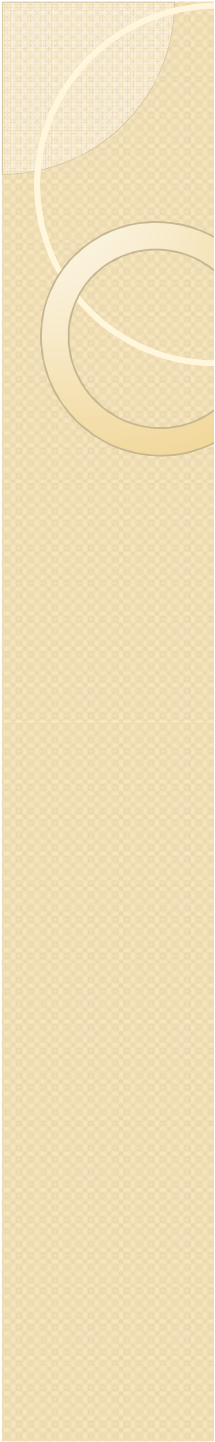


Directional Plasmonic Nano-Antennae

J. Munárriz, A.V. Malyshev, V.A. Malyshev, J. Knoester



Outline

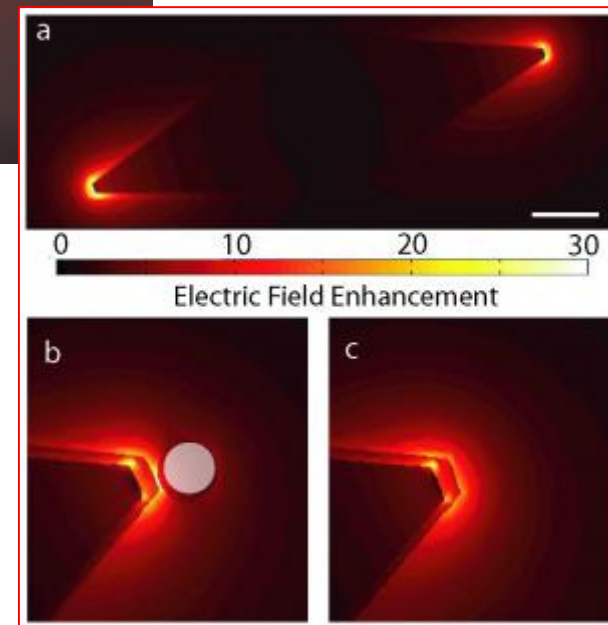
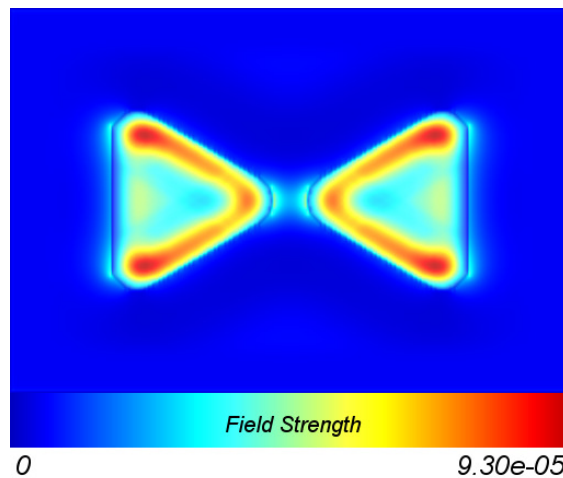
1. Polar Pattern Design
 1. System under consideration
 2. Calculation Methods
 3. Results
2. Hot Spot Control
 1. System under consideration
 2. Results
3. Conclusions
4. Outlook

Motivation

Nano-emitters

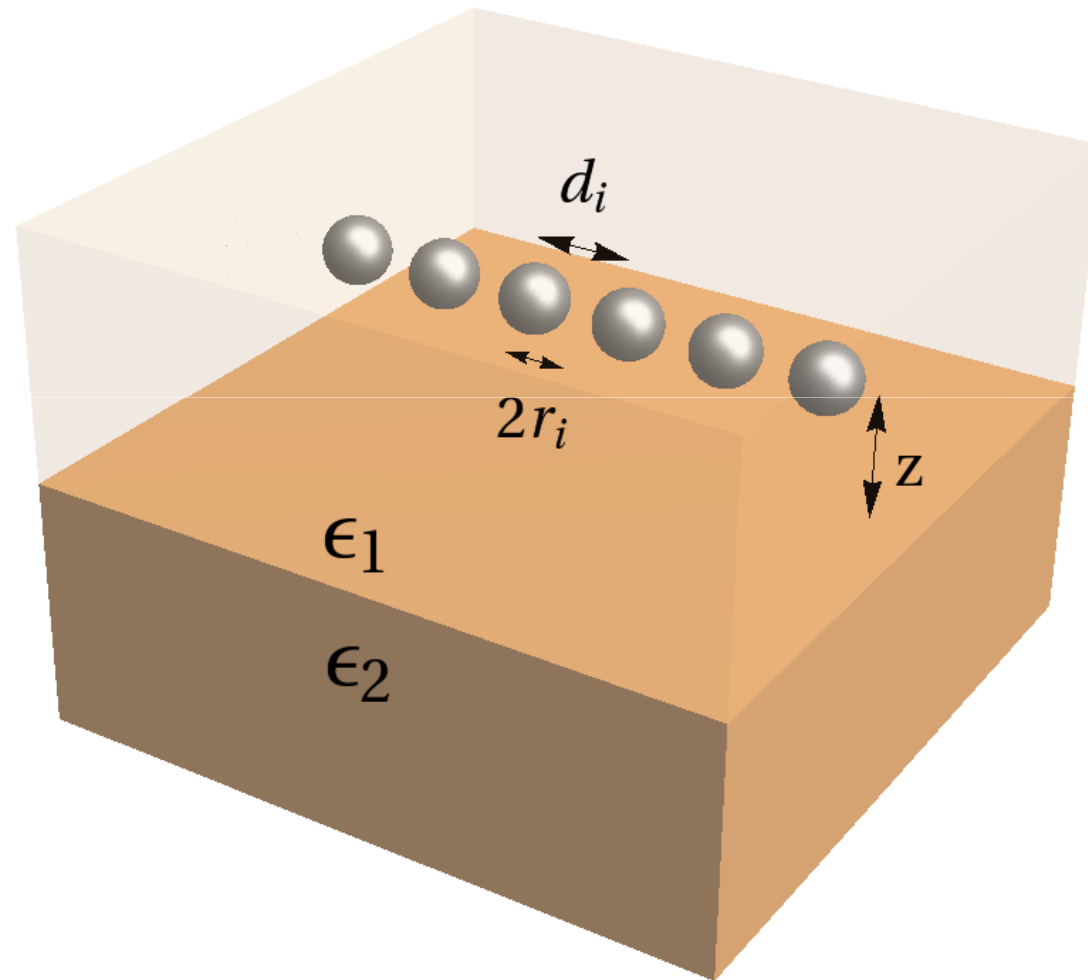


Field enhancement,
hot spots for SERS...



Polar Pattern Design

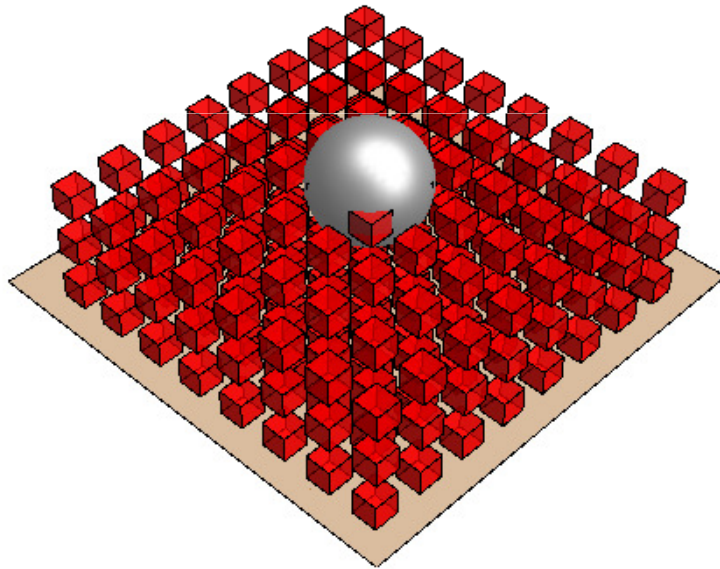
- System under Consideration



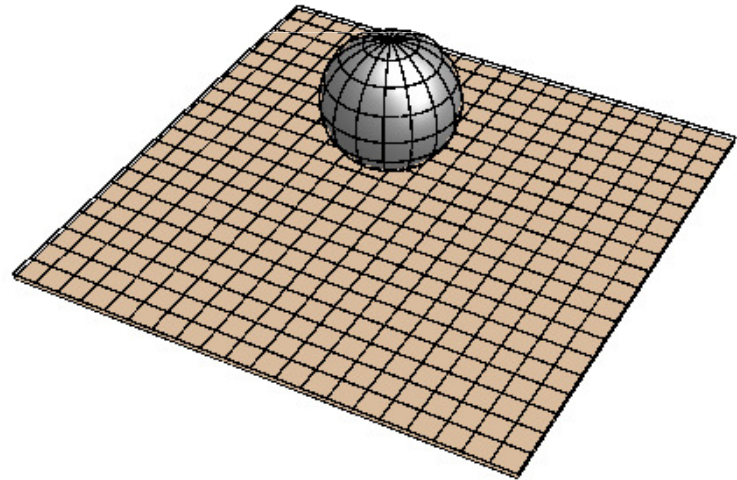
Polar Pattern Design

· Calculation Methods

FDTD



BEM



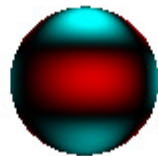
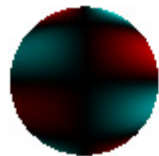
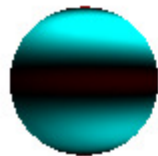
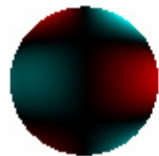
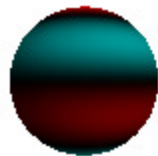
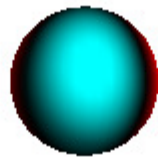
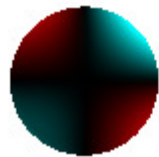
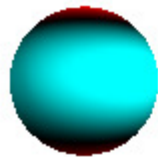
Polar Pattern Design

· Calculation Methods



- Dipole approximation

- r small compared to λ : 20-100 nm
- Interparticle distance $d_i > 3r_i$

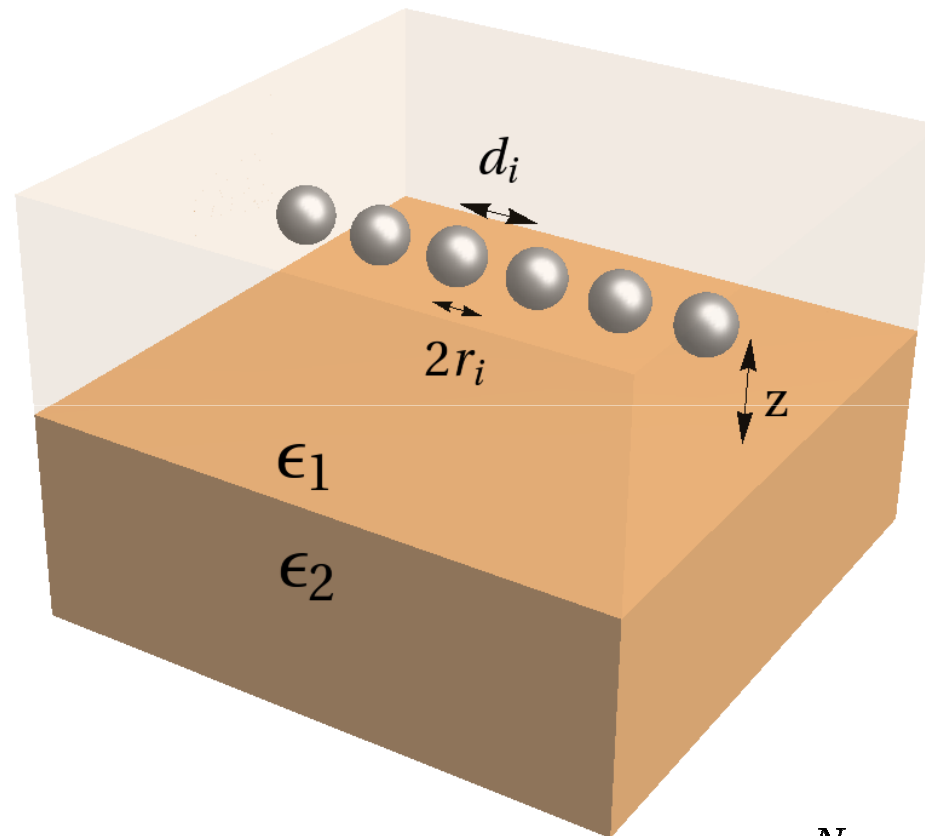


- Consequences:

- Point dipoles
- Volume information, in $\alpha(r)$
- Particle response $\vec{p}_i = \alpha \vec{E}_{\text{total}}(\vec{r}_i)$
- Particle radiation $\vec{E}_i(\vec{r}_j) = \hat{G}(\vec{r}_i, \vec{r}_j)$

Polar Pattern Design

- Point-dipole approximation



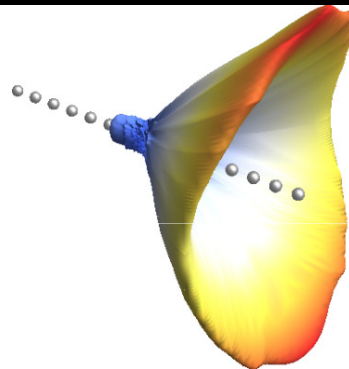
$$\vec{p}_n = \alpha_n \left(\vec{E}_n(r_n) + \sum_{m=n} \hat{G}_{m,n}(\vec{r}_m, \vec{r}_n, \omega) \vec{p}_m + \sum_{n=1}^N \hat{G}_{m,n}^{\text{refl}}(\vec{r}_m, \vec{r}_n, \omega) \vec{p}_m \right)$$

Polar Pattern Design

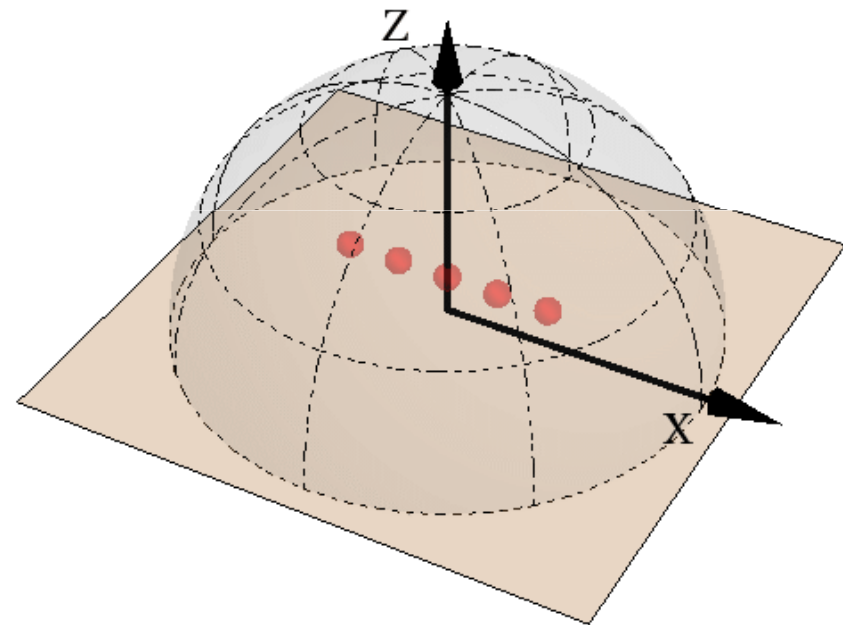
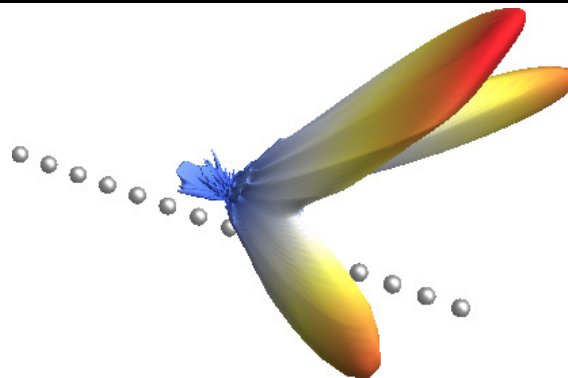
· Results

The interface allows us to design very sharp patterns

System without interface



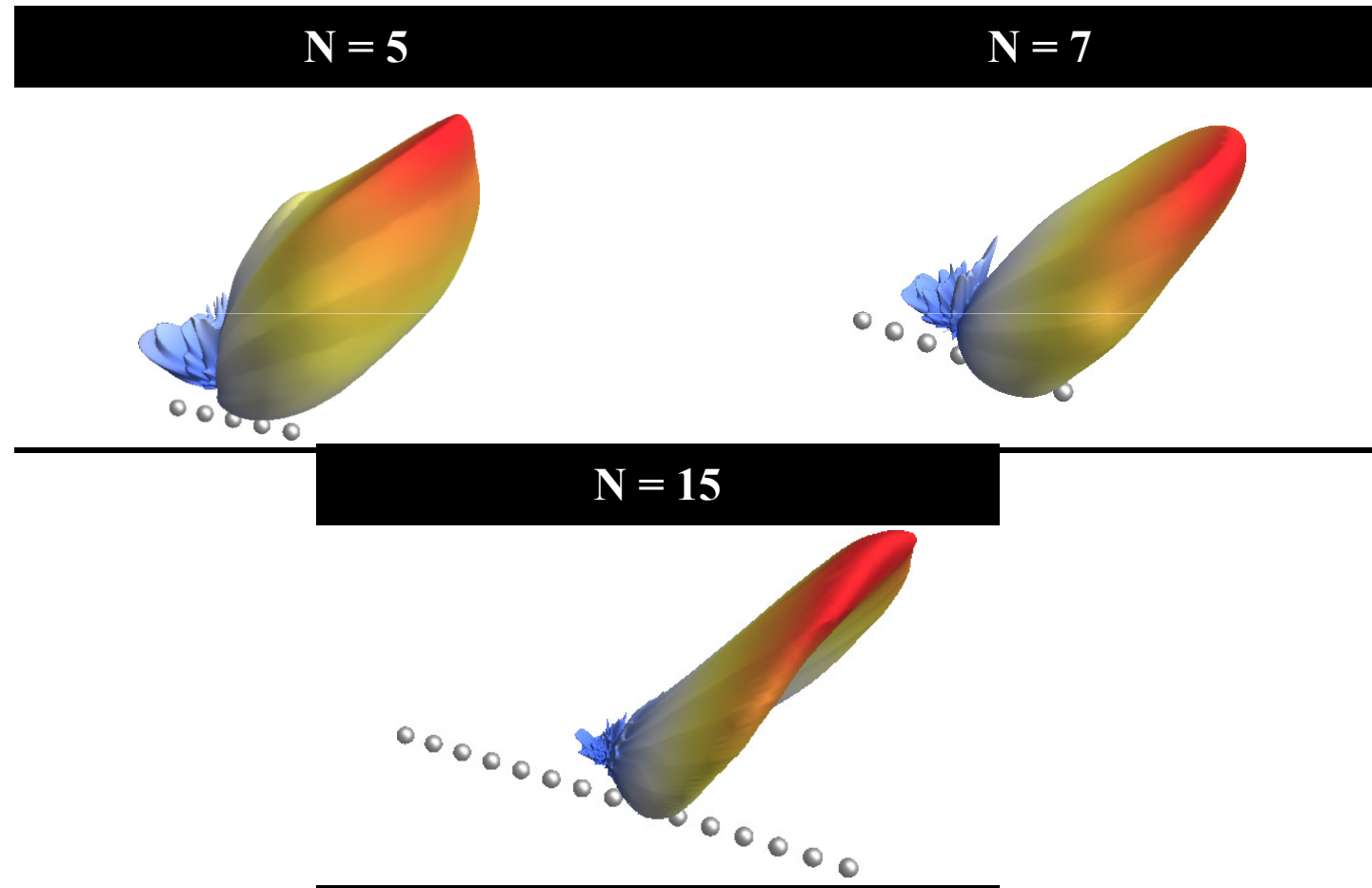
System with interface



Polar Pattern Design

· Results

The thickness of the maximum's ring, inverse to N

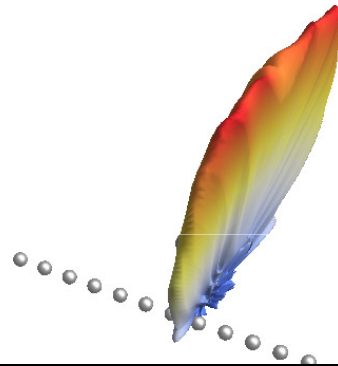


Polar Pattern Design

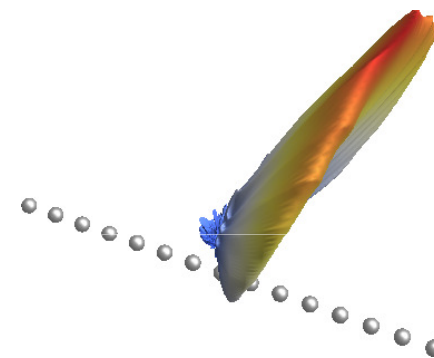
· Results

Θ , Φ for the incoming field alter its position

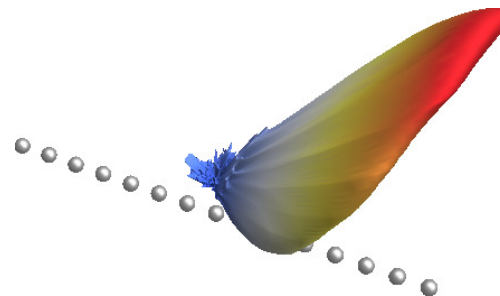
$\Theta=30^\circ$



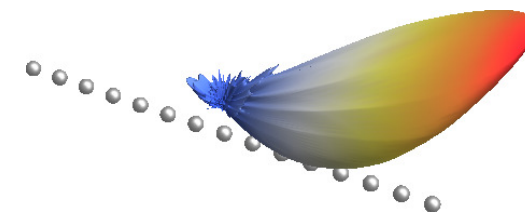
$\Theta=45^\circ$



$\Theta=60^\circ$



$\Theta=75^\circ$

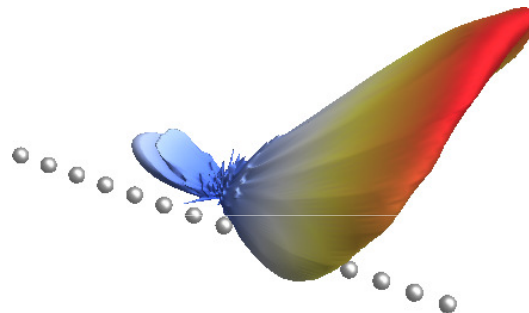


Polar Pattern Design

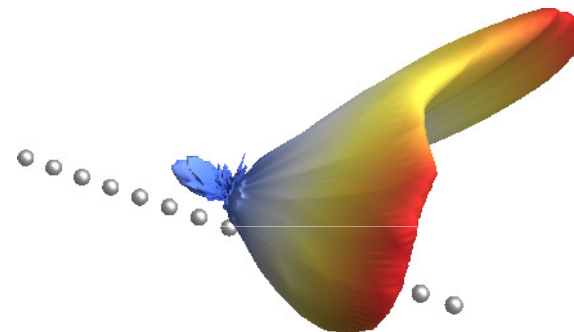
· Results

The height z creates patterns in the ring

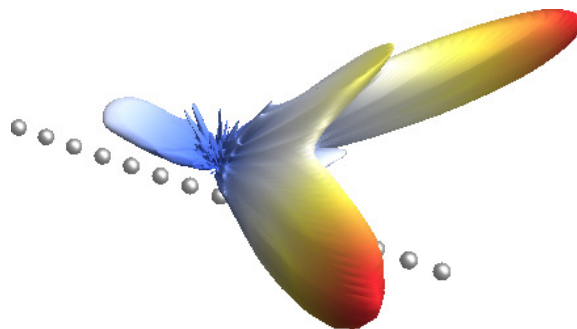
$z=140$ nm



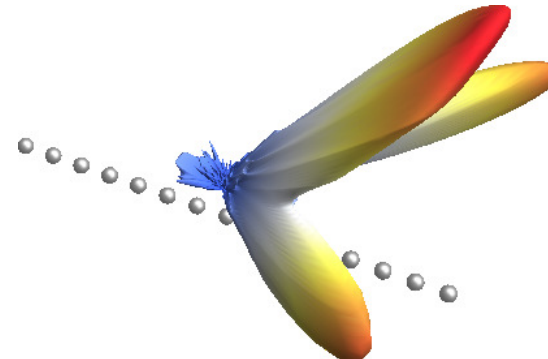
$z=220$ nm



$z=300$ nm



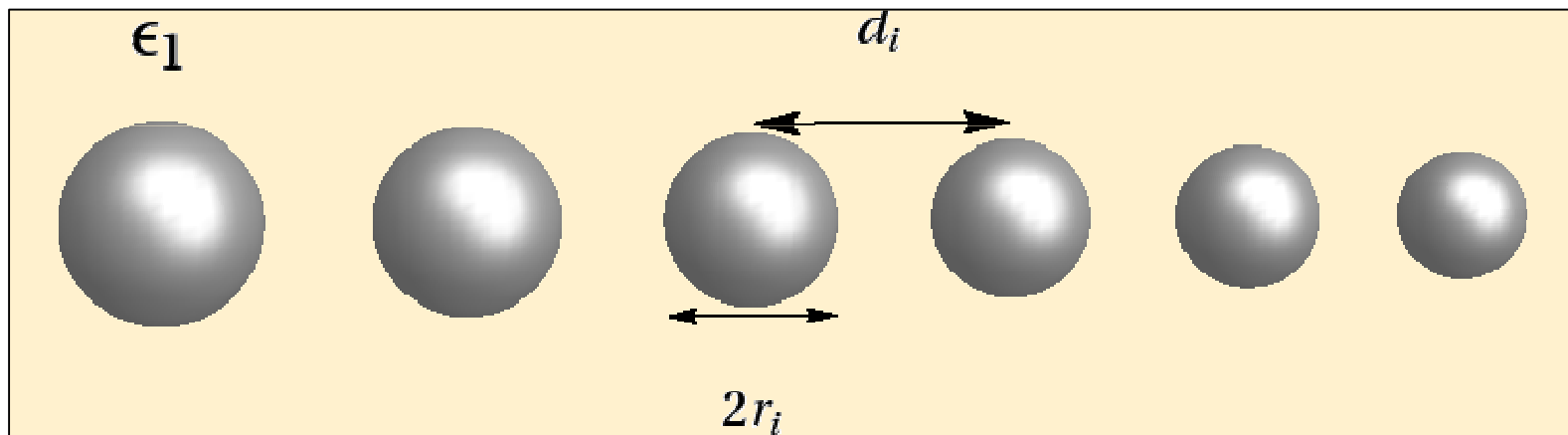
$z=380$ nm



Hot Spot Control

· System under Consideration

- Particle radii decay linearly along the chain
- Interparticle distances are proportional to their size

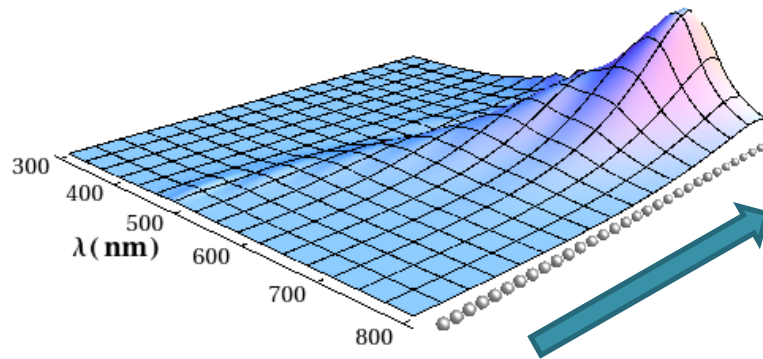


Hot Spot Control

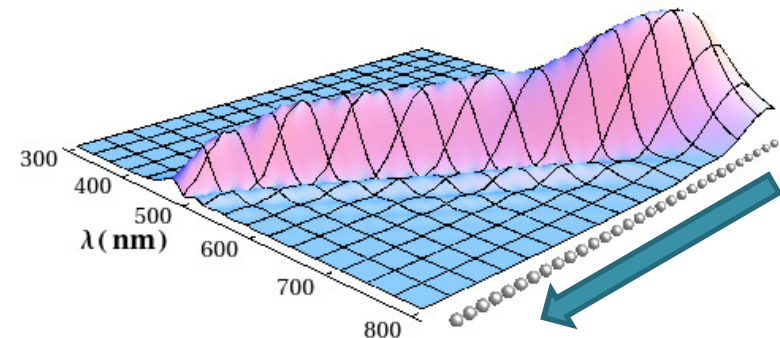
• Hot Spot Localizations

- Old results with two important features:
 1. Broadband response, specially for $\theta = 180^\circ$
 2. Strong localization of the response

Momento del sistema para $\theta = 0^\circ$

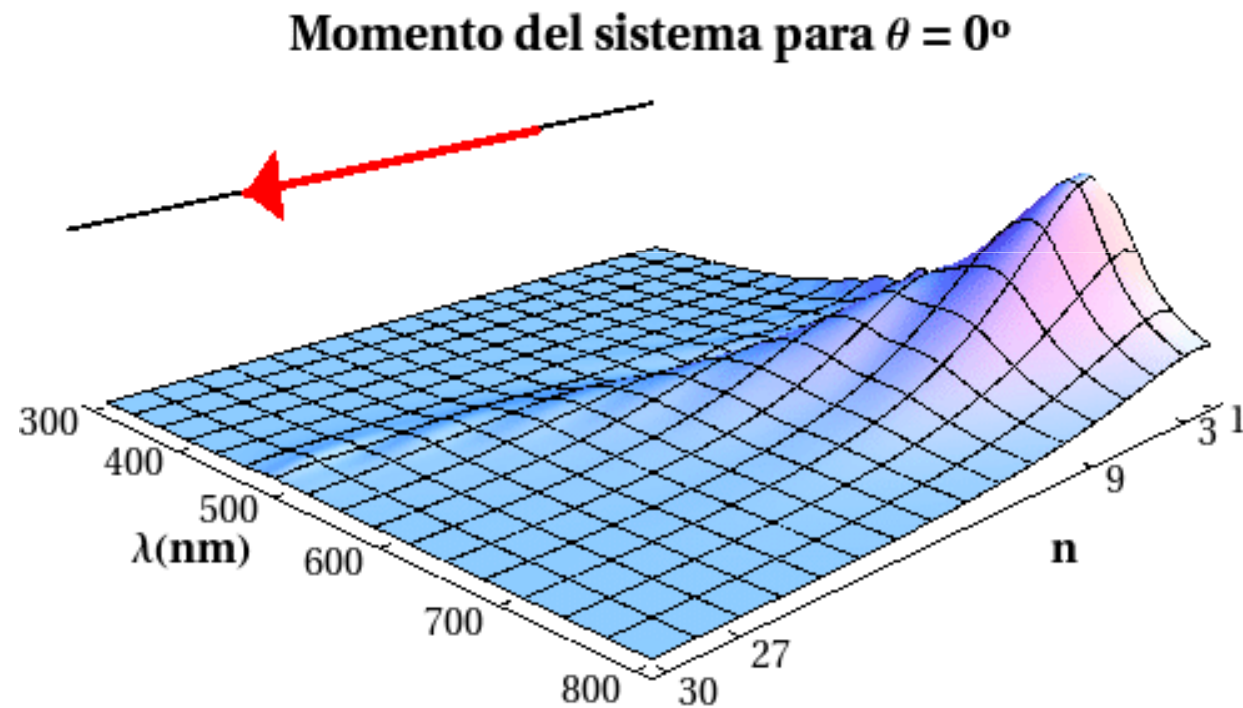


Momento del sistema para $\theta = 180^\circ$



Hot Spot Control

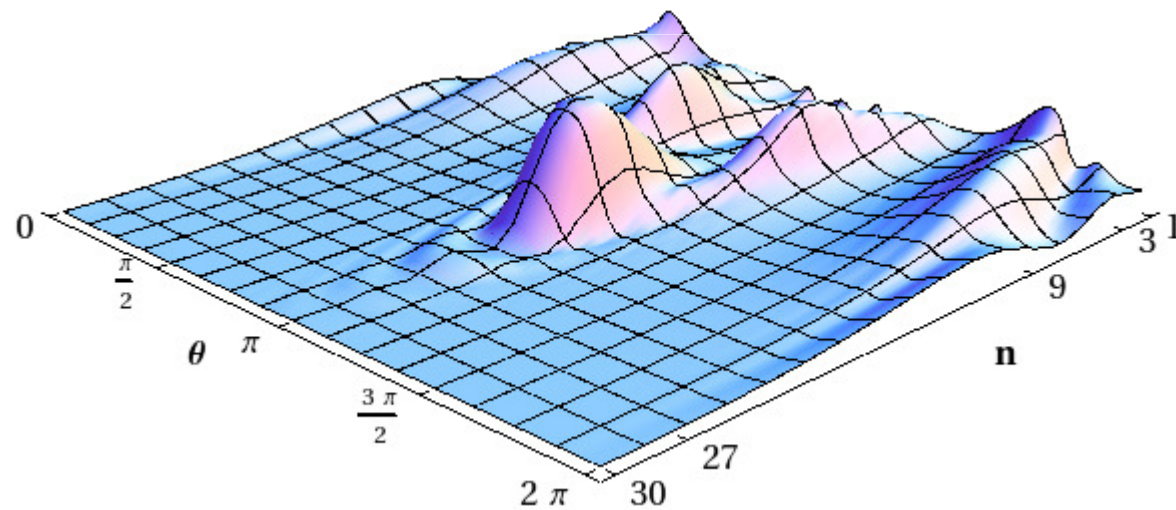
- Hot Spot Localizations
- θ is a continuous parameter



Hot Spot Control

- Hot Spot Localizations
- The localization change for a given λ is clear

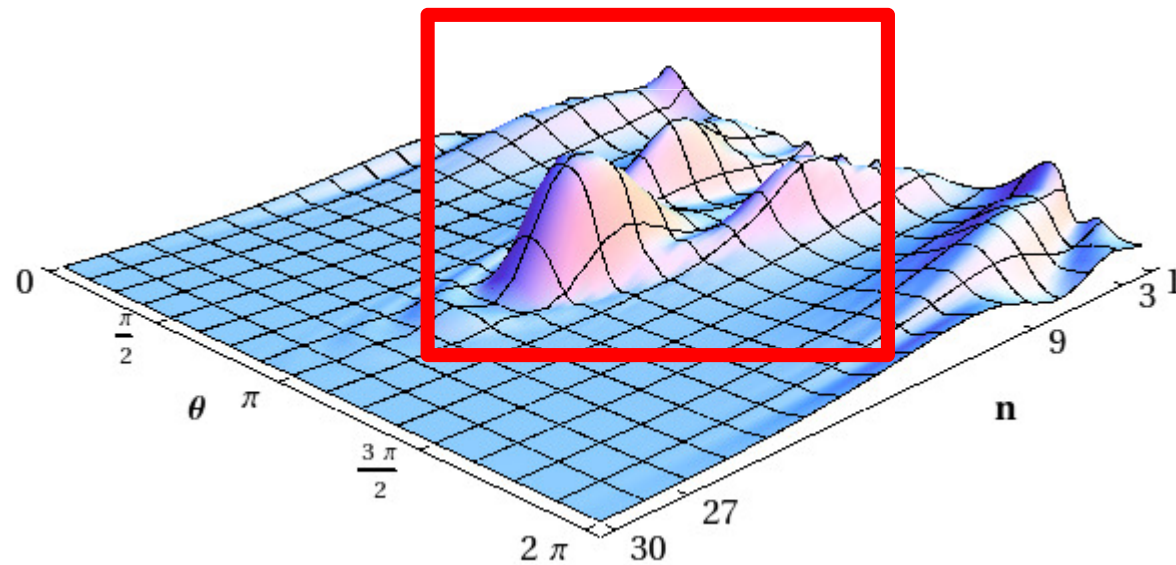
Momento del sistema para $\lambda = 585 \text{ nm}$

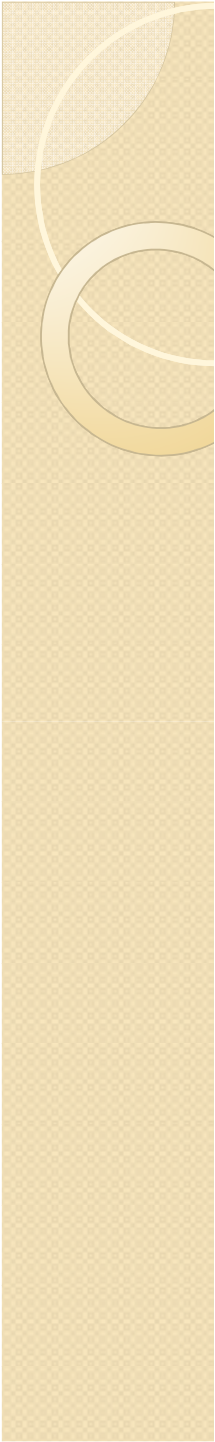


Hot Spot Control

- Hot Spot Localizations
- The localization change for a given λ is clear

Momento del sistema para $\lambda = 585$ nm





Conclusions

Polar patterns:

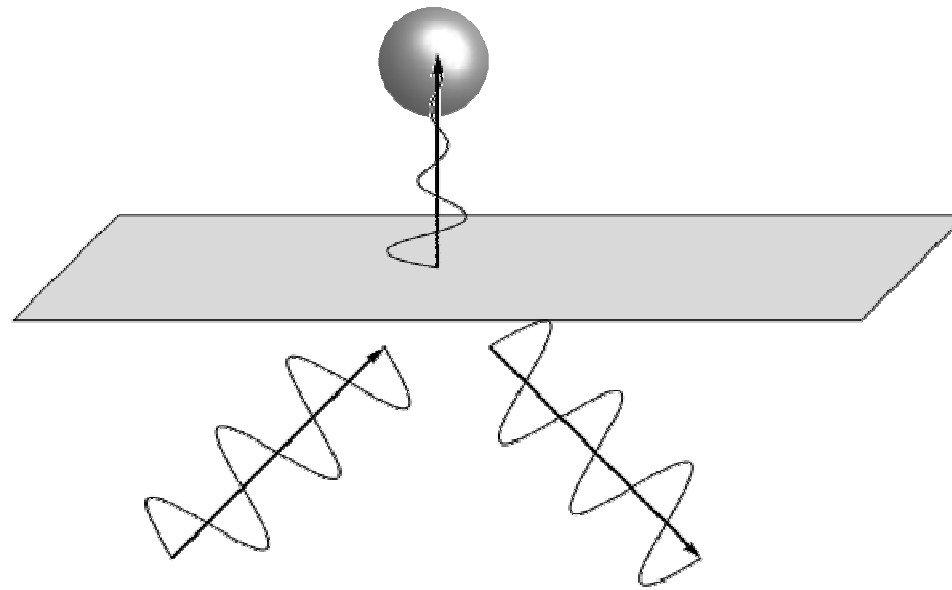
1. Placing a homogeneous-sized antenna close to an interface allows to design polar patterns.
2. Response can be controlled by means of external parameters (orientation of the incoming light)

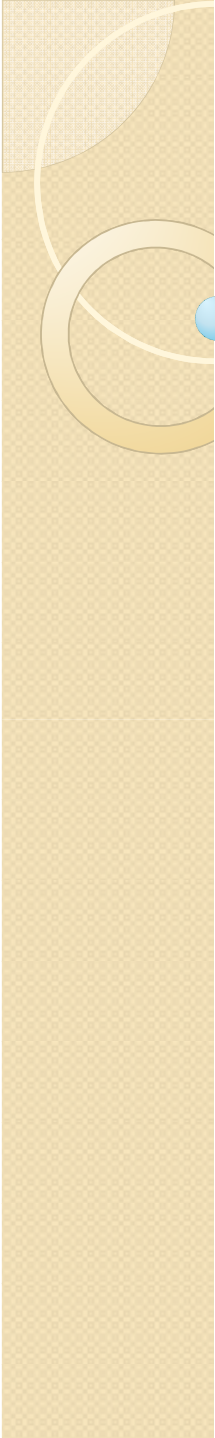
Hot Spot Control

1. Hot Spot position can be tuned using the direction of the incoming field, which is more feasible than by changing the wavelength.

Outlook

- Consider different particle shapes: ellipsoids, etc.
- Add dynamically controlled parameters
- Use more sophisticated methods (BEM)
- Use indirect illumination schemes





Thank you for your attention!