# High Refractive Index dieletric dimer as element unit for switching devices

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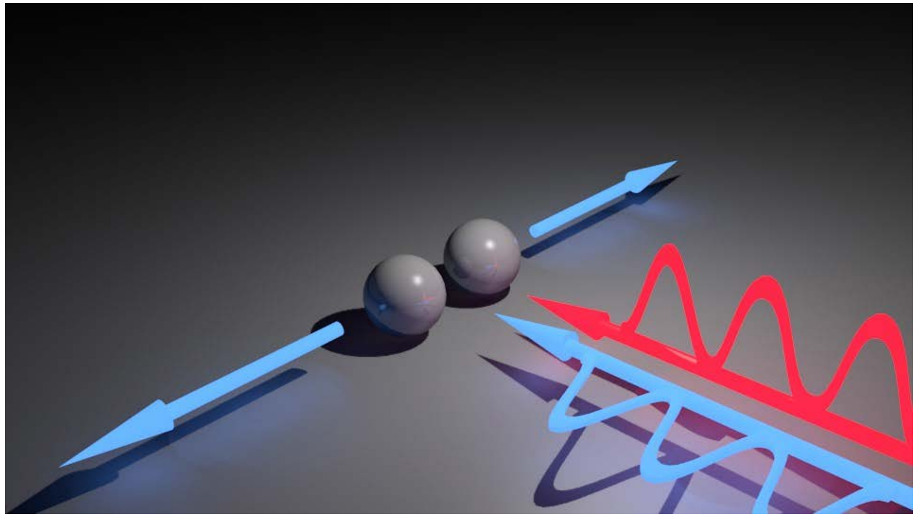

# Outline

- Introduction
- Objective
- Numerical methods & Experimental setup
- Results
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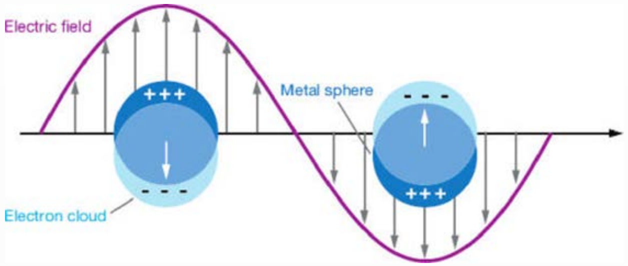
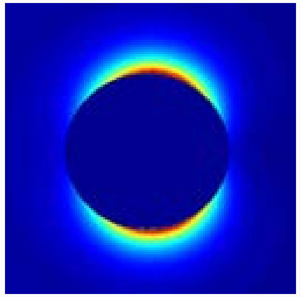
# Nanophotonics

**Metalic Nanoparticles** → Localized Surface Plasmons

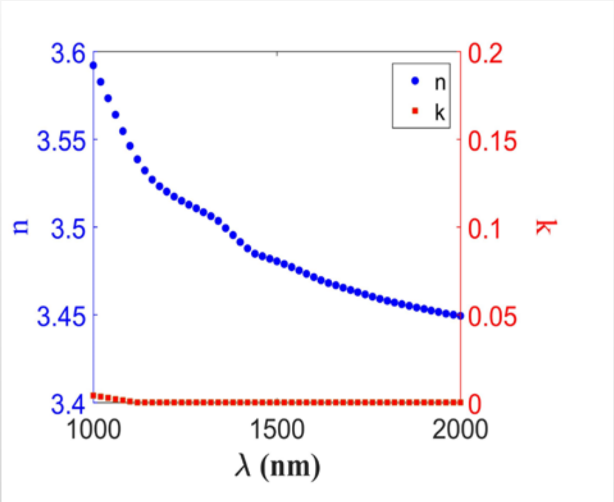



**At resonance** →



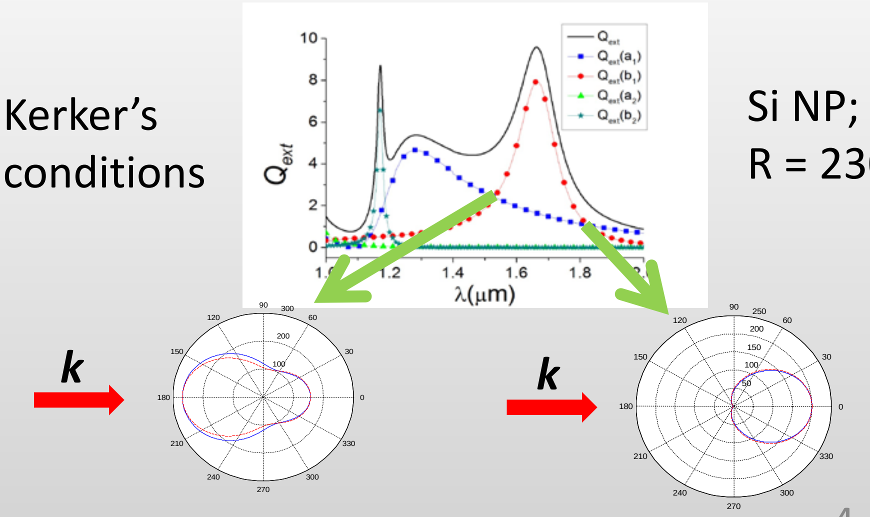

**High Refractive Index dielectric Nanoparticles** → Whispering gallery modes

**No Joule losses between 1 µm and 2 µm**




**They present magneto-dielectric properties**

Kerker's conditions

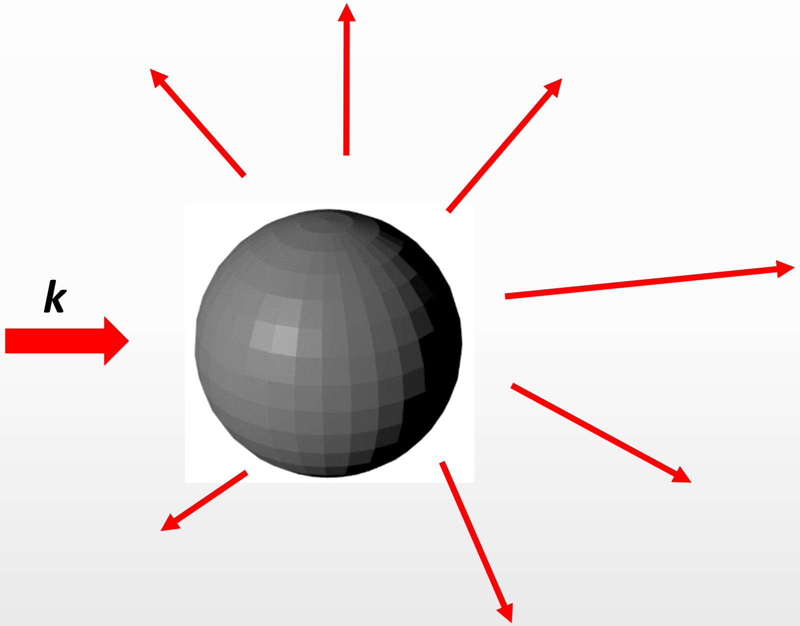



Si NP;
R = 230 nm

Si optical constant, E. D. Palik, Handbook of Optical Constants of Solids (Academic Press, 1998)

.García-Etxarri et al. Opt. Express 19, 4815-4826 (2011) → Si
-R. Gómez-Medina et al. J. Nanophot. 5, 053512 (2011) → Ge

# $P_L(90°)$ vs Energy measurements



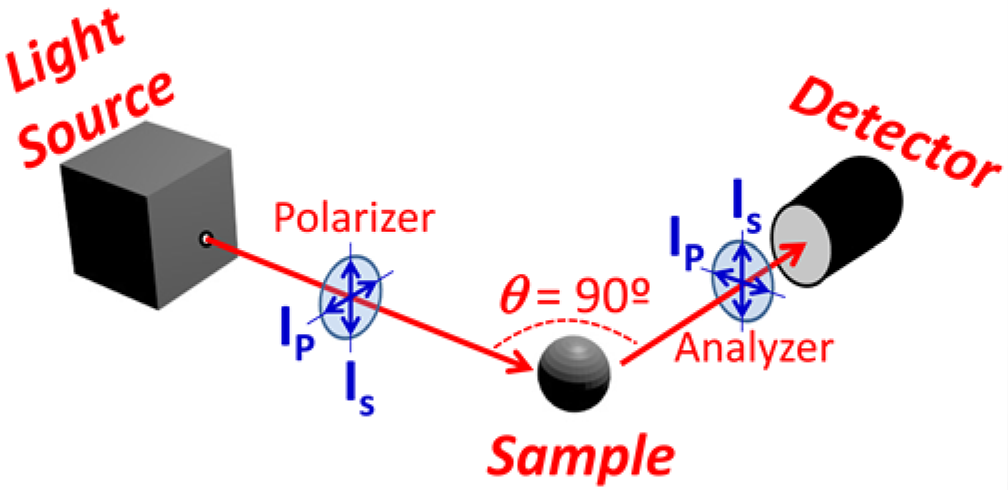

Energy (Scat., Abs,…)

- Near Field Maps
- Far Field
- Ext. Cross Sect.
- …..

Polarimetry

- Mueller Matrix
- Linear Polarization Degree

# Linear polarization degree, $P_L$




**Linear Polarization Degree**

$$P_L(\theta = 90^o) = \frac{I_S - I_P}{I_S + I_P}$$

Dipolar Electric    Dipolar Magnetic

$$P_{L(\theta = 90°)} = \frac{|a_1|^2 - |b_1|^2}{|a_1|^2 + |b_1|^2}$$

**$P_L$(90°) provides information about either the electric or magnetic nature of resonances**

**Measuring at 90°: avoid any parasitic effect due to the incident radiation**

Geffrin, J. M. et al. Nat. Commun. 3, 1171 (2012)

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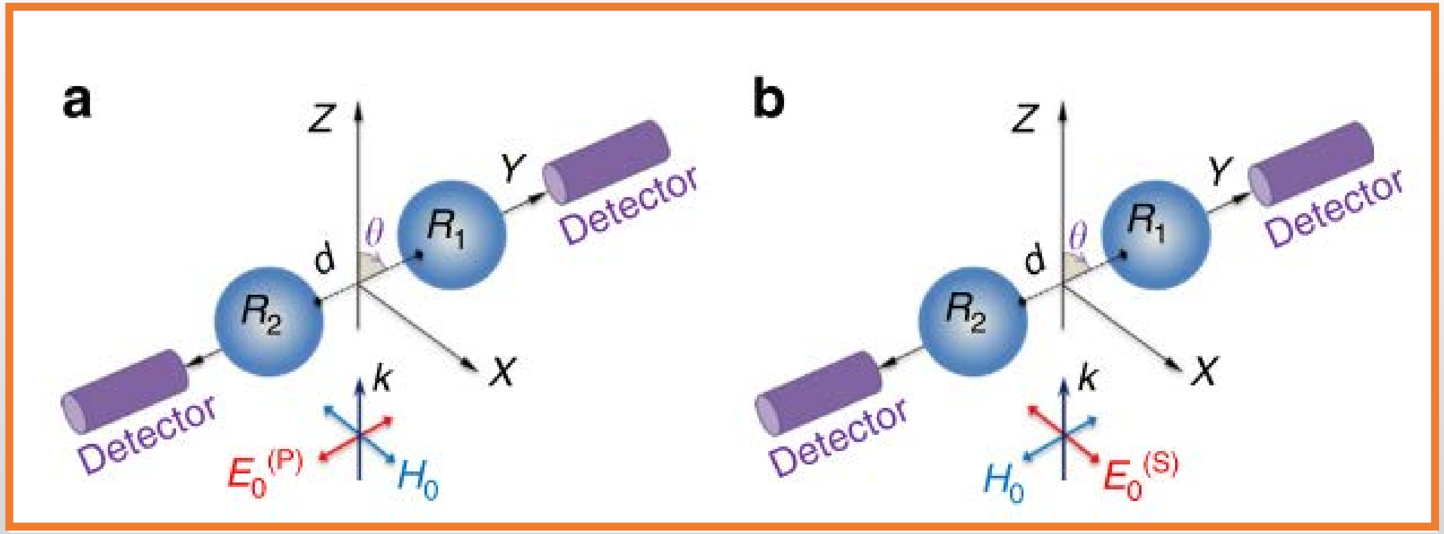
# Objective

## Use $P_L(90°)$ to assess:

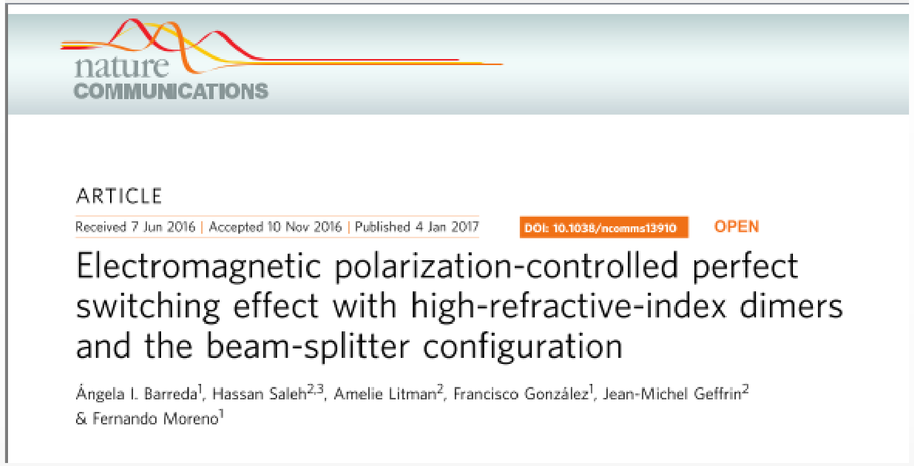
The possibility of using a dimer of spherical particles made of a HRI material, as elementary unit for building a binary switching device. The binary state depends on the excitation polarization.




$R_1 = R_2 = 9mm$
d = 18 / 3 mm
$\varepsilon = 15.7+0.3i$

Barreda, A. I et al. Electromagnetic polarization controlled perfect switching effect with high refractive index dimers. the beam-splitter configuration. Nat. Commun. 8, 13910 (2017)

# Objective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Electromagnetic polarization-controlled perfect switching effect with high-refractive-index dimers and the beam-splitter configuration

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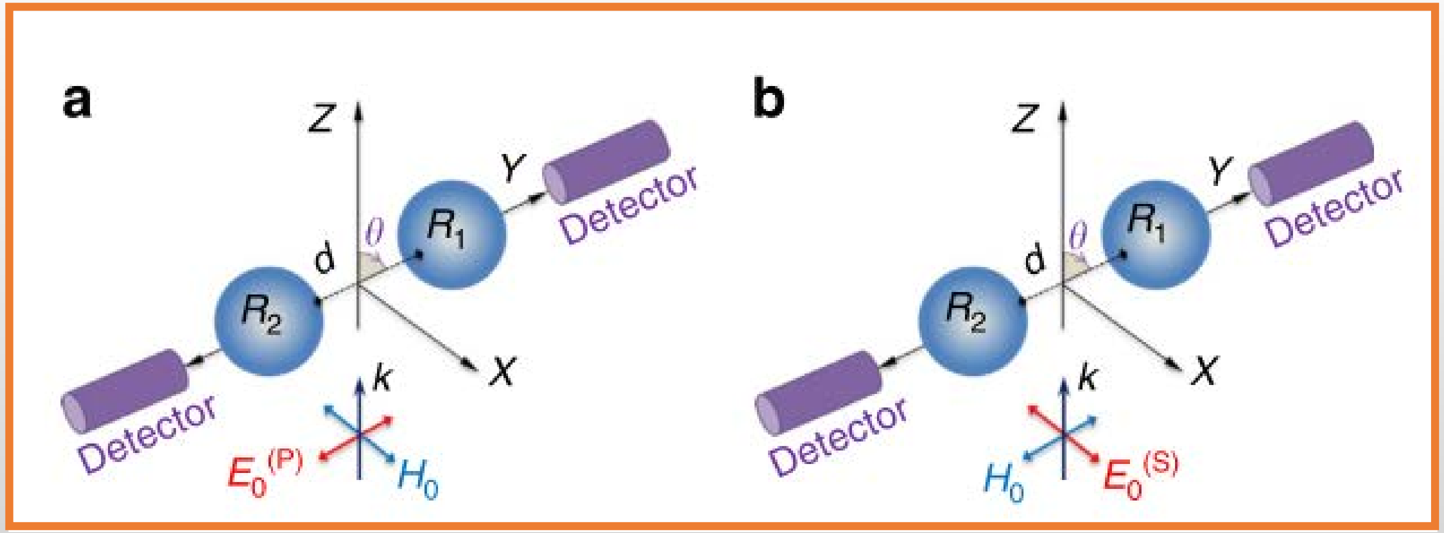


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Barreda, A. I et al. Electromagnetic polarization controlled perfect switching effect with high refractive index dimers. the beam-splitter configuration. Nat. Commun. 8, 13910 (2017)

# Objective

**Maximum difference** between the parallel and perpendicular to the scattering plane intensities for the **right-angle scattering configuration**

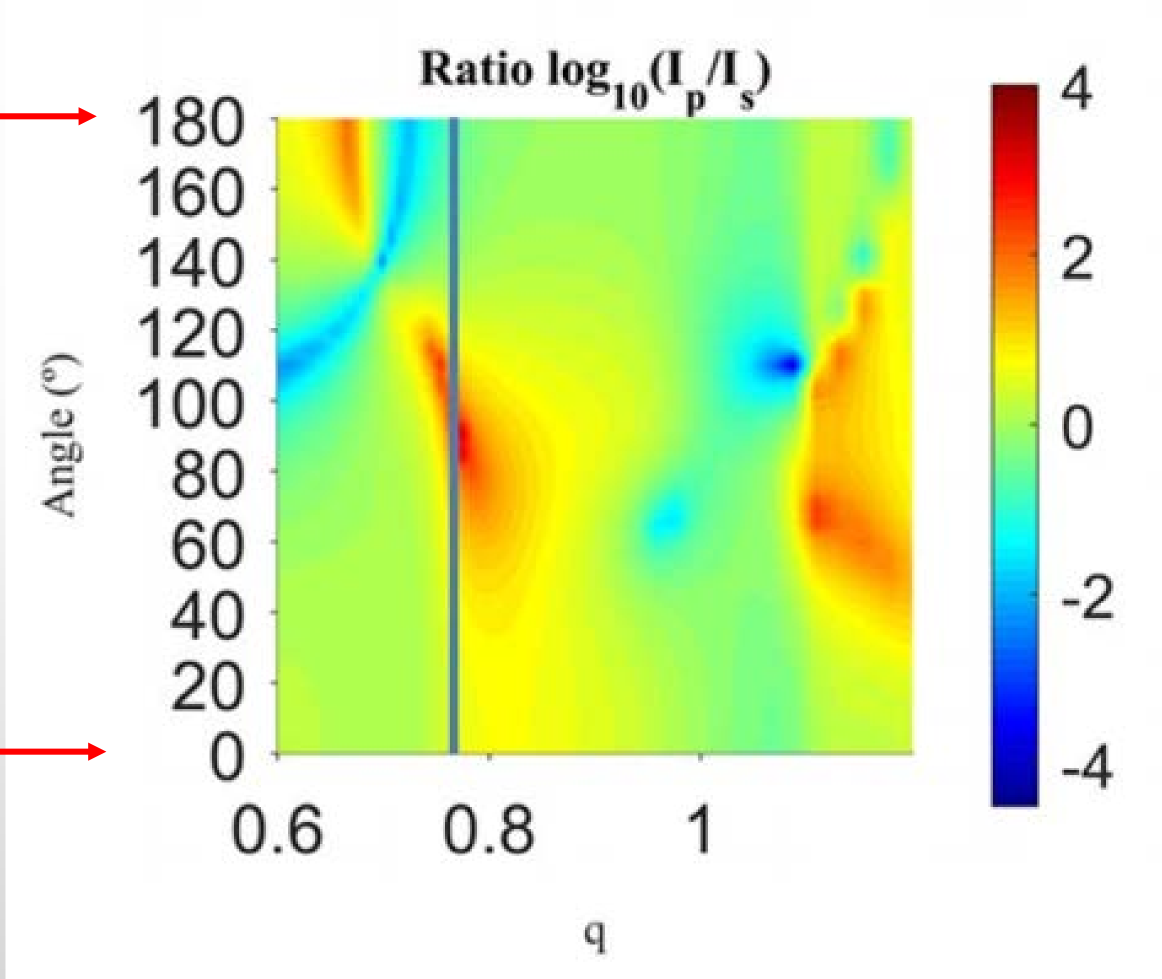
**Forward measurements:** the scattered (wanted) signal is mixed with the incident beam

**Backward measurements:** the scattered field is not easy to isolate without using some sort of beam-splitter

**Two identical outputs** can be handled at the same time with the same scattering unit and for one incidence

Backward direction

Forward direction





Yan, J. et al. ACS Nano 9, 2968–2980 (2015).
Chang, W. S. et al. Nano Lett. 12, 4977–4982 (2012)

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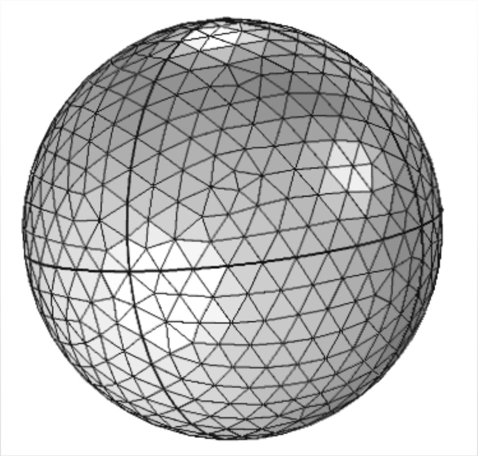
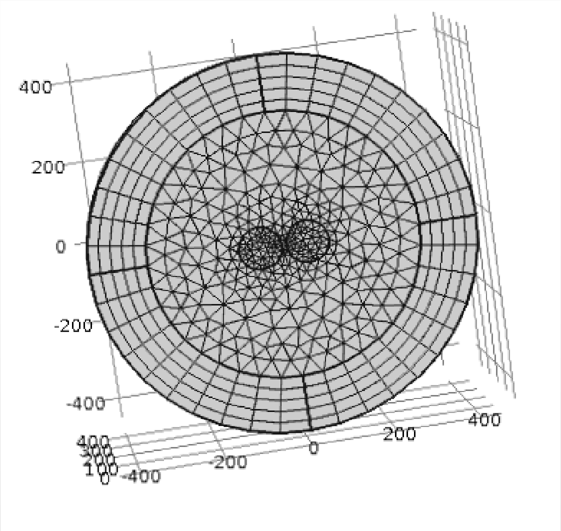
# Numerical methods & Experimental setup

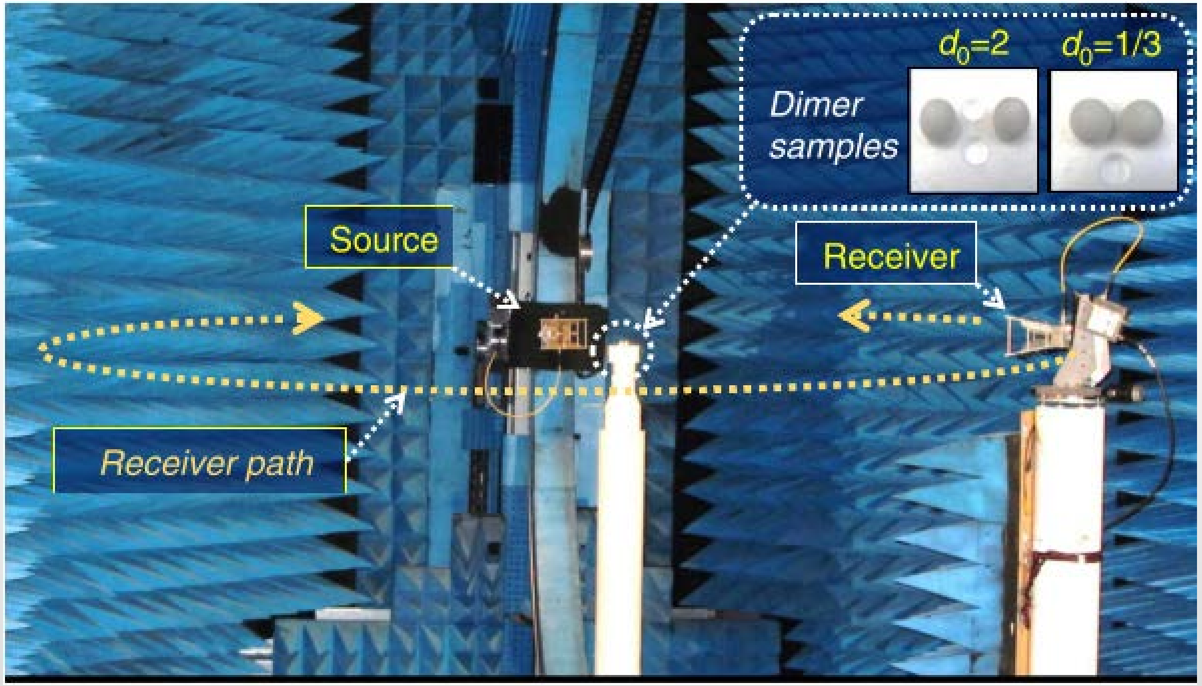
**FEM: COMSOL**

COMSOL: it is based on finite element method.
It is very efficient for solving partial differential equations






**Anechoic Chamber**



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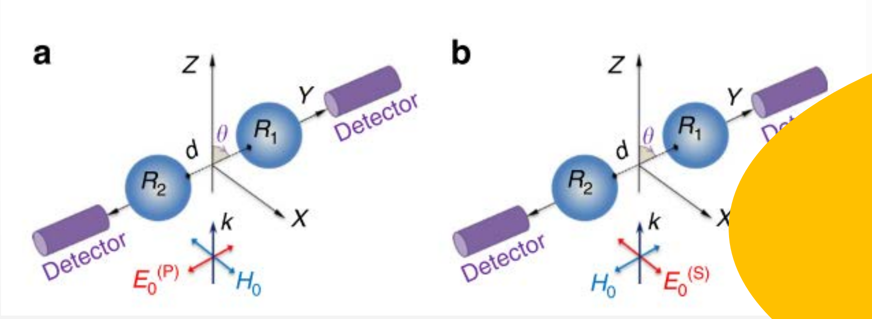
# $P_L(90°)$ measurements

The analysis of the switching effect is performed through the determination of $P_L(90°)$



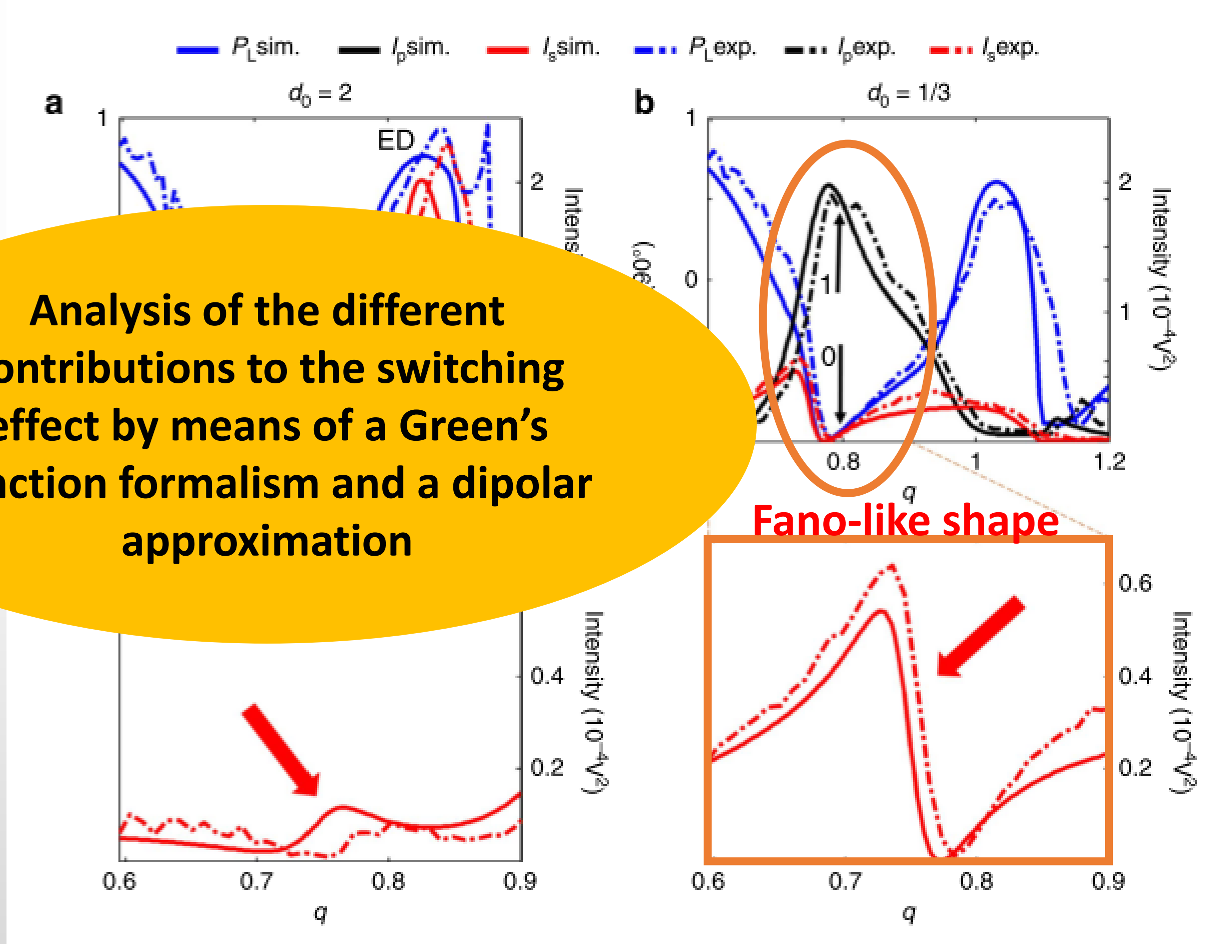

*Switching effect*

$q = 0.773$; $d_0 = 1/3$

$q = 2\pi R/\lambda$; $d_0$ d/R; d =gap

The binary state depends on the excitation polarization

Analysis of the different contributions to the switching effect by means of a Green's function formalism and a dipolar approximation

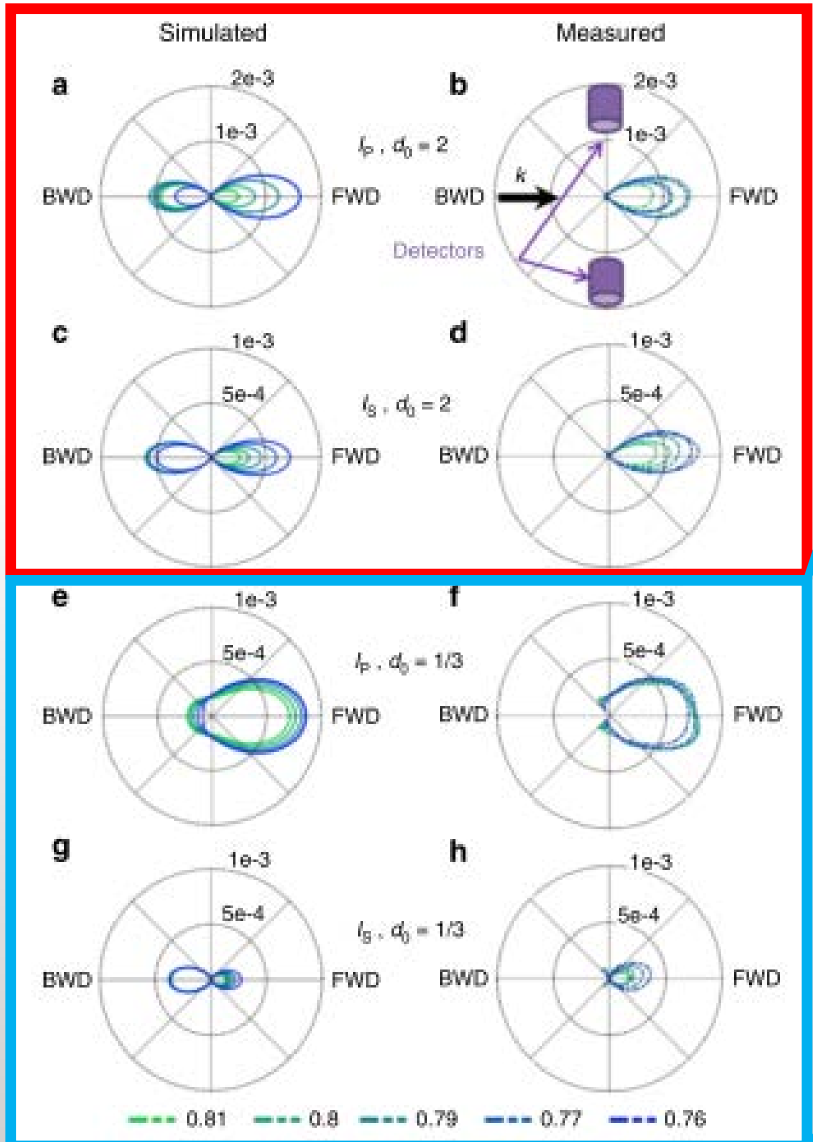


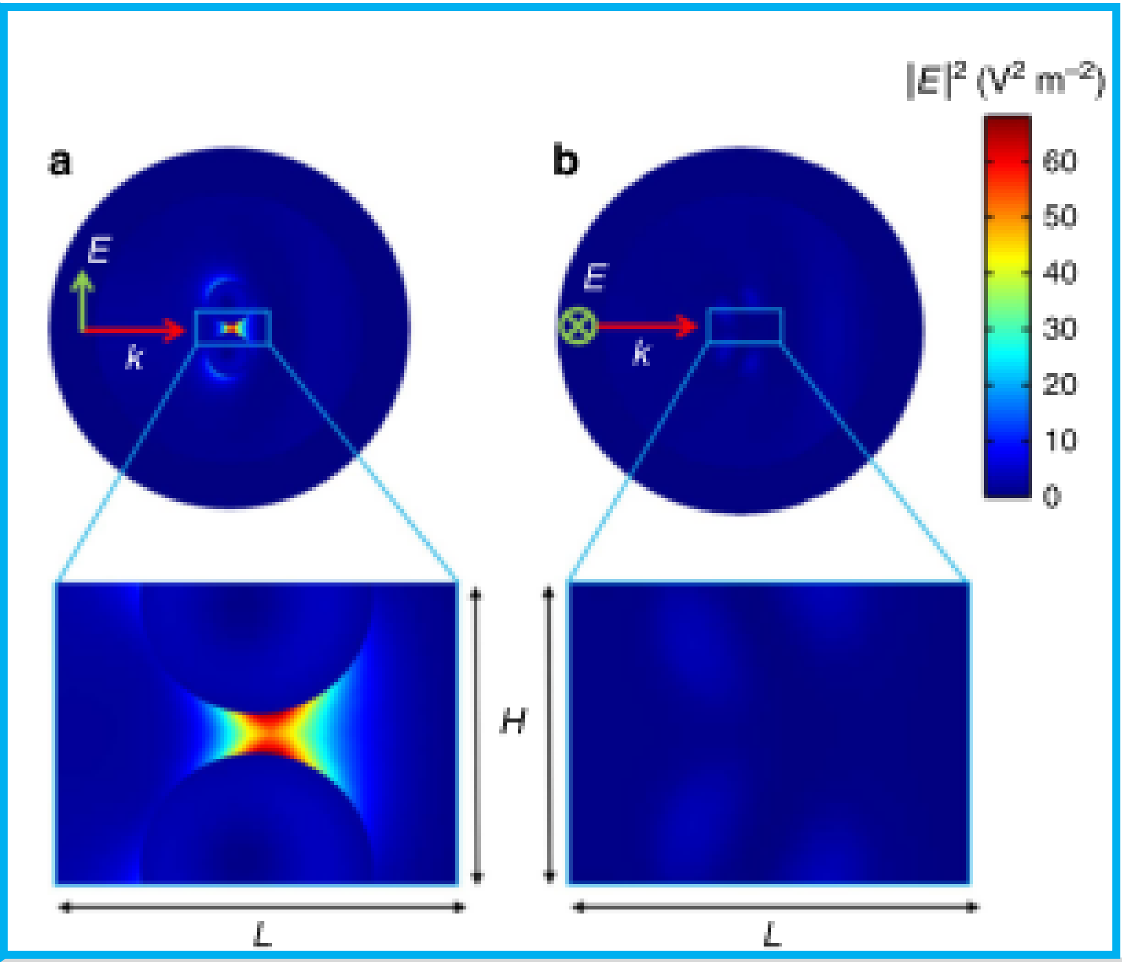
# Scattering patterns & near field maps

**Scattering plane (z-y)**

**Non-Interacting case**

**Interacting case**



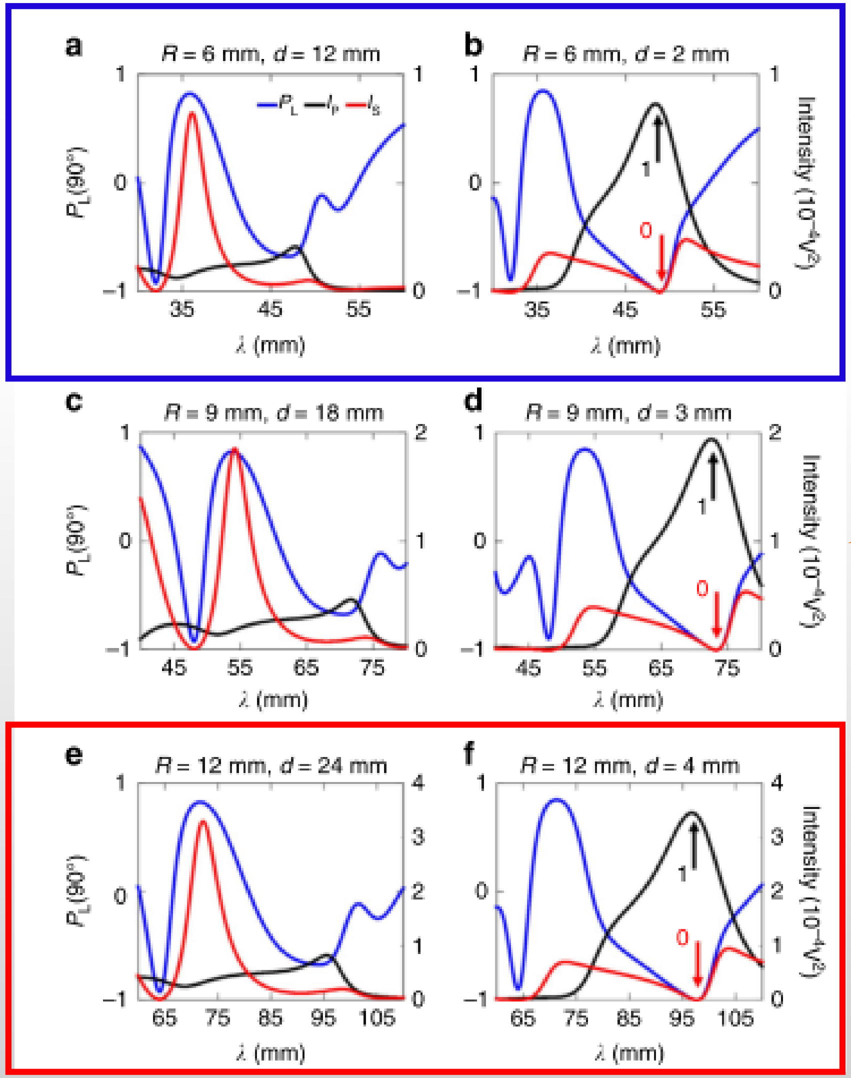



# Tuning the switching frequency

Reproducibility of the switching effect in different spectral ranges

For our switching device, the switching frequency is perfectly tunable to different wavelengths by only changing the size of the particles

The gap-to-particle size ratios $d_0$ take the same values




As the particle size decreases, the resonances are blue shifted

Green's function

As the particle size increases, the resonances are red shifted

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# Conclusions

- A homogeneous dimer of HRI dielectric spheres has been proposed as a perfect binary polarization controlled switching device
- The binary state ("on"-"off") depends only on the polarization of the exciting radiation
- The analysis of the switching effect is performed through the determination of $P_L(90°)$
- The switching effect is produced by the spectral evolution of one of the natural resonances (the dipolar magnetic) of the isolated particle to an asymmetric shape resonance (Fano-like)
- The switching effect can be tuned to different spectral regions by only changing the particle size of the dimer components

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# Thank you
# for your attention!!


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