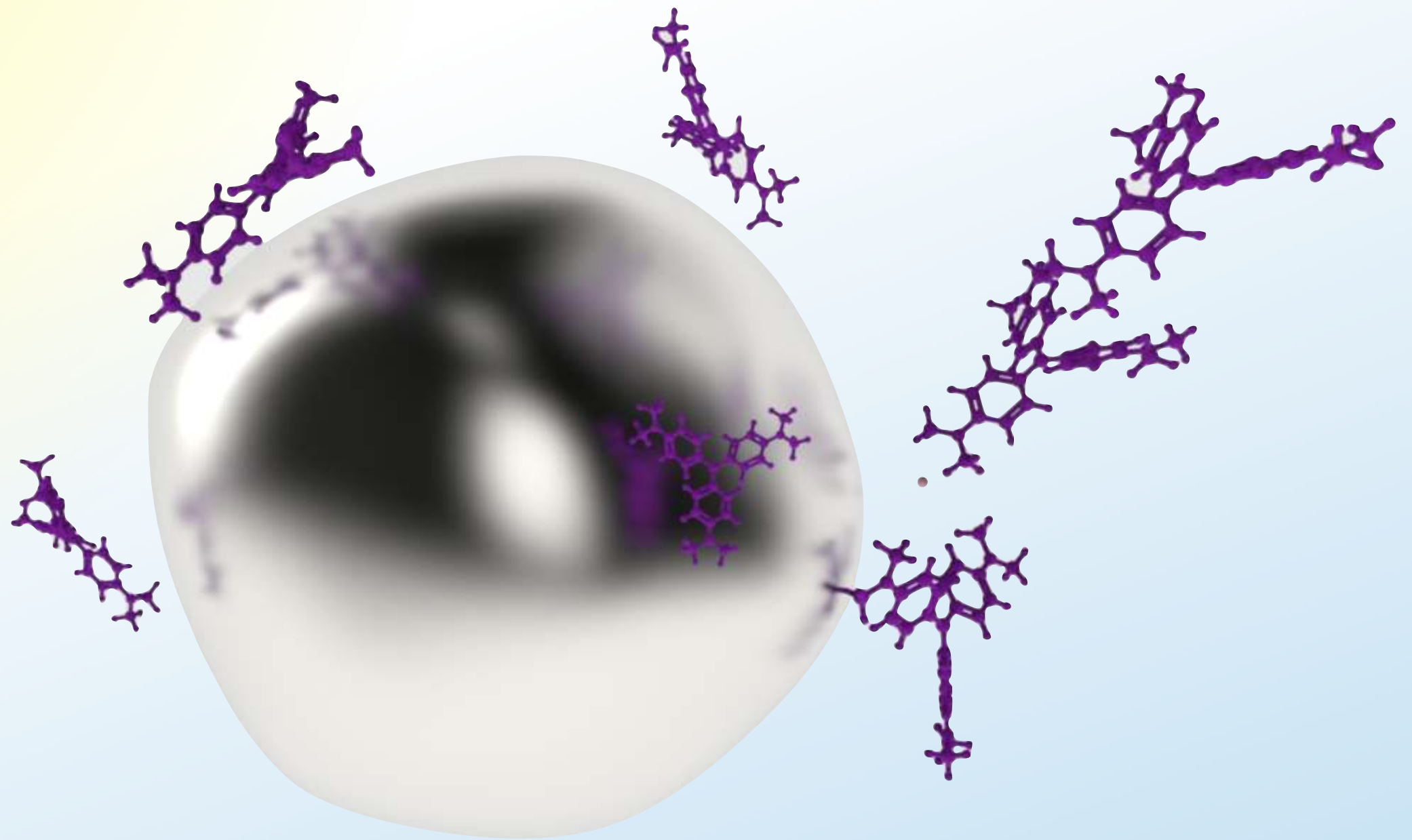
Simulations with thin film-measured dielectric functions

Olmon *et al* Phys. Rev. B 86, 235147 (2012)

Le Ru *et al* ACS Nano 14, 17597–17605 (2020)

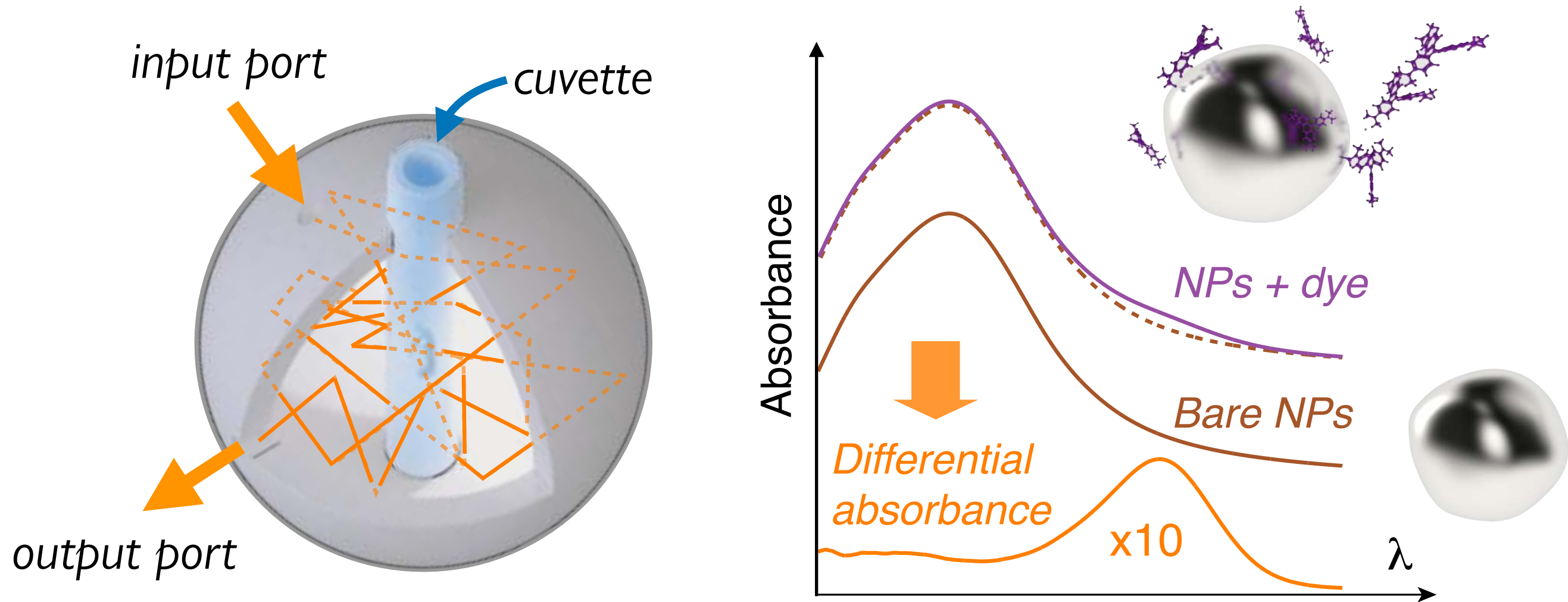
Le Ru *et al* Anal. Chem. 91, 14639–14648 (2019)





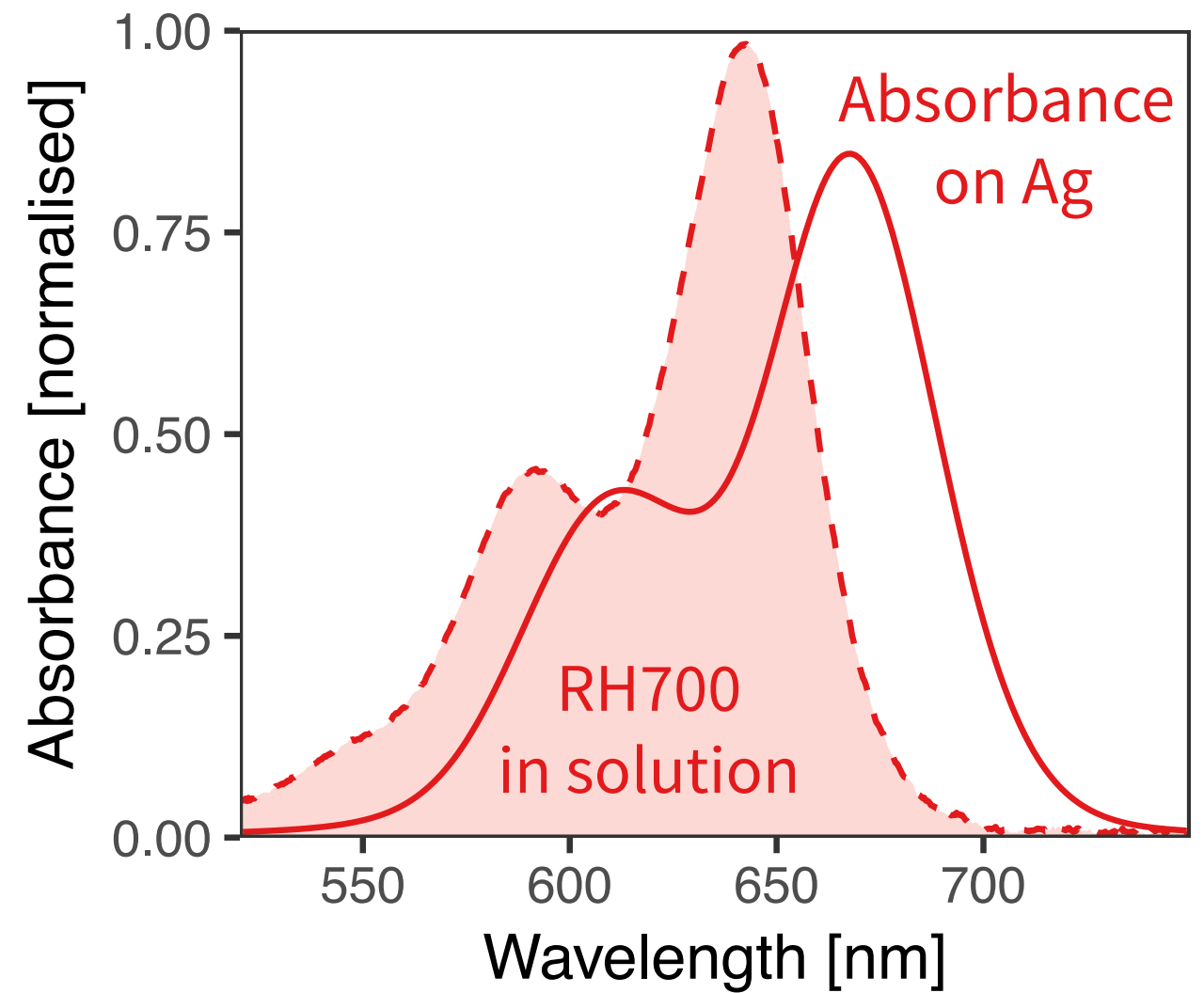
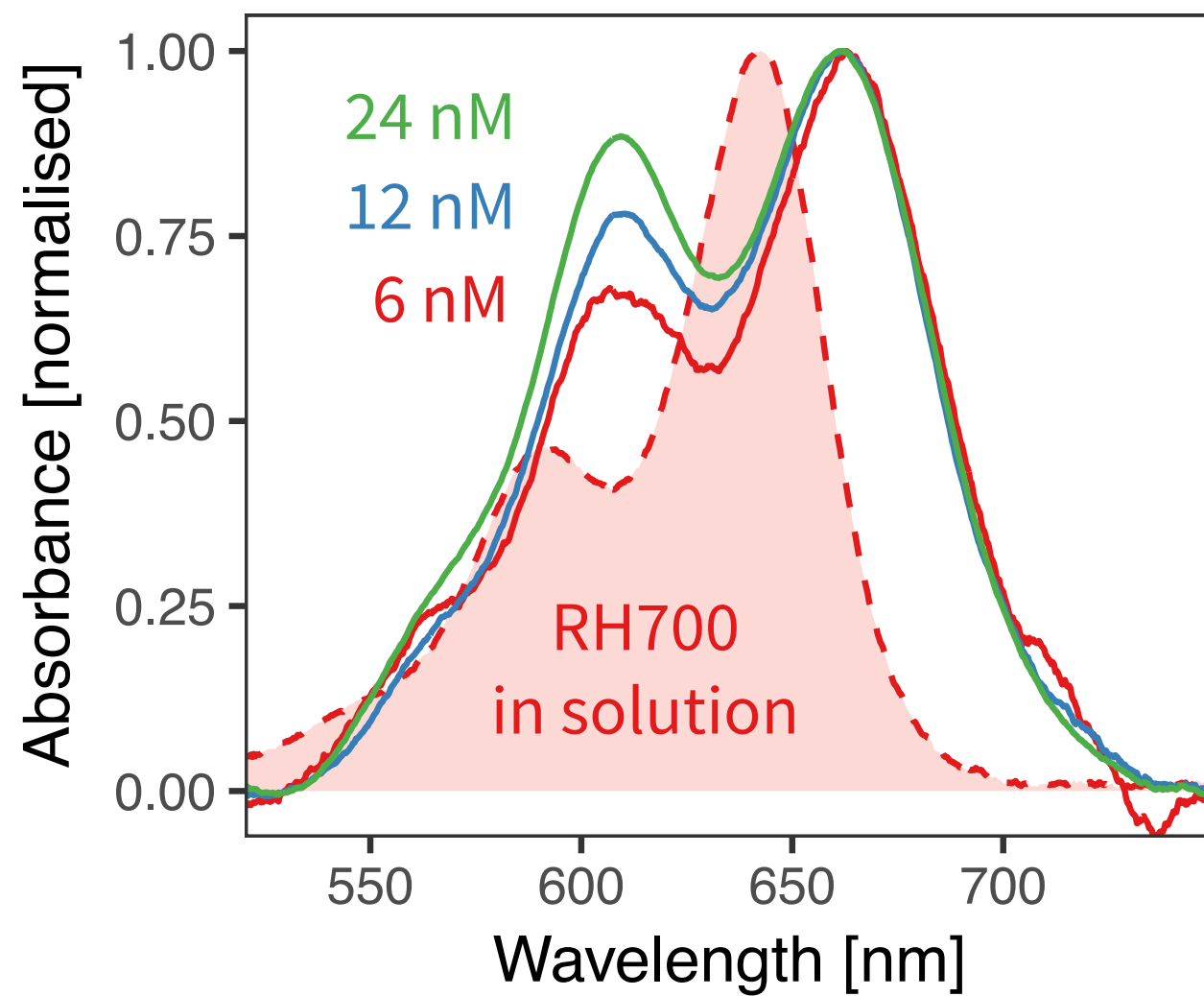
**UV–VIS ABSORPTION OF MOLECULES
ADSORBED ON A METALLIC NANOPARTICLE**

UV–VIS SPECTROSCOPY OF TURBID SAMPLES



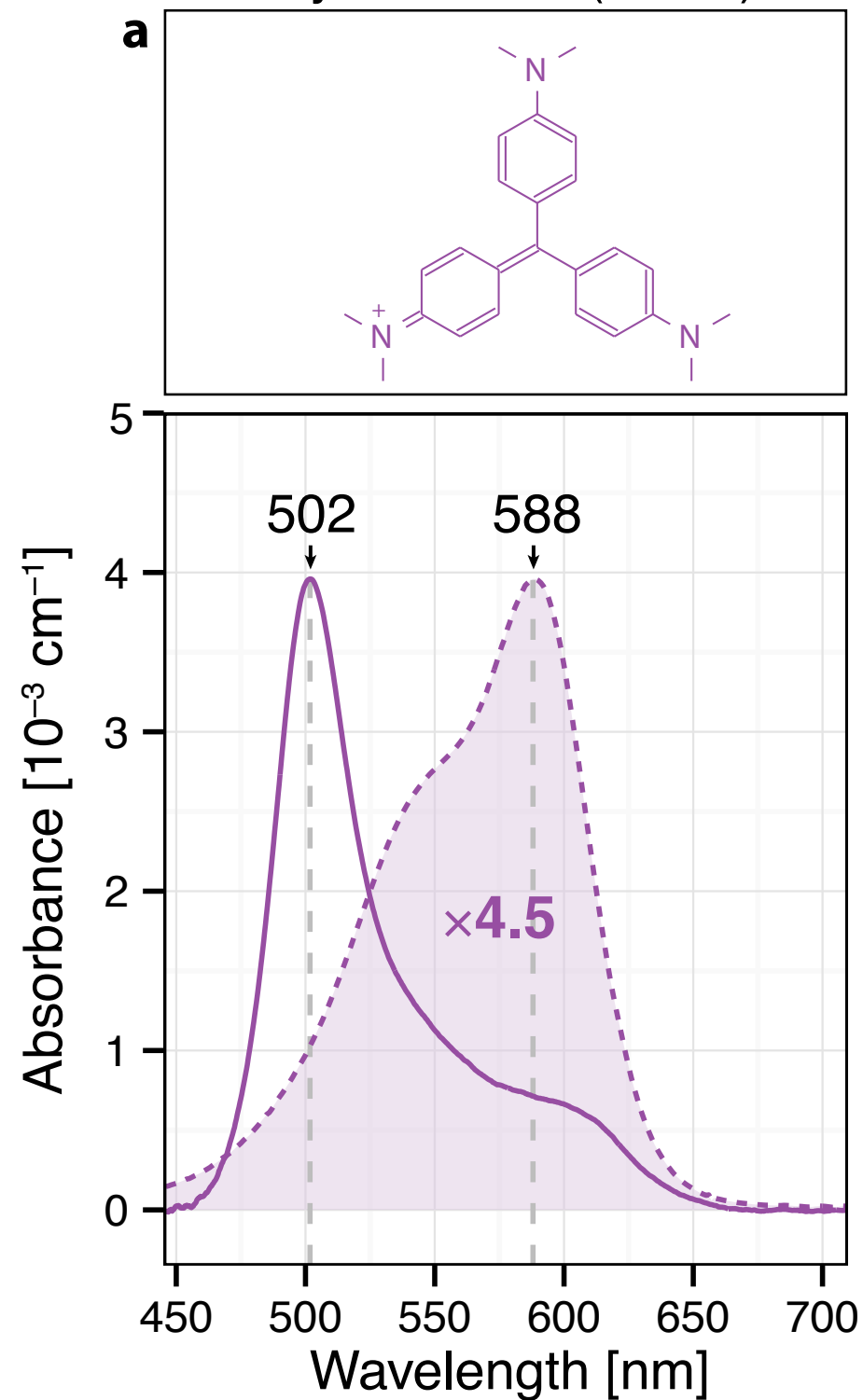
Modified optical absorption of molecules on metallic nanoparticles at sub-monolayer coverage – Nat. Photon. 10, 40–45 (2016)

SPECTRAL CHANGES, CONCENTRATION DEPENDENCE

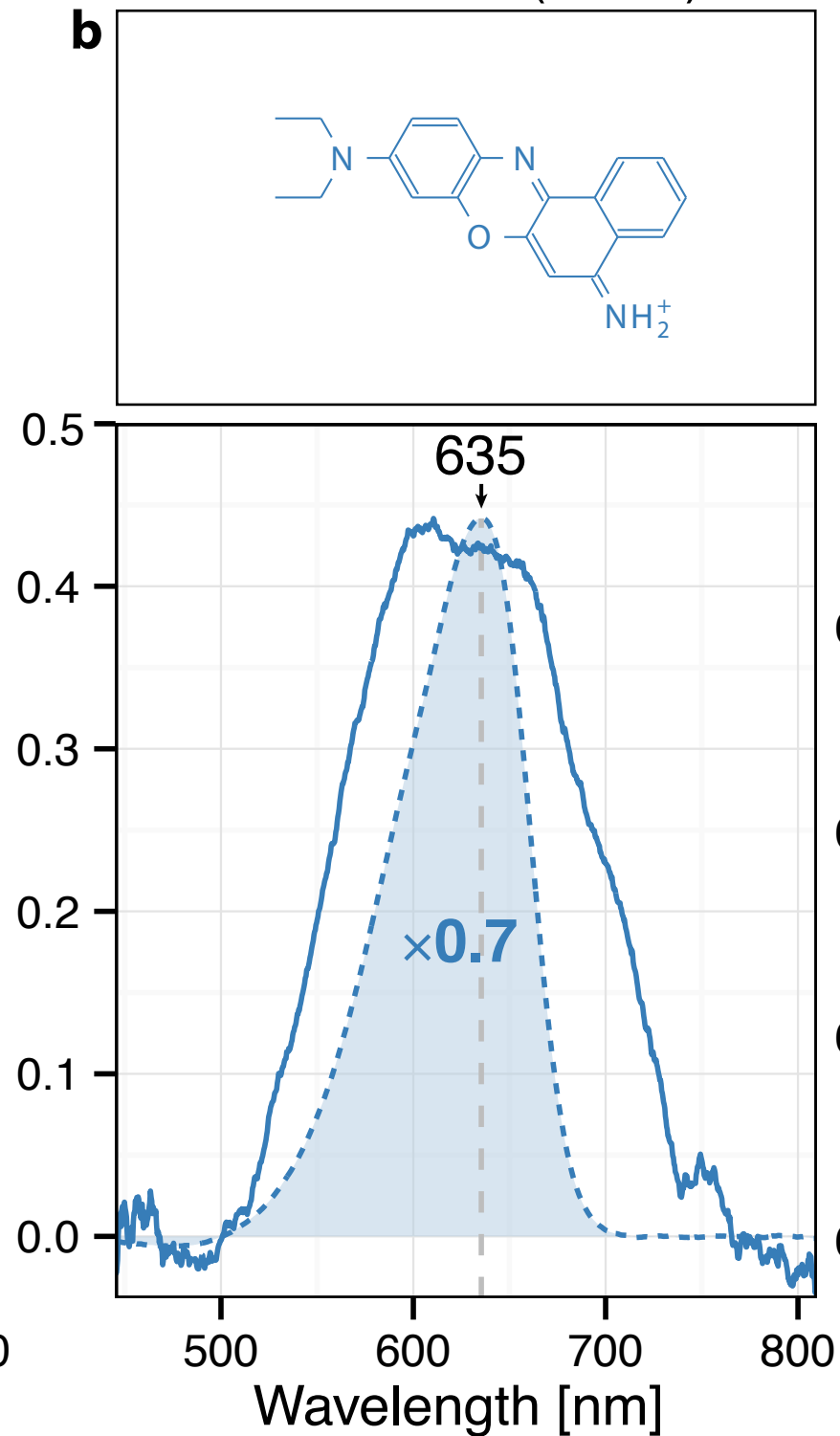


DIFFERENT MOLECULES

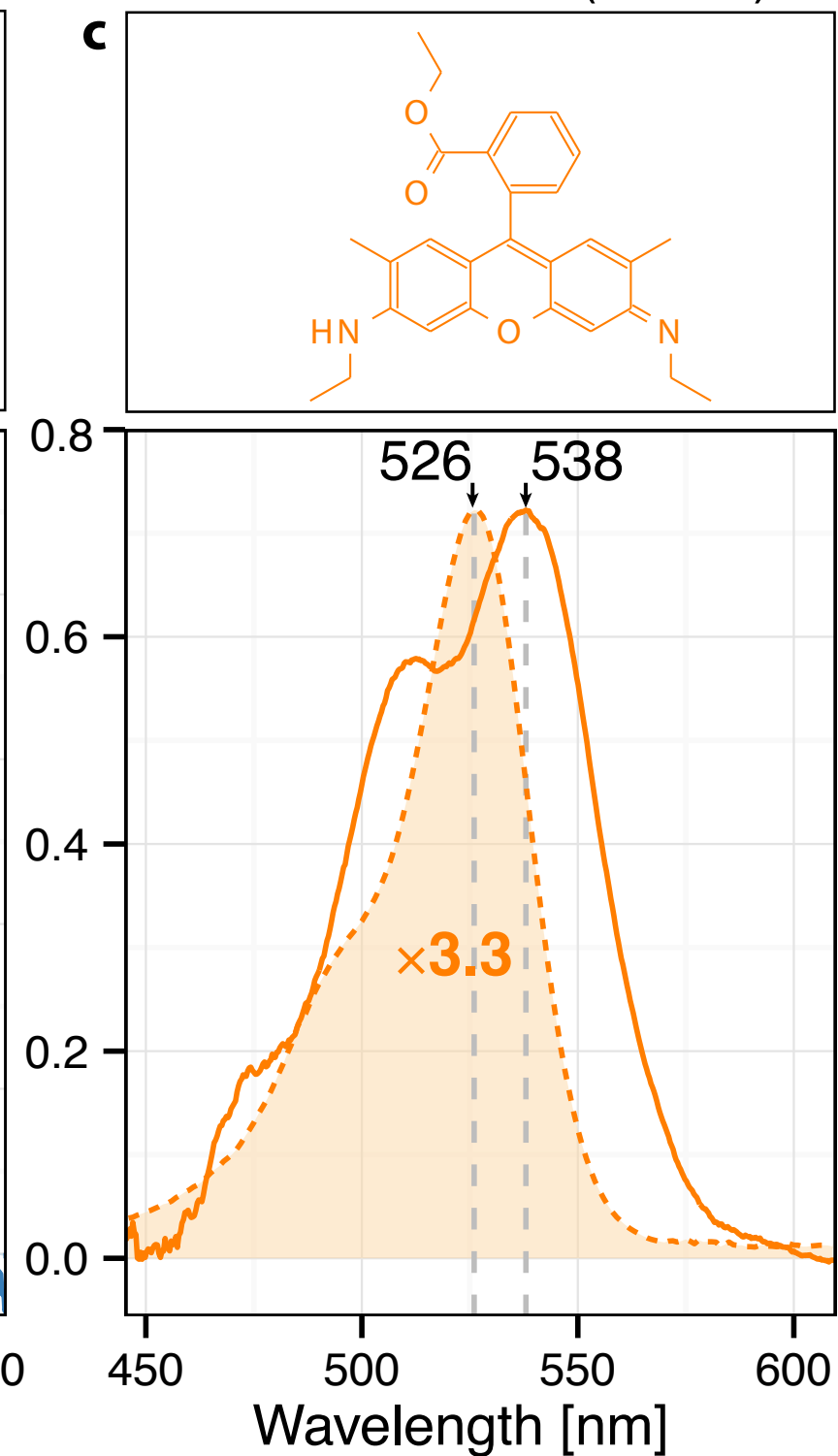
Crystal Violet (10nM)



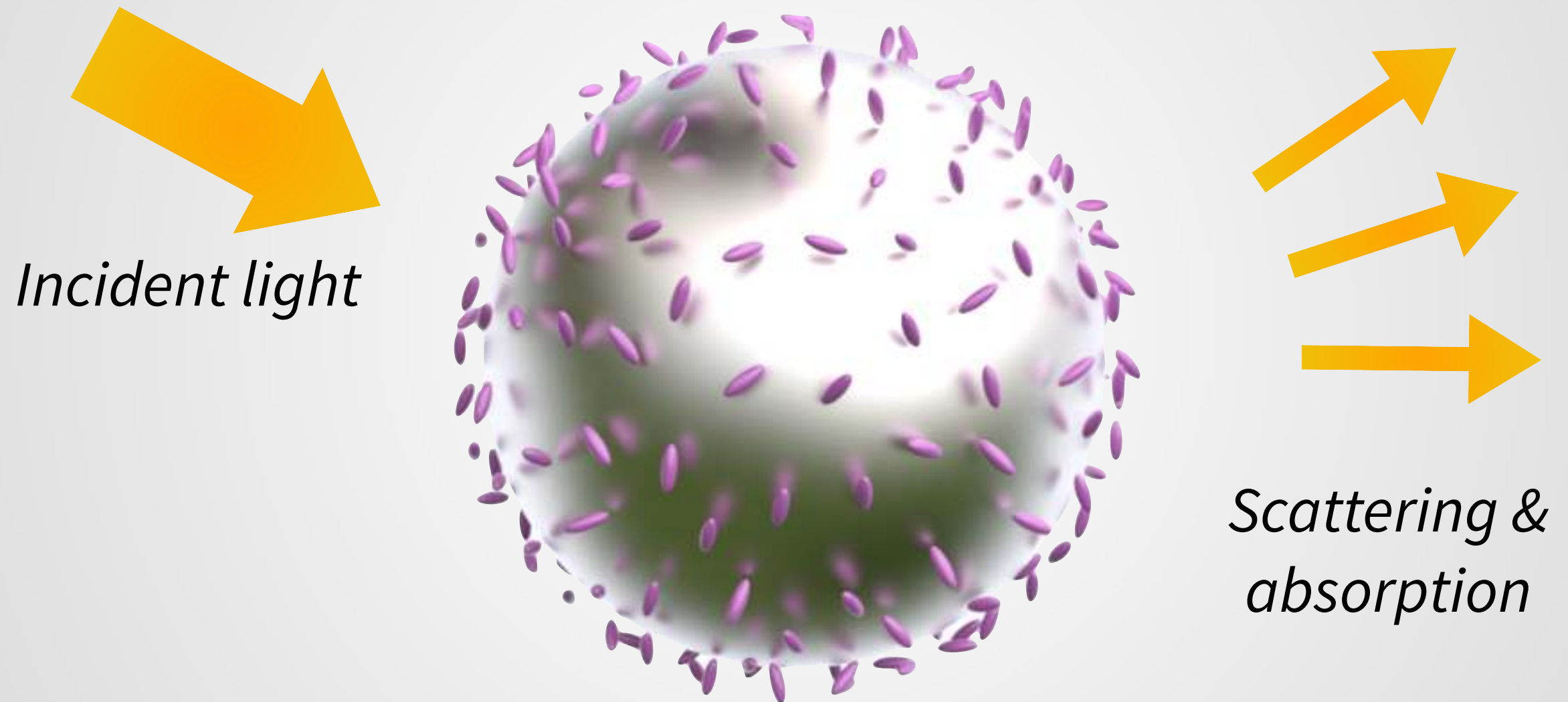
Nile Blue A (10nM)



Rhodamine 6G (2.5nM)

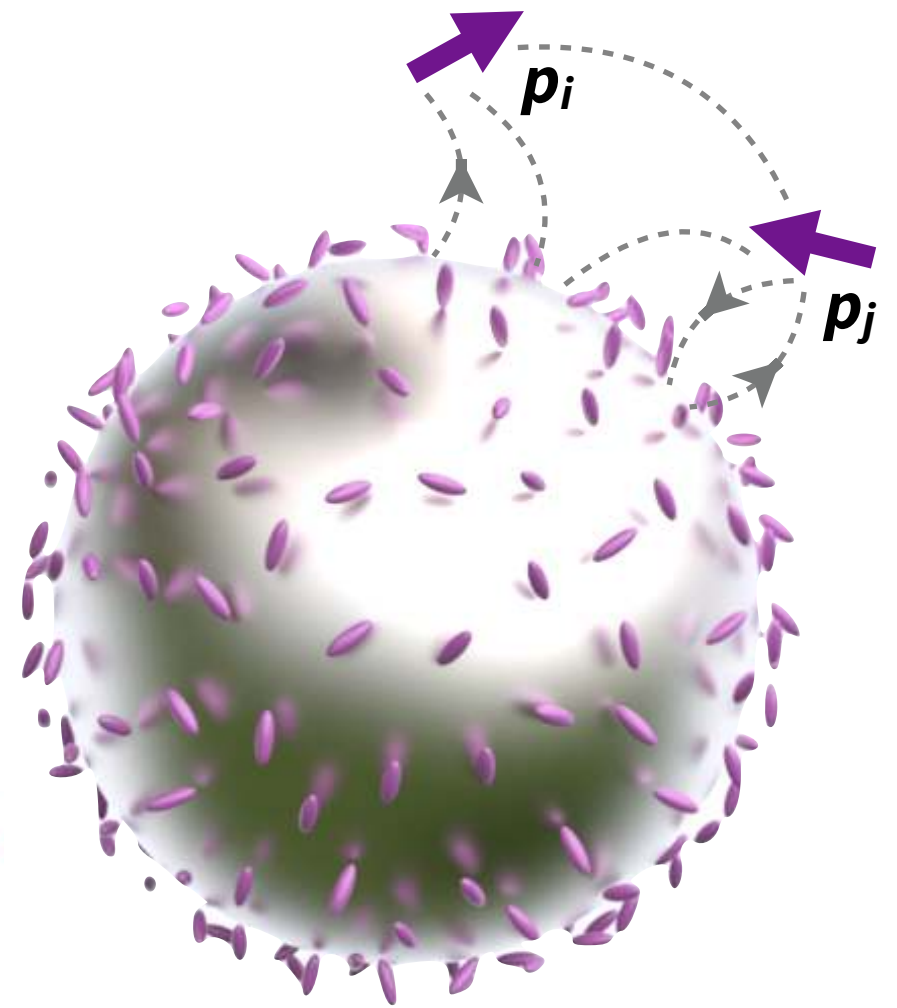
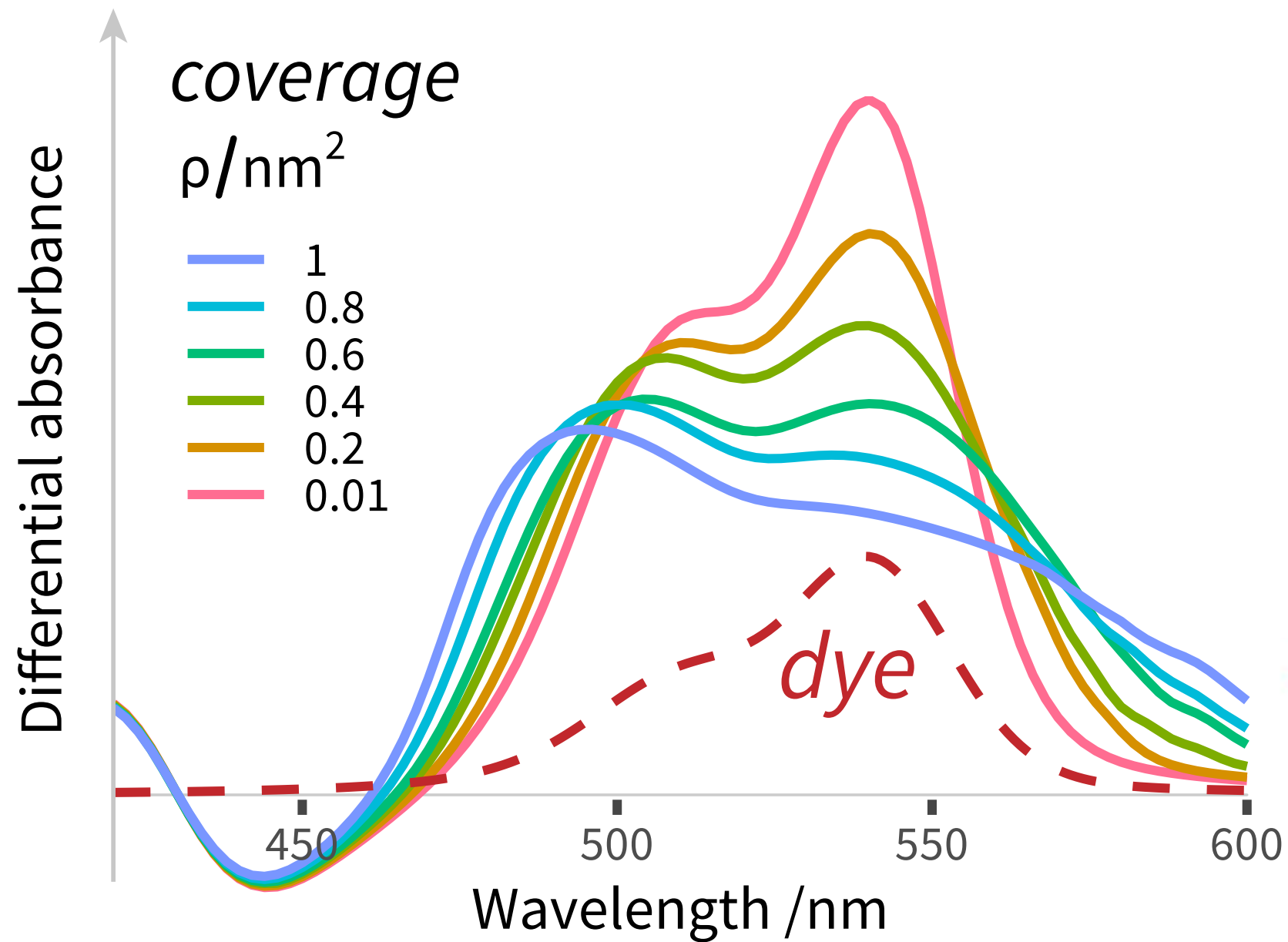


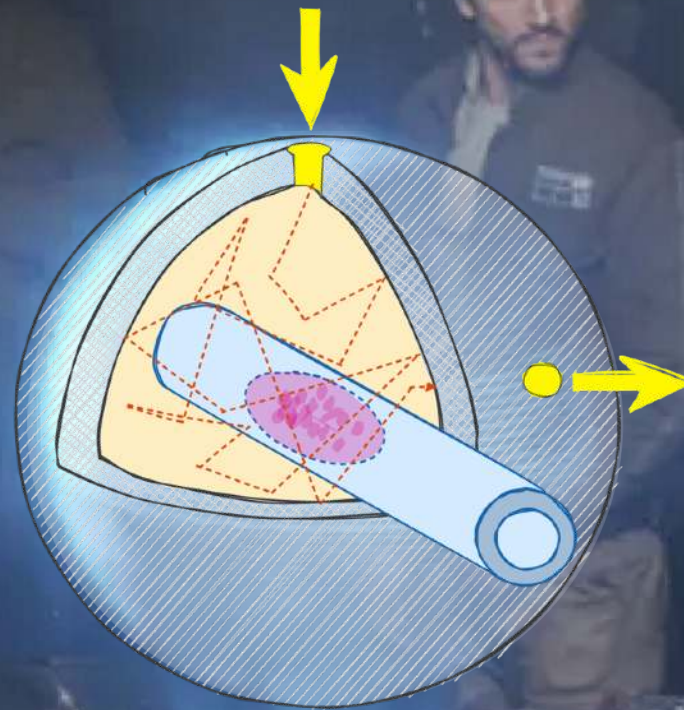
LIGHT SCATTERING PROBLEM



DIPOLE-DIPOLE & DIPOLE-SPHERE INTERACTIONS

COUPLED DIPOLES AROUND A NANOSPHERE

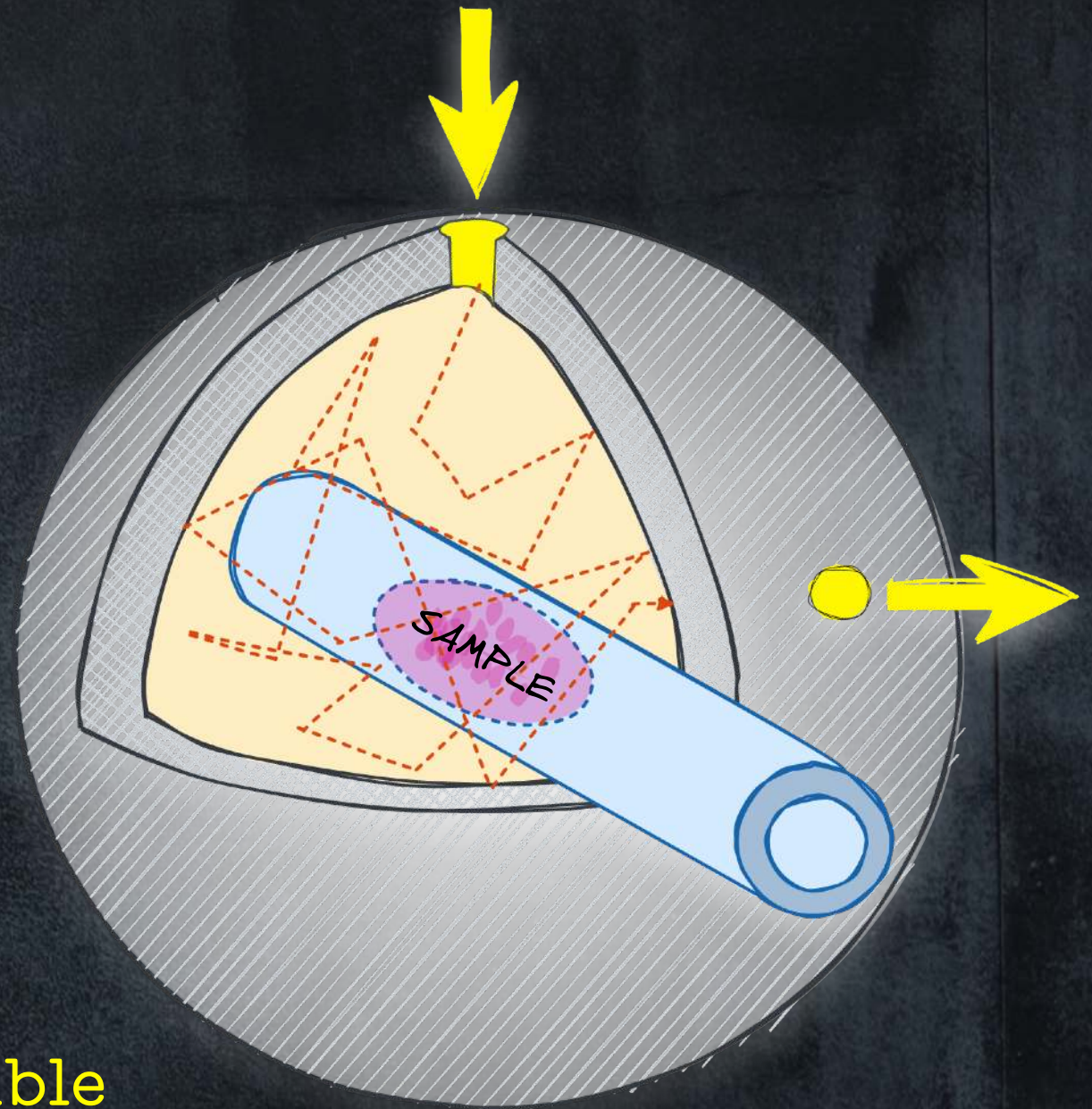




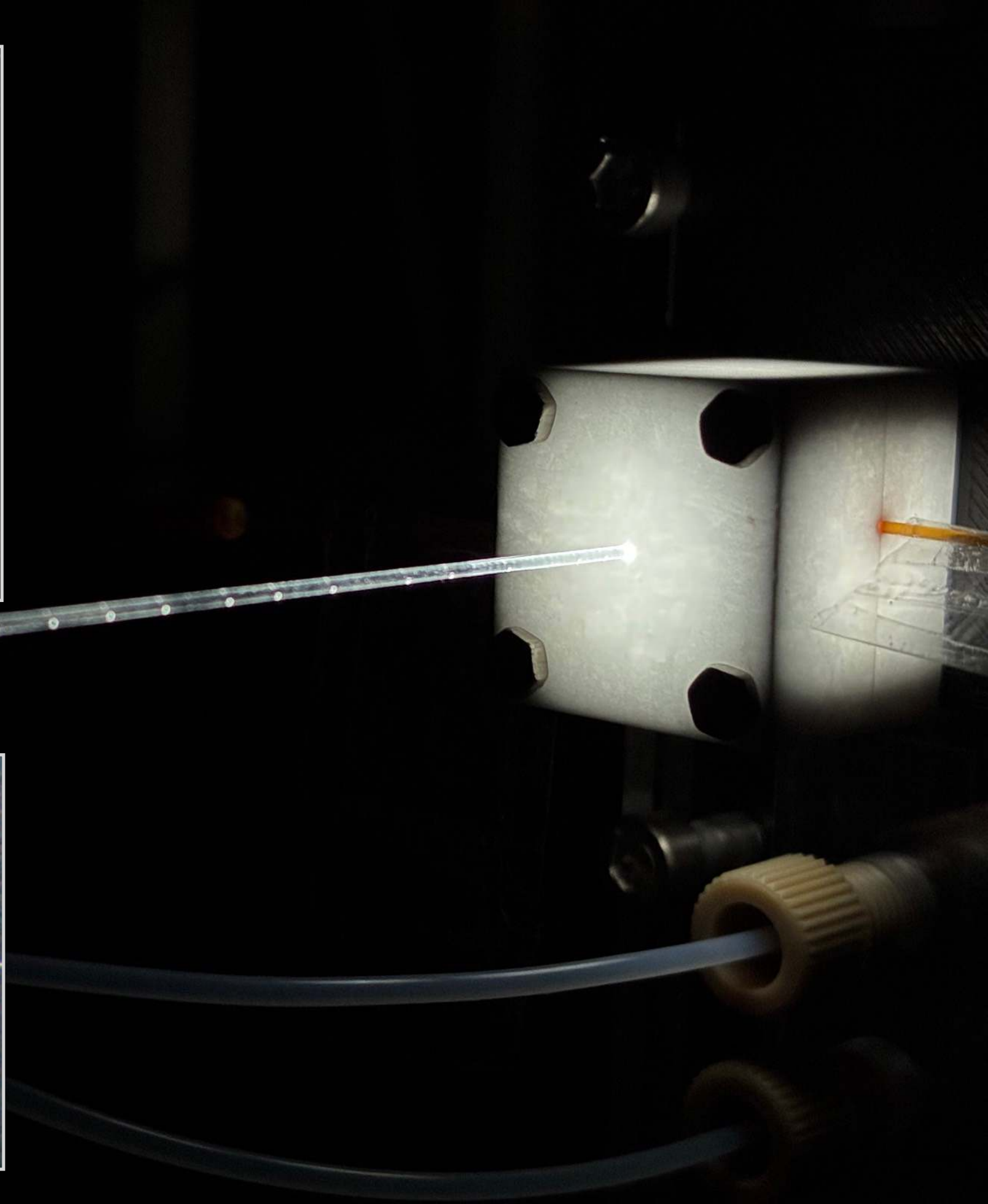
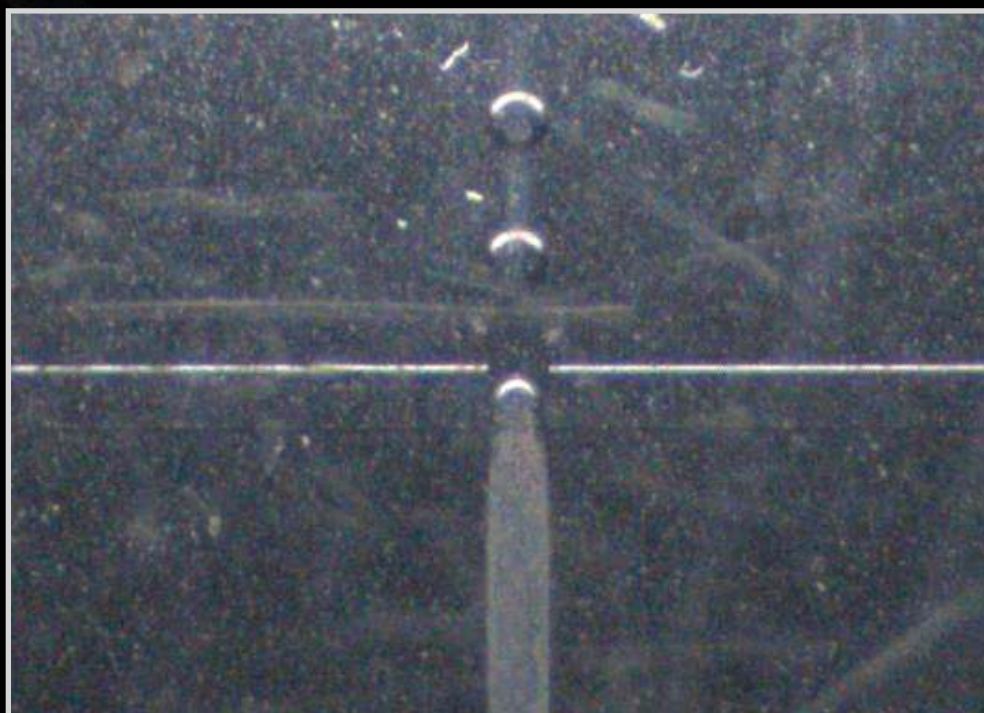
***UV-VIS SPECTROSCOPY OF
ULTRA-SMALL SCATTERING SAMPLES
AND INDIVIDUAL MICRO-PARTICLES***

NEW PLATFORM

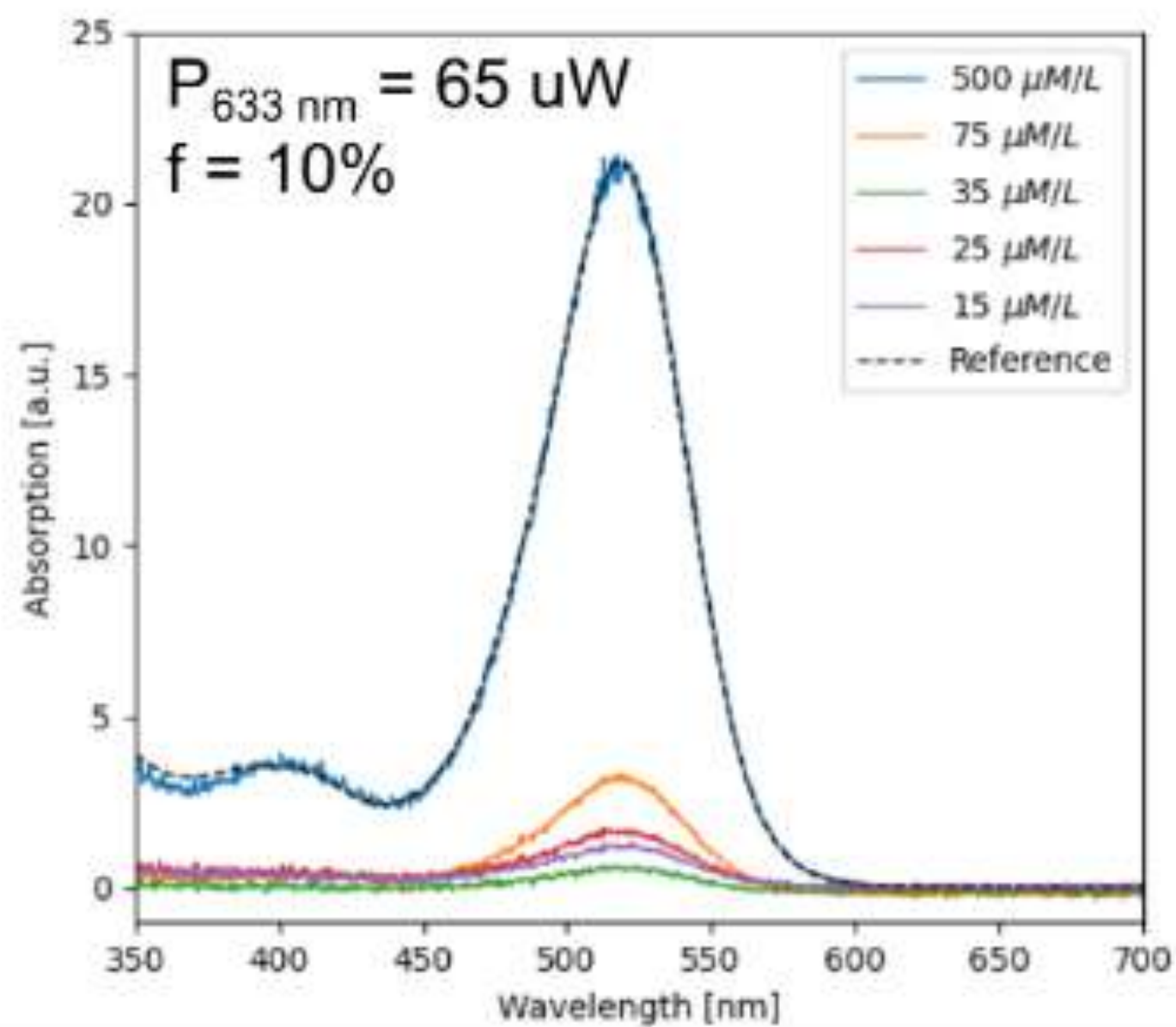
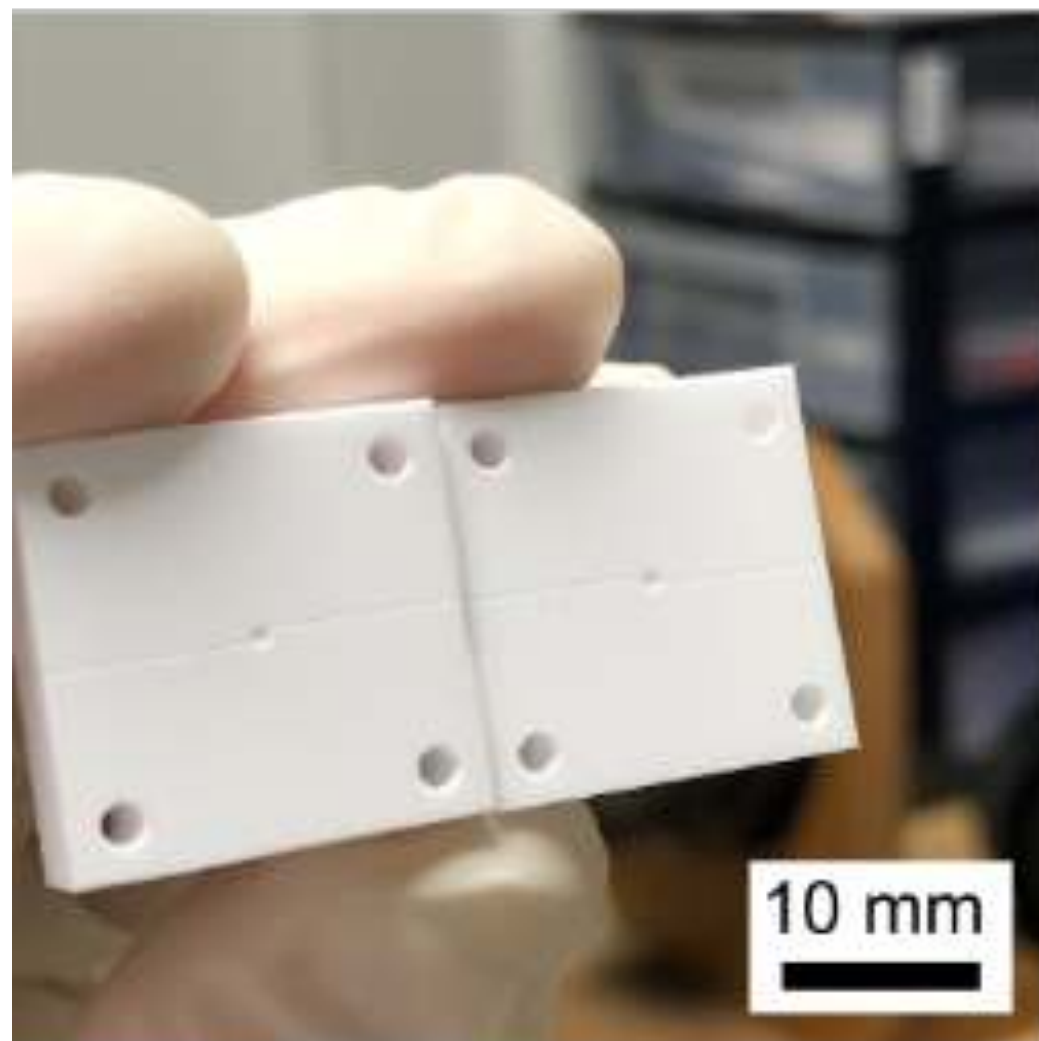
- ✓ Insensitive to scattering
- ✓ Orientation averaging
- ✓ Path length increase
- ✓ Non-imaging optics
- ✓ Small sample volume
- ✓ Droplet microfluidics compatible



HOW SMALL CAN WE GO?



0.9 mm sphere



UV-VIS OF INDIVIDUAL DROPLET AND/OR SINGLE MICROPARTICLE

ZOOSPORES

BACTERIA

CELLS, GUVS

DIATOMS

MICROPLASTICS



Thank you!

Raman Kashyap for hosting me!



Eric Le Ru

Pablo Etchegoin

Volker Nock



Andrés Guerrero-Martínez

Luis Liz-Marzán

Javier García de Abajo



Emiliano Cortés

Alejandro Fainstein

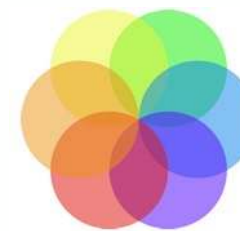
Paula Angelomé



William (Bill) Barnes



Te Mana
Tangata Whakawhanake
**MacDiarmid
Institute**
Advanced Materials
& Nanotechnology



DODD-WALLS CENTRE
for Photonic and Quantum Technologies

RUTHERFORD
DISCOVERY FELLOWSHIPS

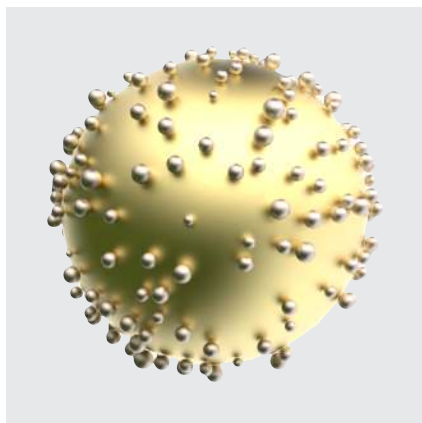
ROYAL
SOCIETY
TE APĀRANGI



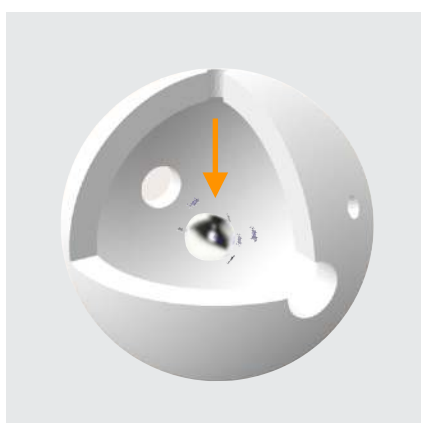
VICTORIA UNIVERSITY OF
WELLINGTON
TE HERENGA WAKA



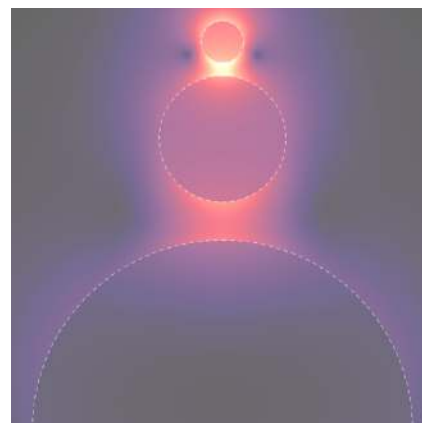
NANO-OPTICS.AC.NZ



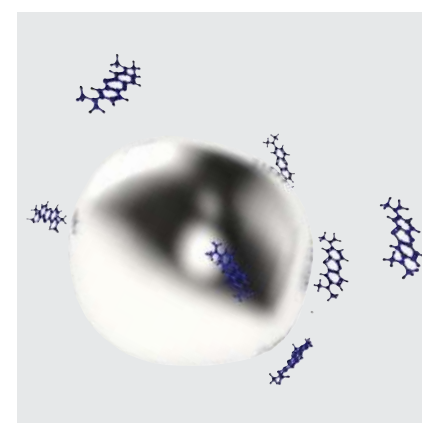
PARTICLE CLUSTERS



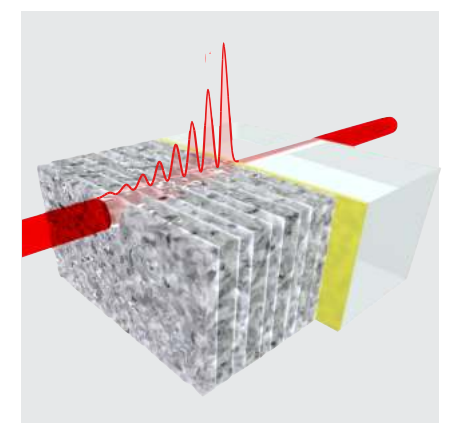
INTEGRATING SPHERES



LIGHT SCATTERING



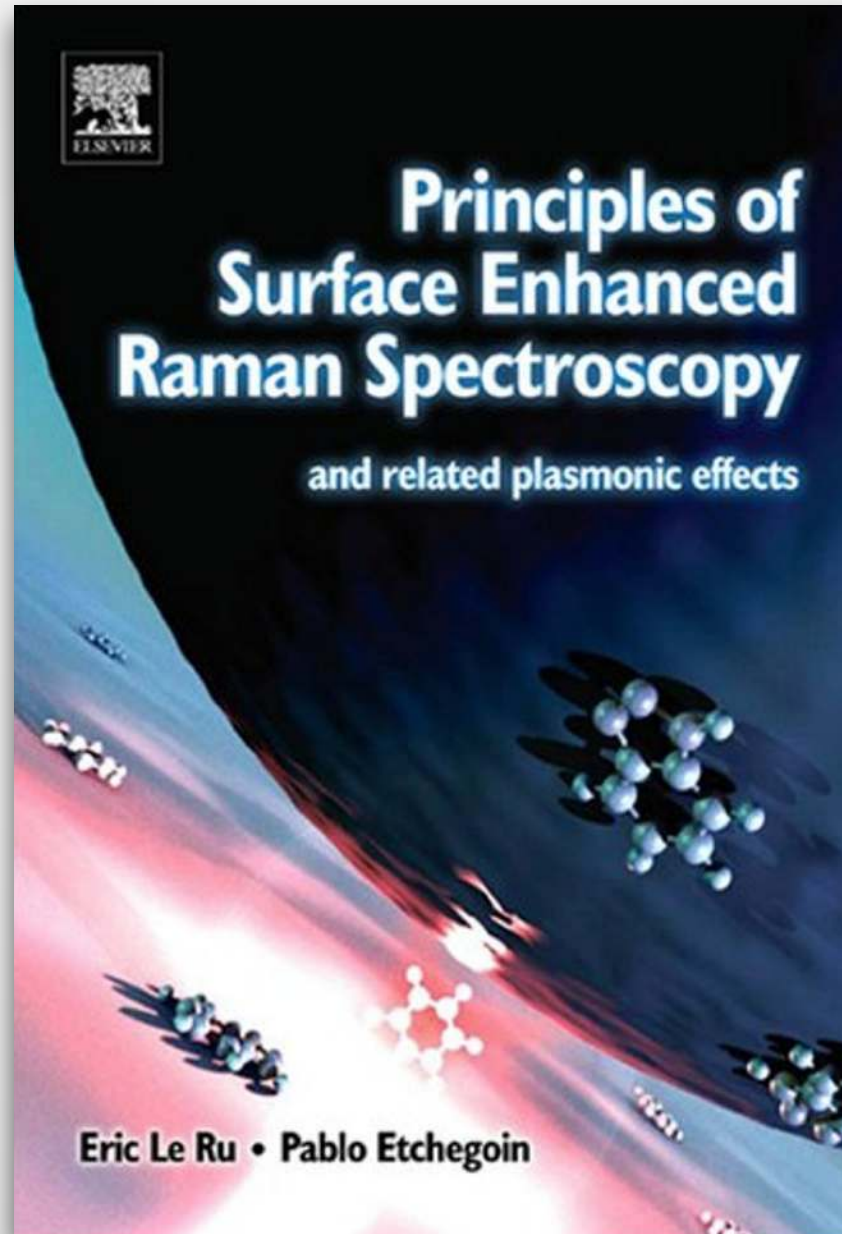
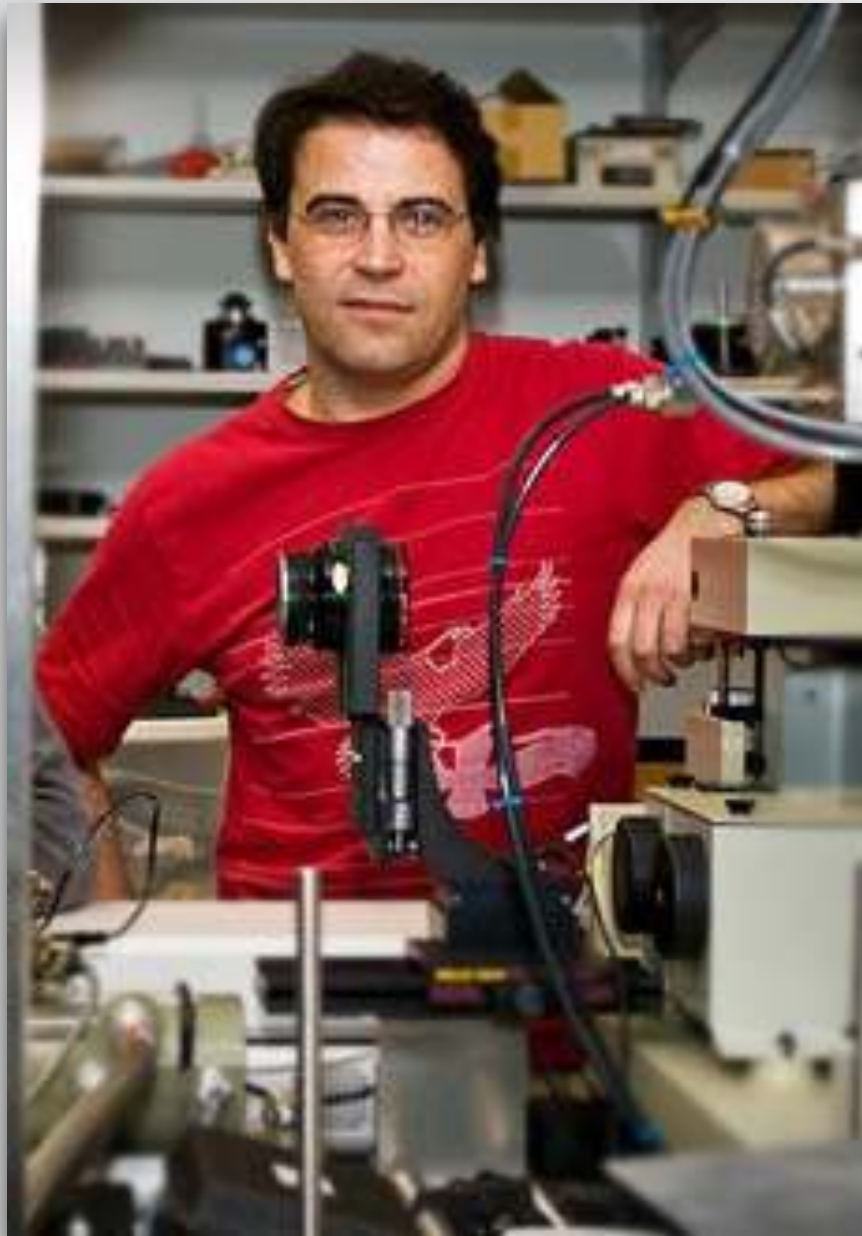
SPECTROSCOPY



PLASMONICS

SUPPORTING SLIDES

'RAMAN' LABORATORY – PABLO ETCHEGOIN, ERIC LE RU



TAMM PLASMON SENSORS

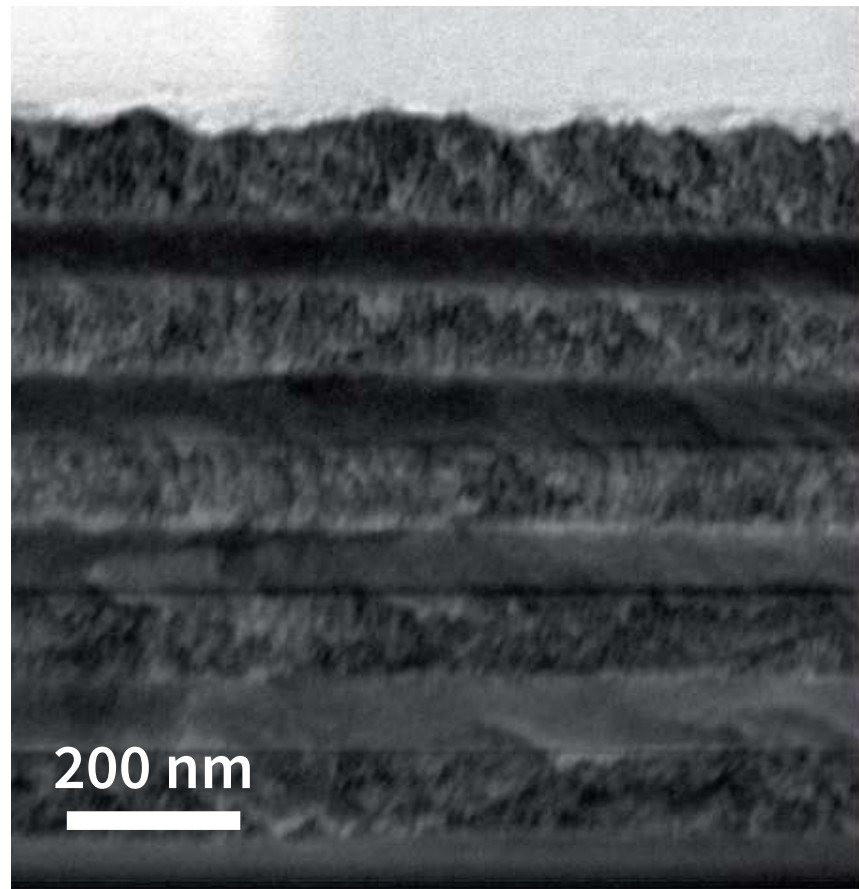
ACS Photonics 1 (2014)

J. Opt. 17 (2015)

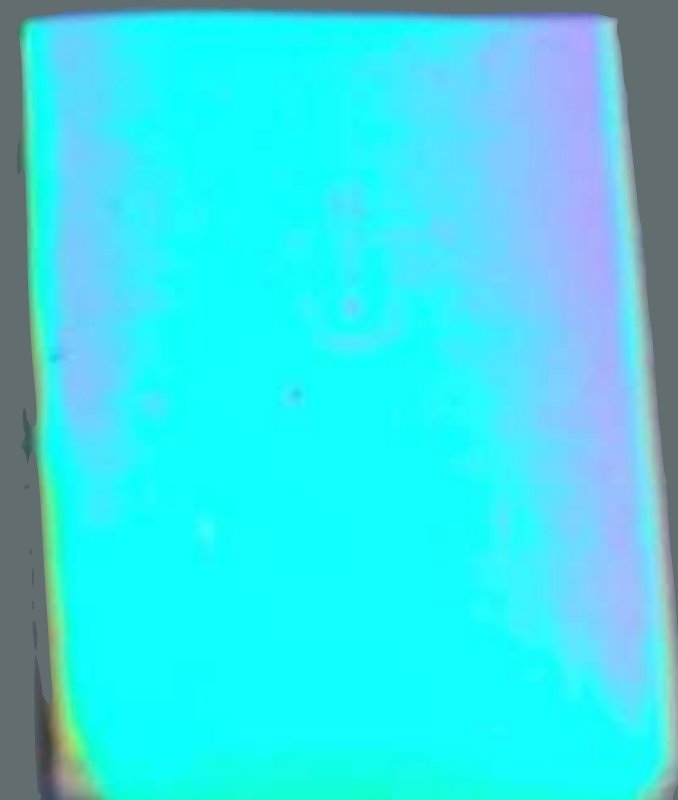
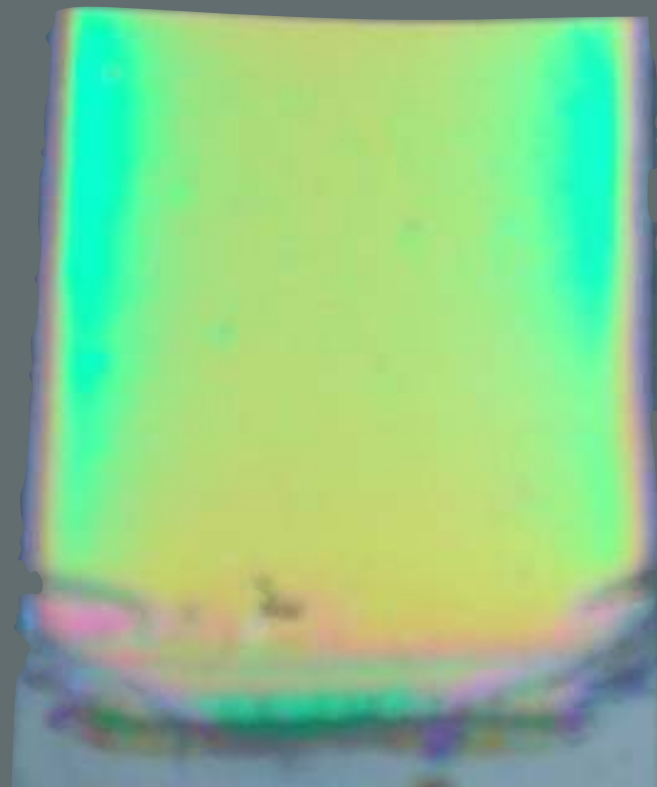
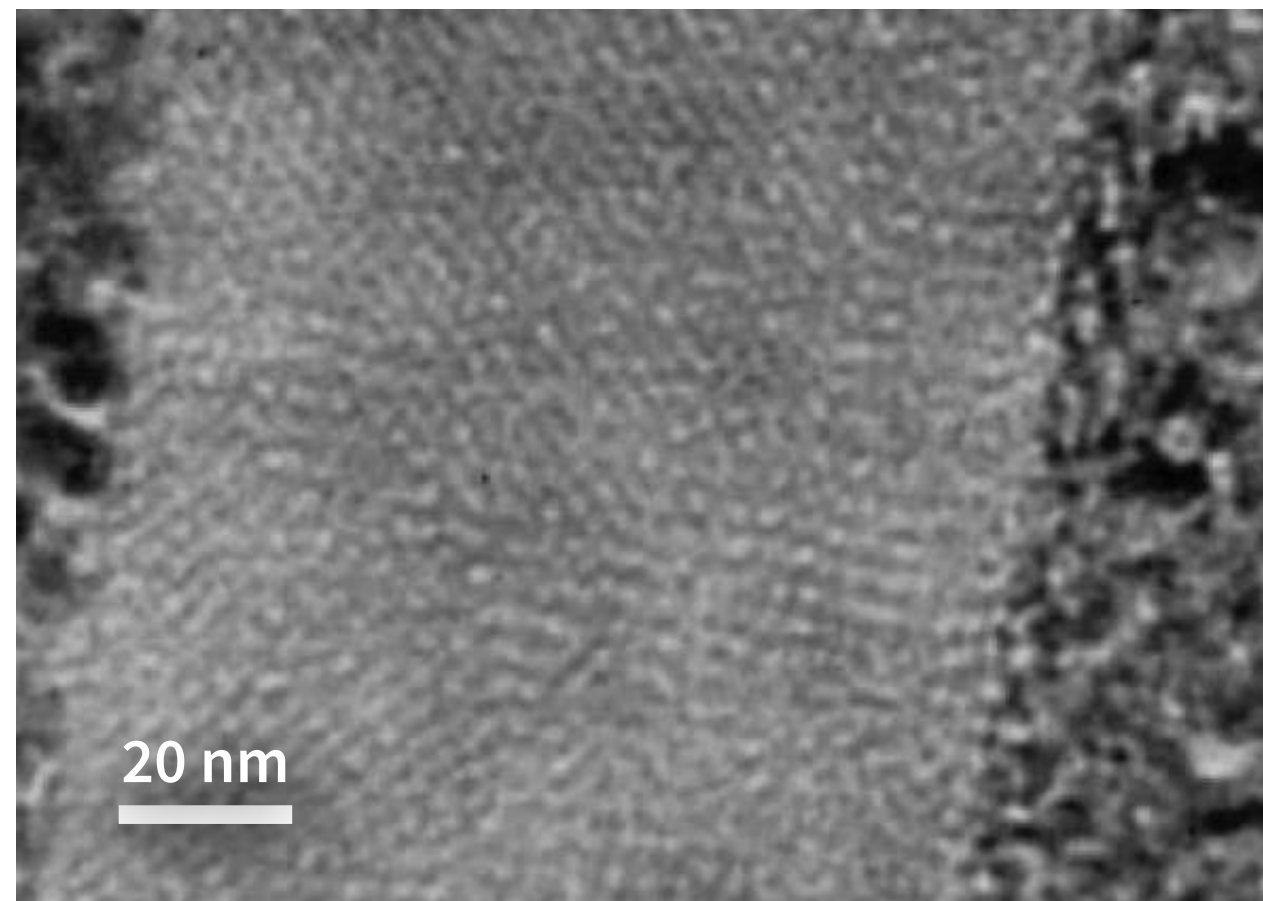
Mater. Adv. 2 (2021)


300 nm



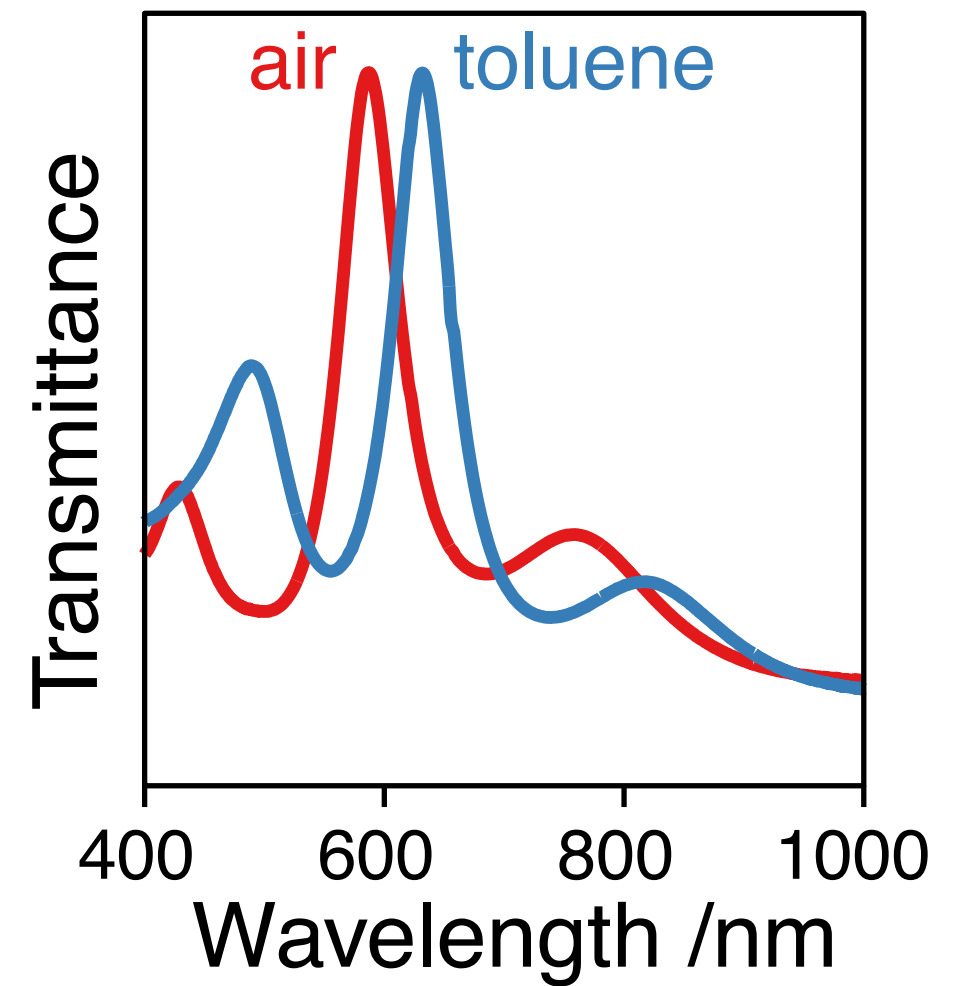
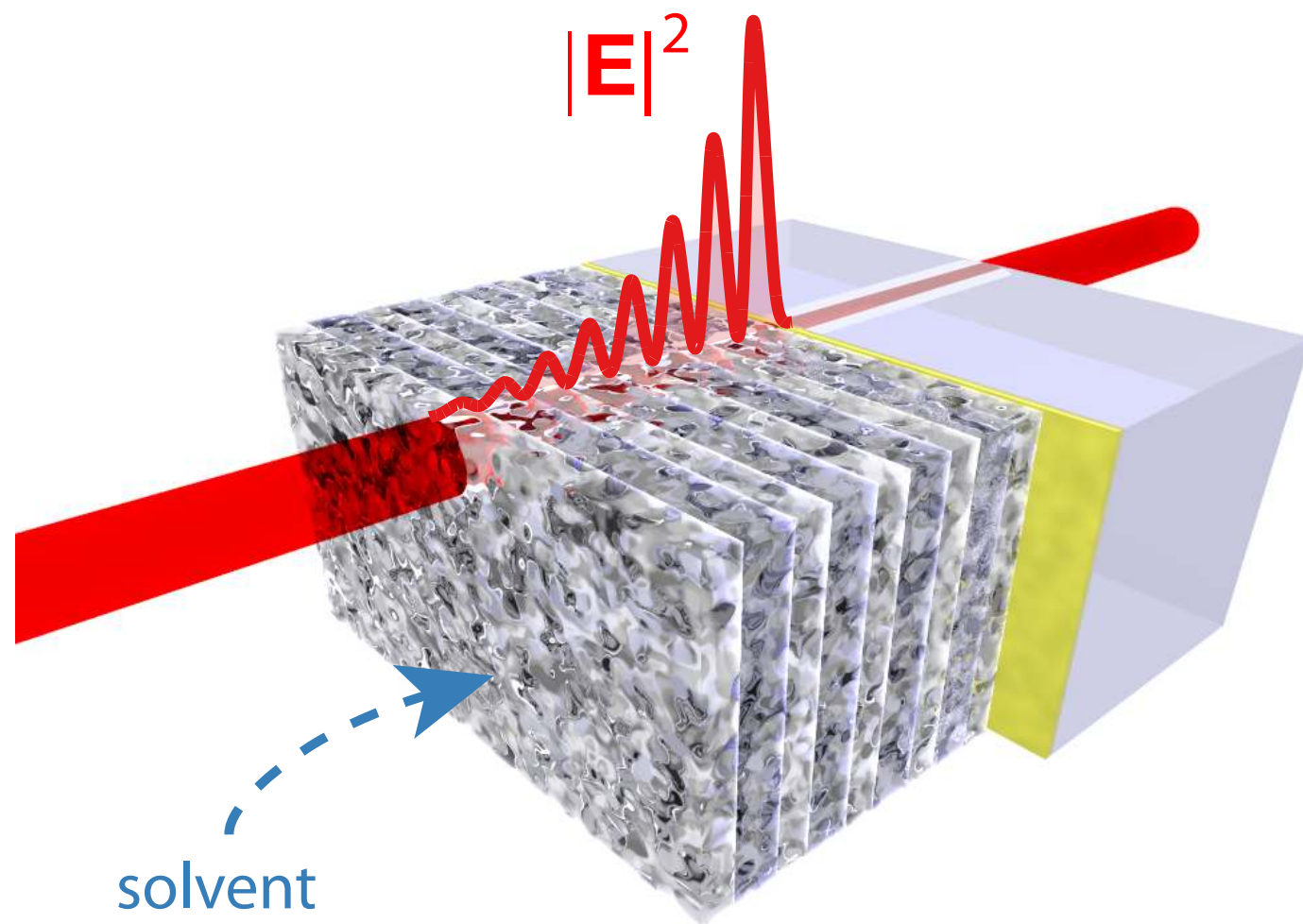


Au 23 nm
TiO₂ 100 nm
SiO₂ 82 nm
TiO₂ 102 nm
SiO₂ 79 nm
TiO₂ 98 nm
SiO₂ 82 nm
TiO₂ 104 nm
SiO₂ 72 nm
TiO₂ 115 nm
glass

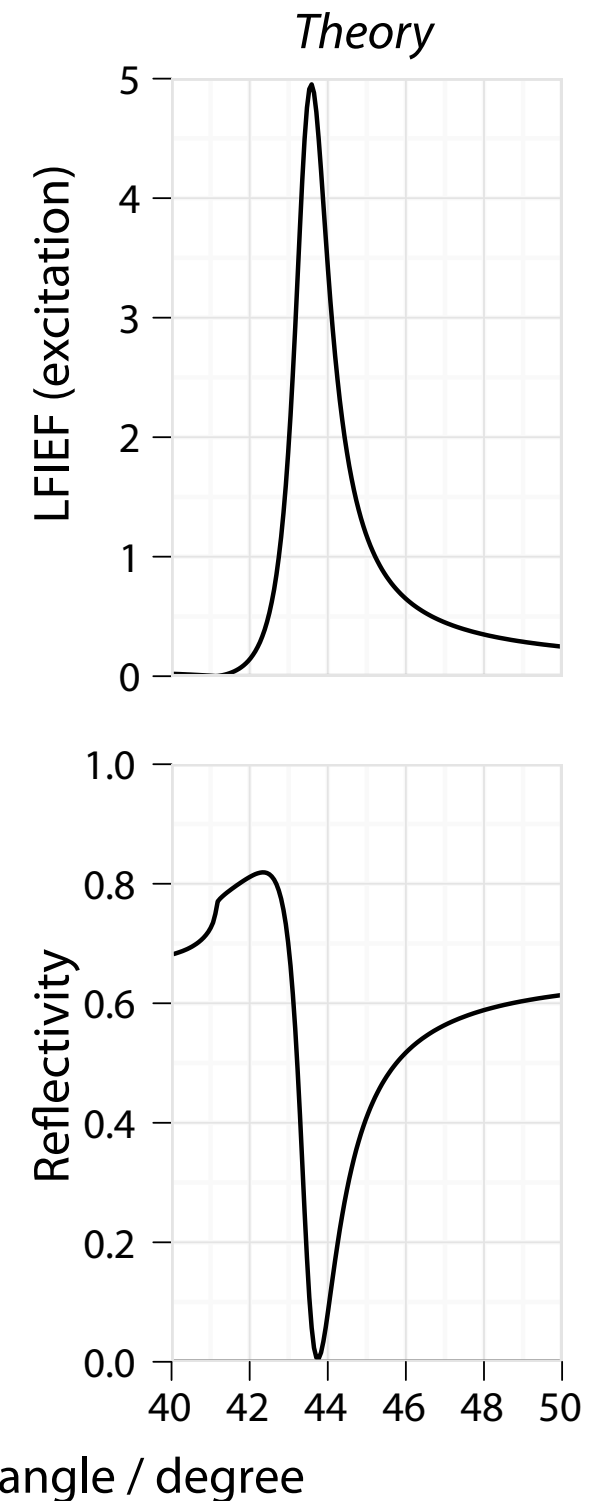
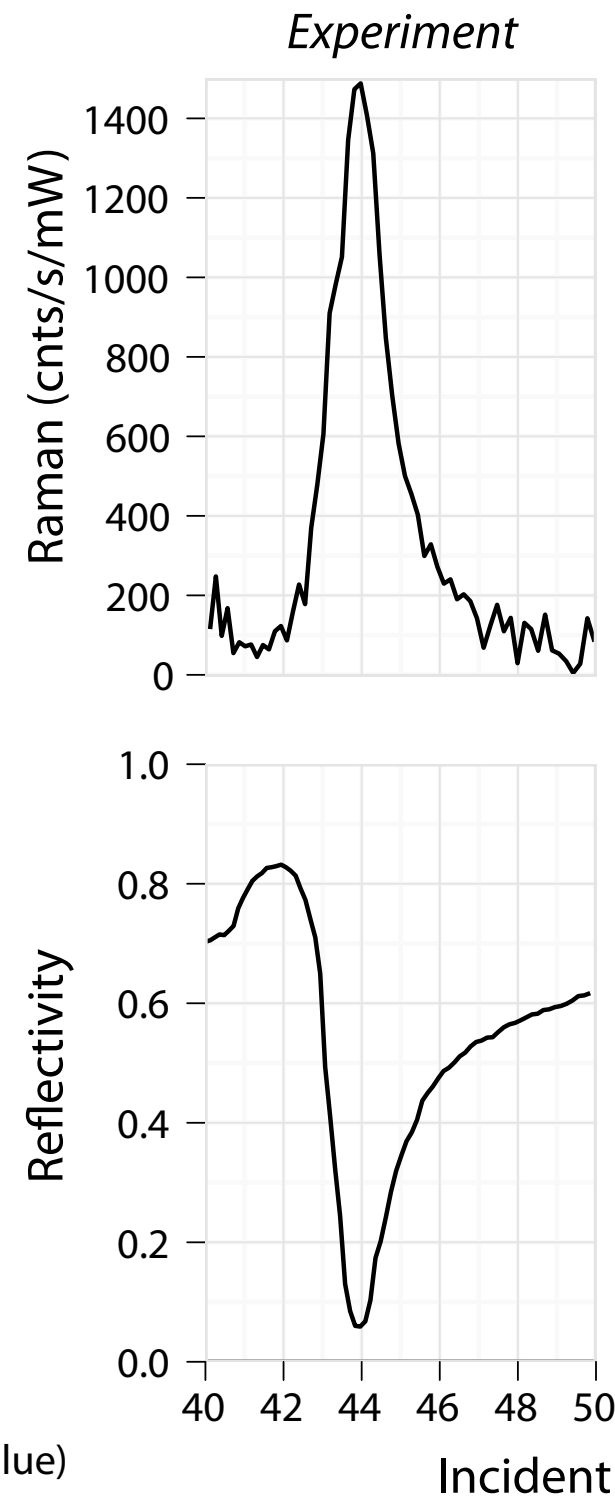
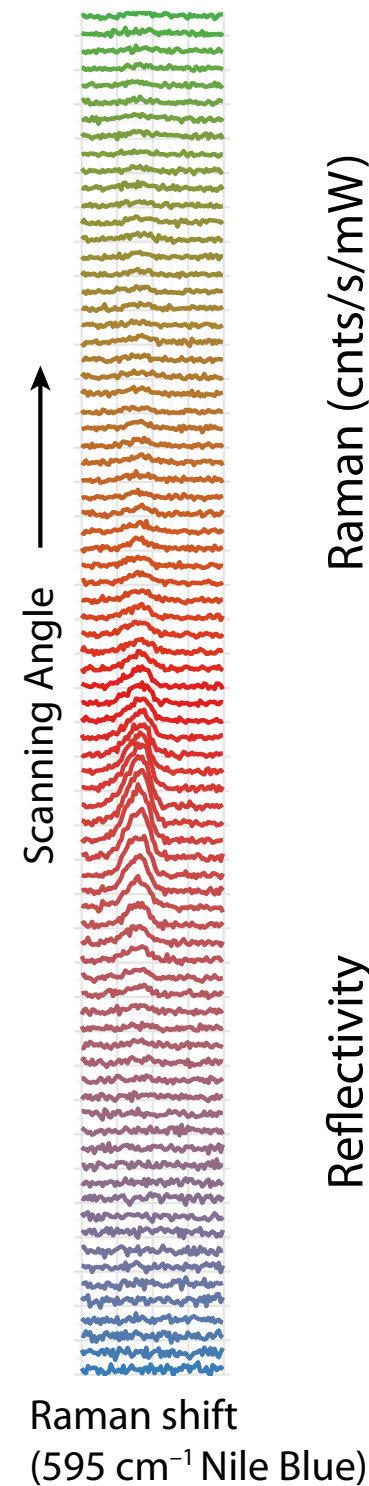
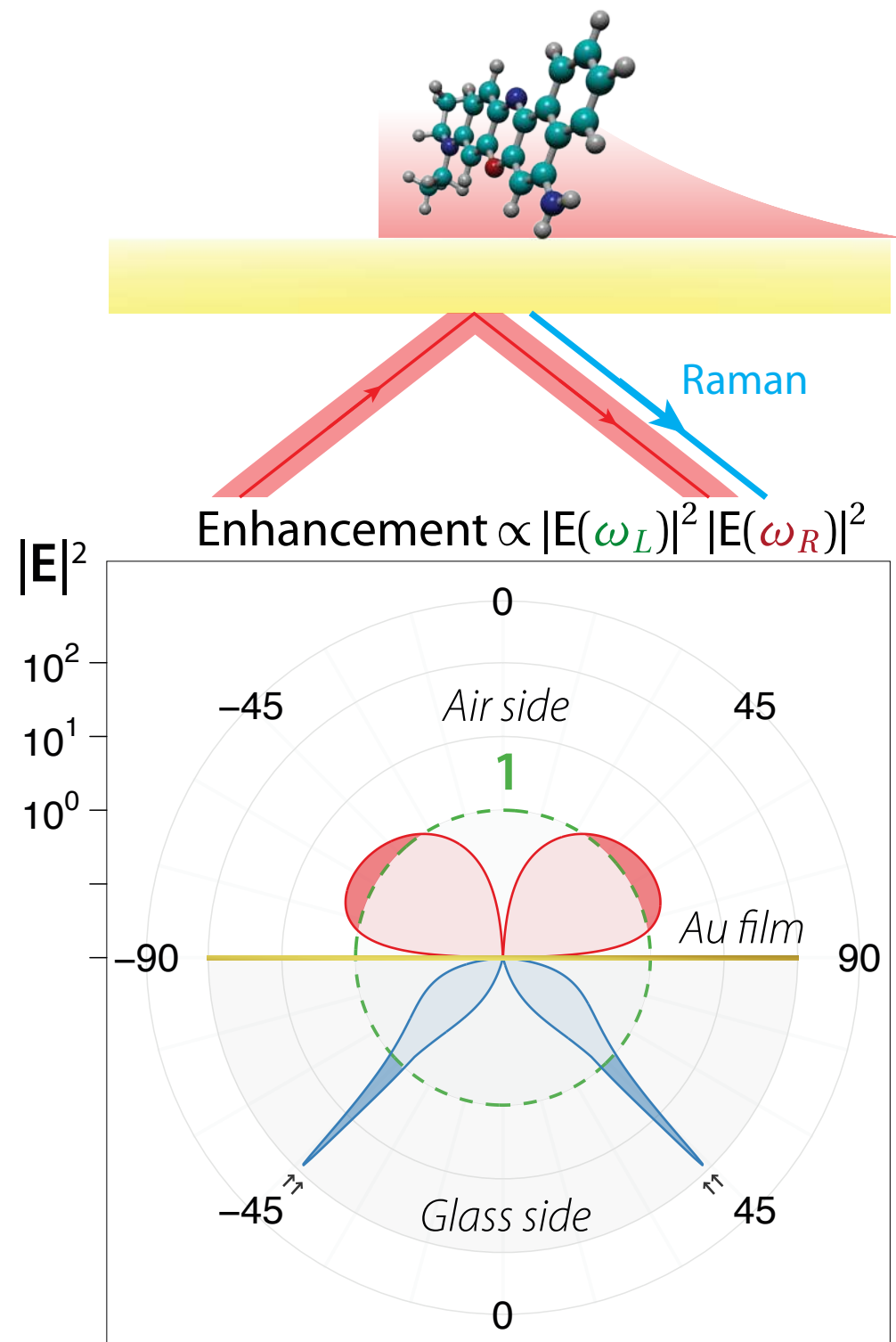


with Dr Cecilia Fuertes & Paula Angelomé, Argentina

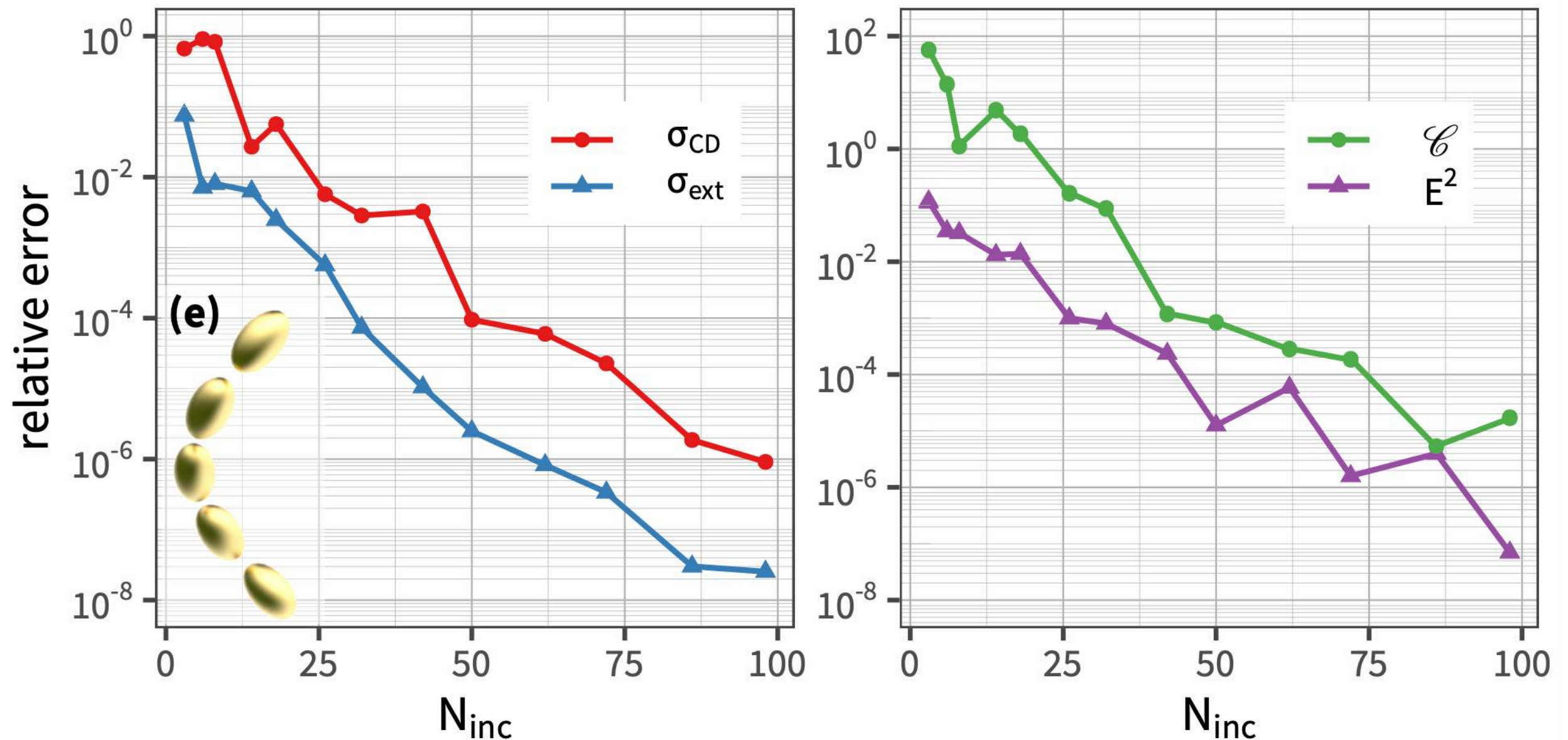
TAMM PLASMON WITH MESOPOROUS LAYERS



PLANAR FILMS: SERS & SPR COMBINED



ORIENTATION AVERAGING BY SPHERICAL CUBATURE



Mater. Adv. 3, 1547–1555 (2022)

JQSRT 286, 108197 (2022)

ELECTROMAGNETIC COUPLING WITH ORIENTED DYES

