

Modeling the magneto-optical response in nanodisks

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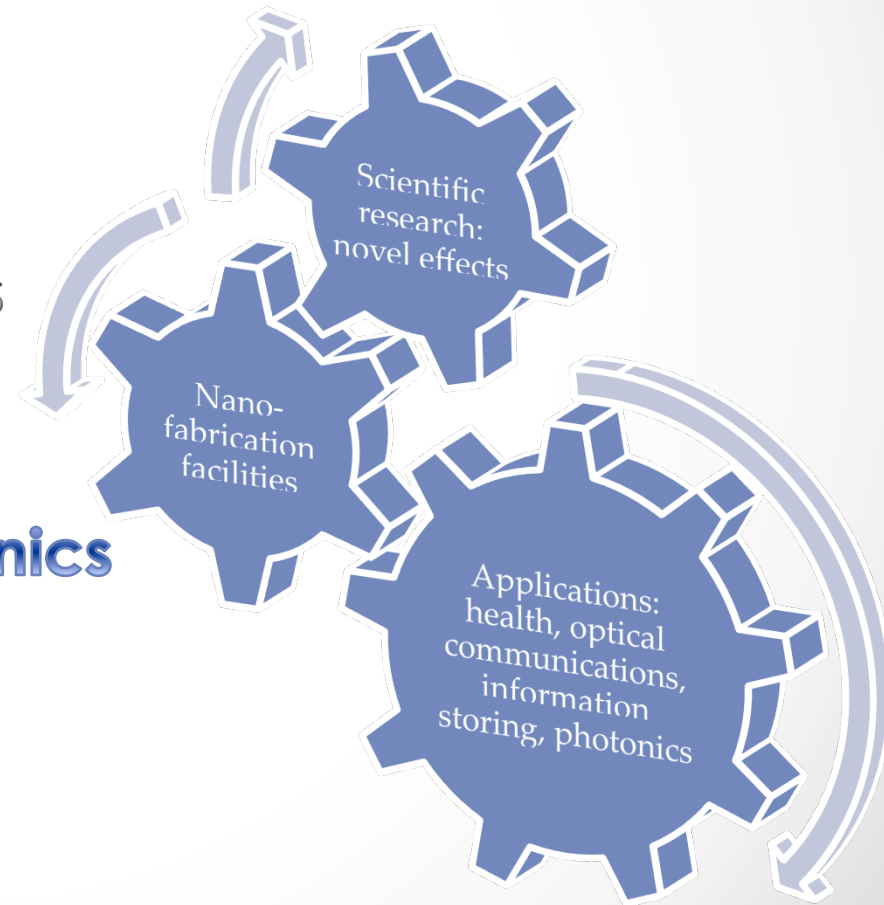
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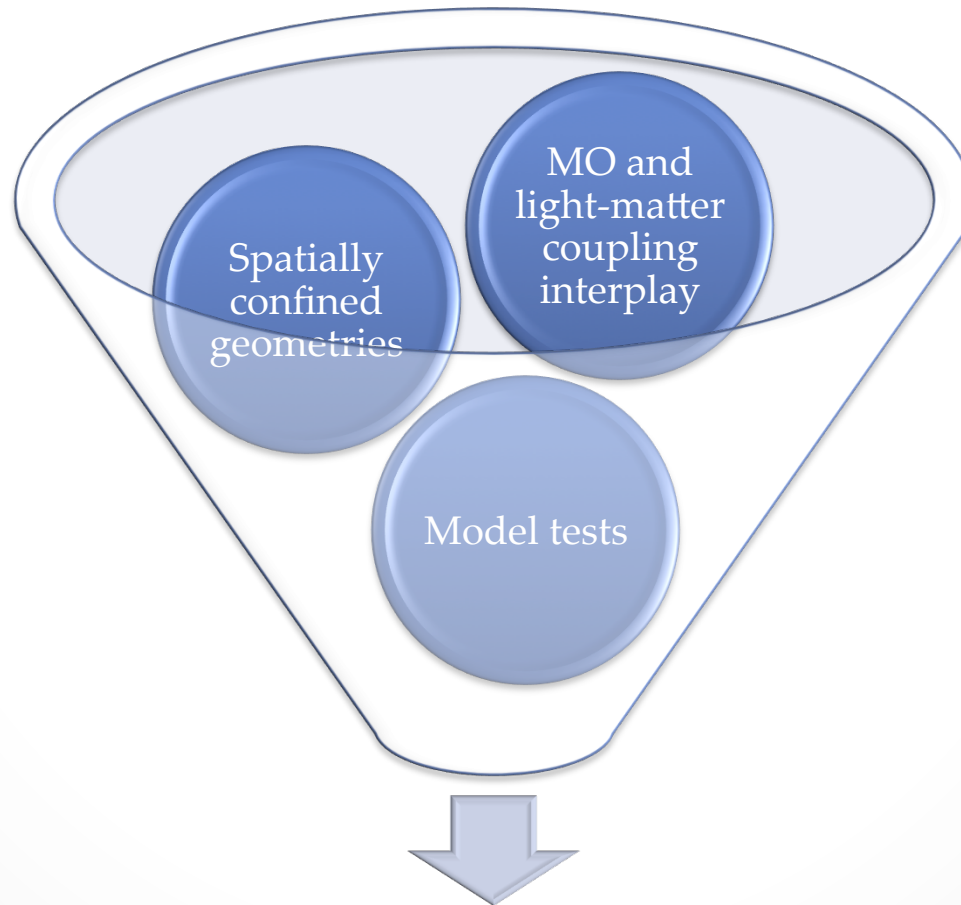
- Introduction / Motivation
- Background
- Results and discussion
- Conclusions

Introduction

- Electromagnetic scattering from nanometer-scale particles -> **HOT TOPIC**
- Recent studies: **plasmonic resonances**
- Magneto-plasmonics
interplay between **plasmonics**
and **magneto-optics**



Motivation



EM response of nano-objects

System description

- Co disk
- **T-MOKE** configuration

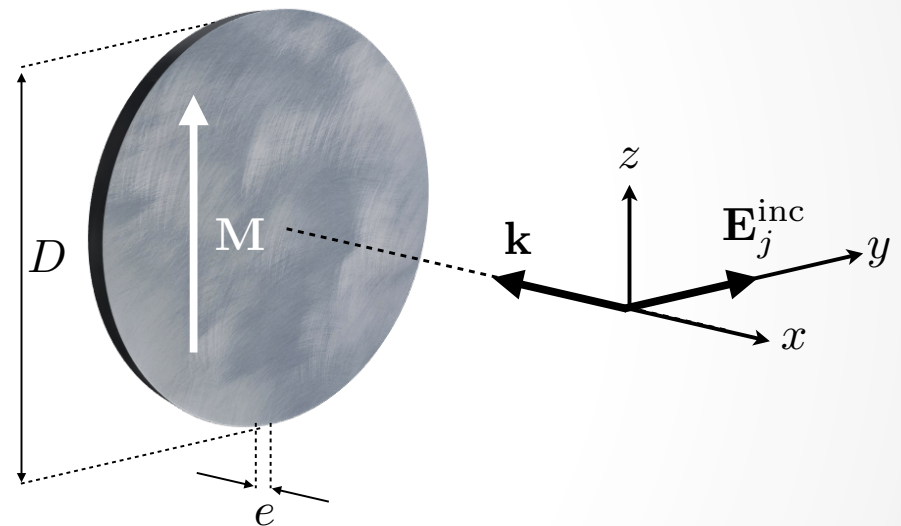
- $\lambda = 632.8 \text{ nm}$
- $D = \{200, 1000\} \text{ nm}$
- $e = 5 \text{ nm}$

- Changes in $\mathbf{M}$:

$$\Delta I = |I(M) - I(-M)|$$

- Dielectric tensor:

$$\bar{\bar{\epsilon}}_r = \begin{pmatrix} \epsilon_d & \pm\epsilon_{\text{off}} & 0 \\ \mp\epsilon_{\text{off}} & \epsilon_d & 0 \\ 0 & 0 & \epsilon_d \end{pmatrix}$$



optical response

MO response

Two models

- **FINITE PARTICLE (FP) APPROACH**

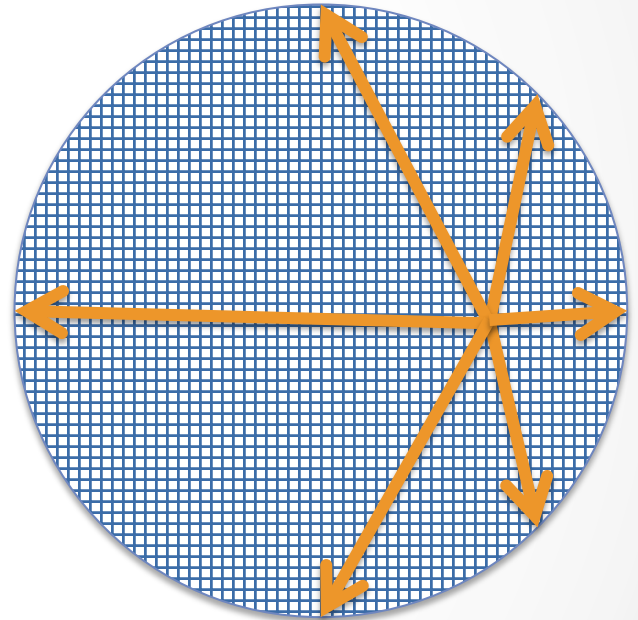
• FINITE PARTICLE (FP) APPROACH

- **INFINITE LAYER (IL) APPROACH**

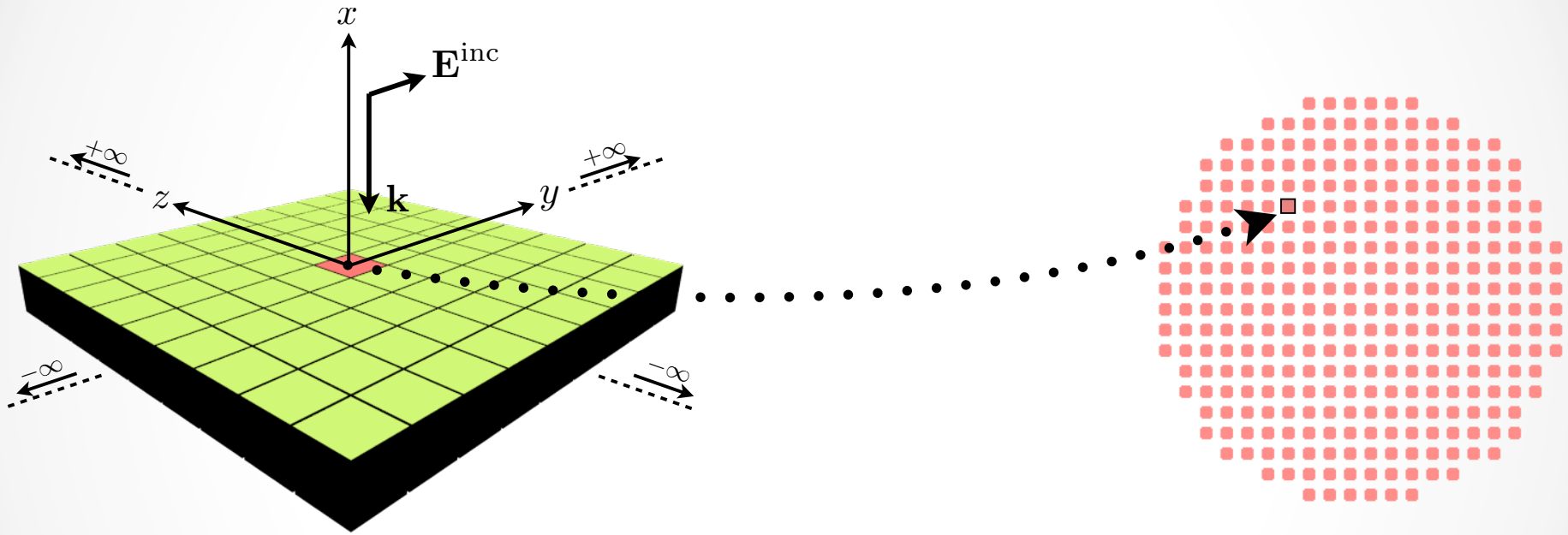
• INFINITE LAYER (IL) APPROACH

Finite particle (FP) approach

- It relies on the recently developed **E-DDA**
- Direct-space discretization scheme
- Self-consistency taking account of **interactions in the real shape**



Infinite layer (IL) approach



- Two steps:

- Perform a real infinite layer calculation
- Use the infinite layer results to estimate how a nanodisk behaves if all its elements had an IL response to the externally applied field.

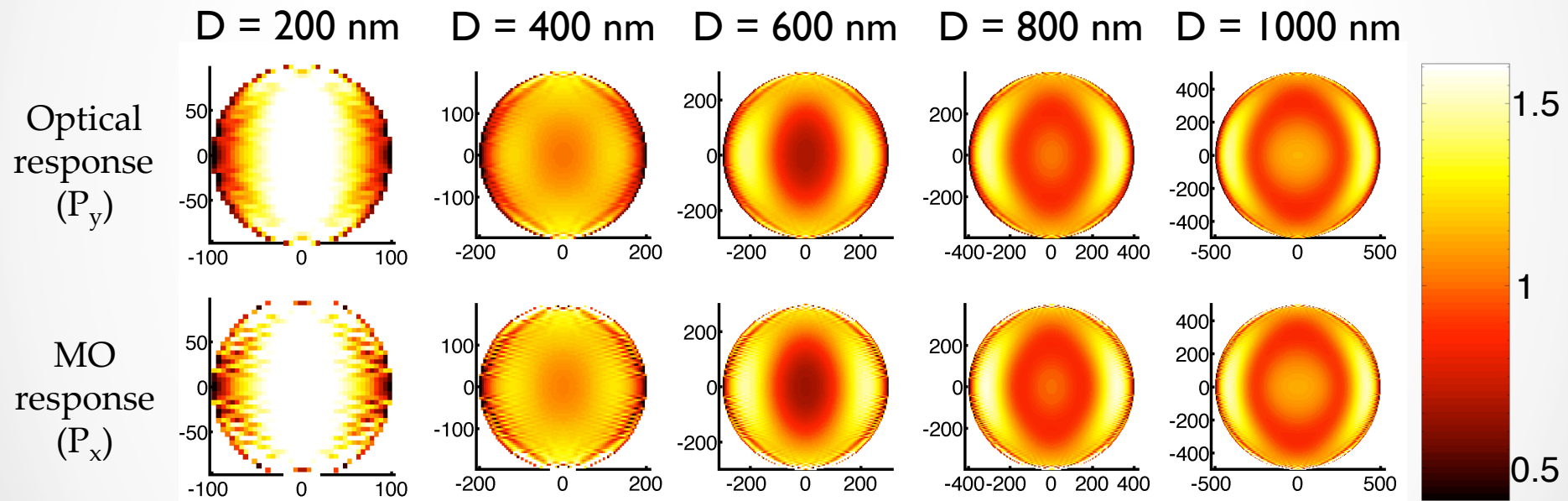
Results

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Dipole moment distributions (module of components)

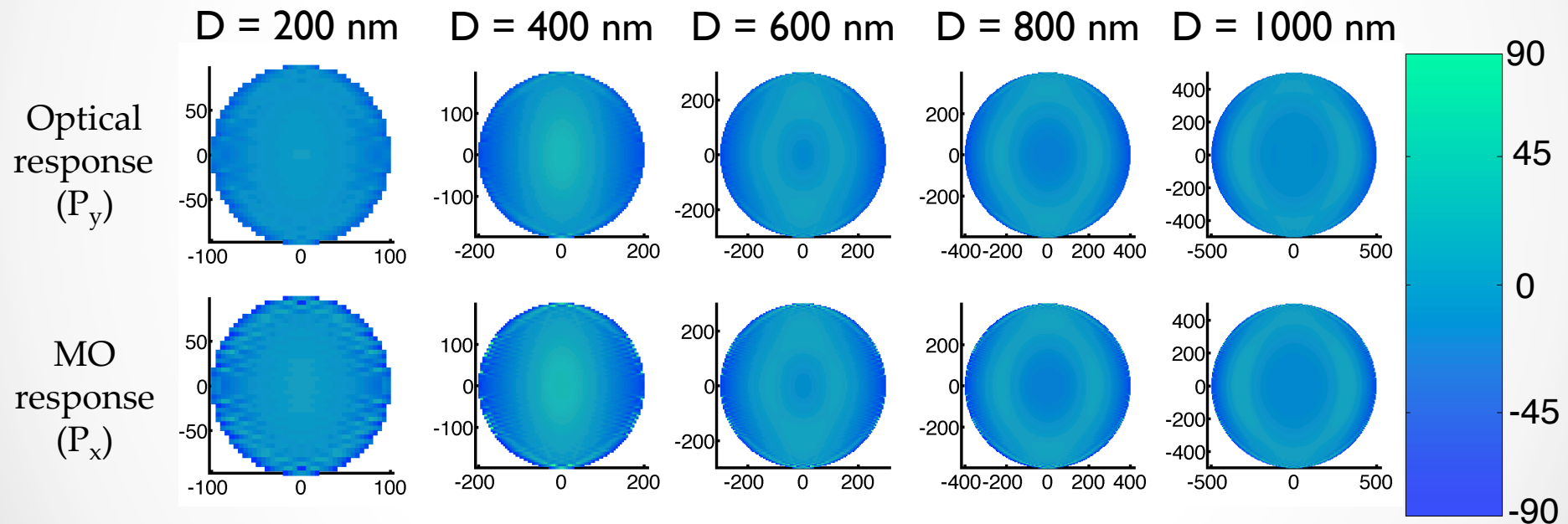
(FP maps normalized by the IL)



- Important **confinement modifications** for all sizes
- **MO** response **follows** the **optical** response

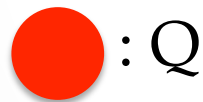
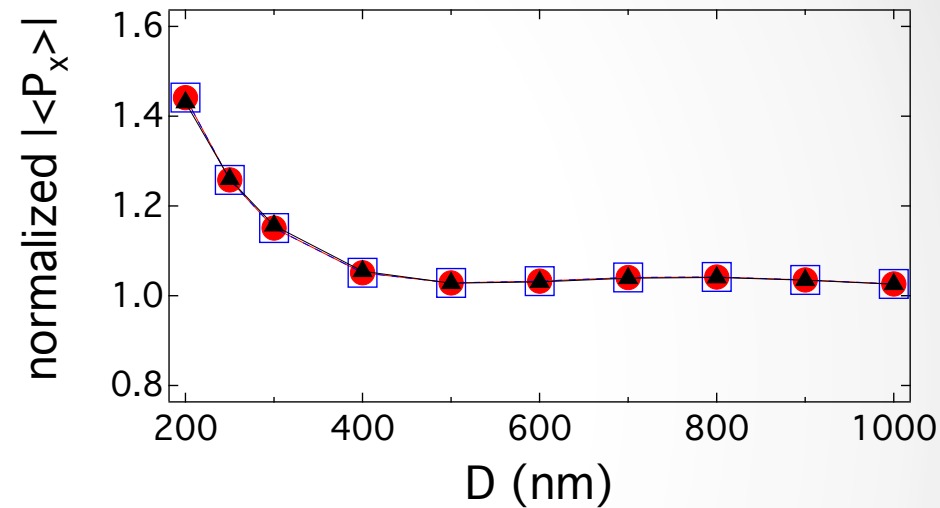
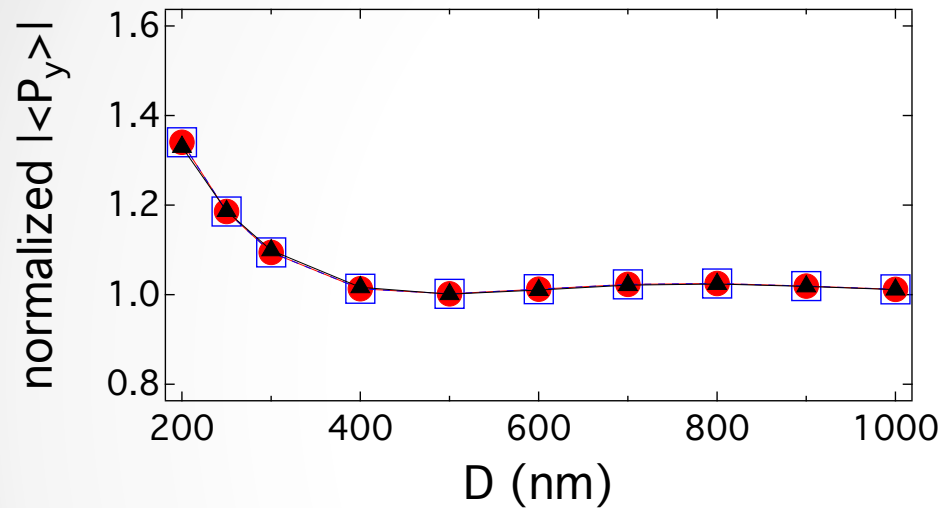
Dipole moment distributions (phase of components)

(FP maps relative to the IL)



- Homogeneous phase distribution for all sizes
- MO response follows the optical response

Average dipole vs D (module of components)



: Q



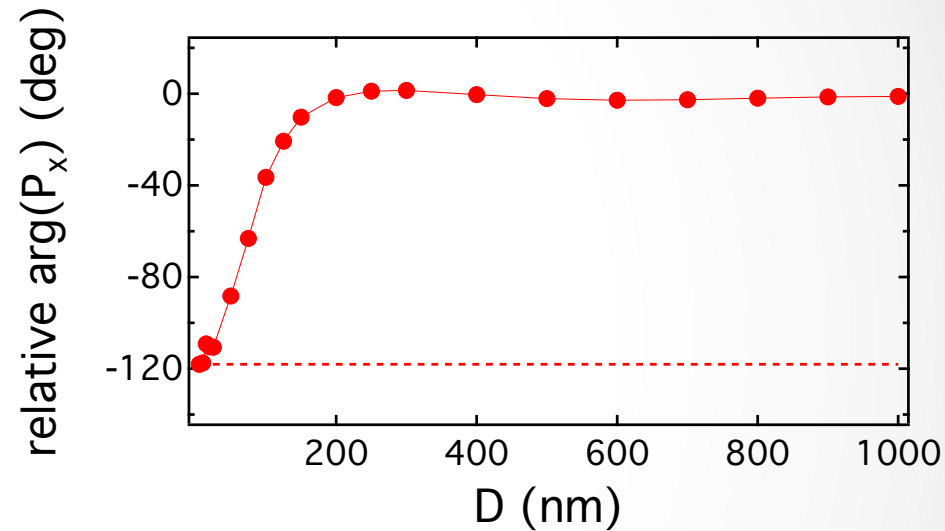
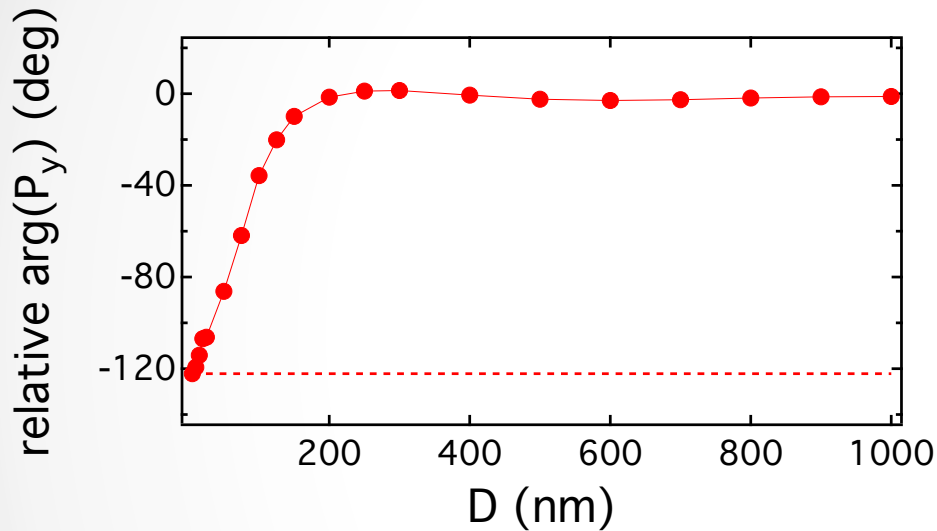
: Q/10



: Q*10

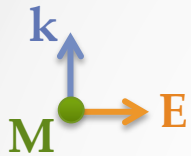
- FP tends to IL with increasing D
- MO response resembles the optical one
(small perturbation regime)

Average dipole vs D (phase of components)



- FP tends to IL with increasing D
- FP tends to single dipole phase when decreasing D
- MO response resembles the optical one (small perturbation regime)

Far-field scattering patterns



disk

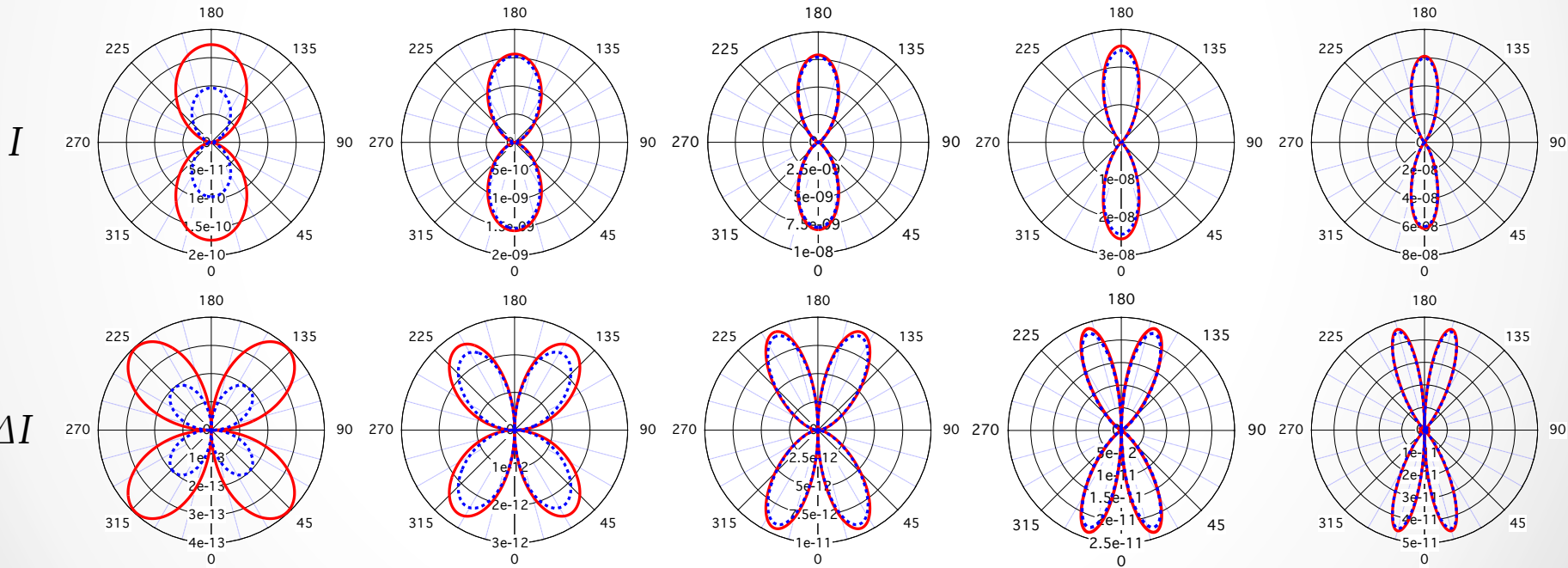
$D=200$ nm

$D=400$ nm

$D=600$ nm

$D=800$ nm

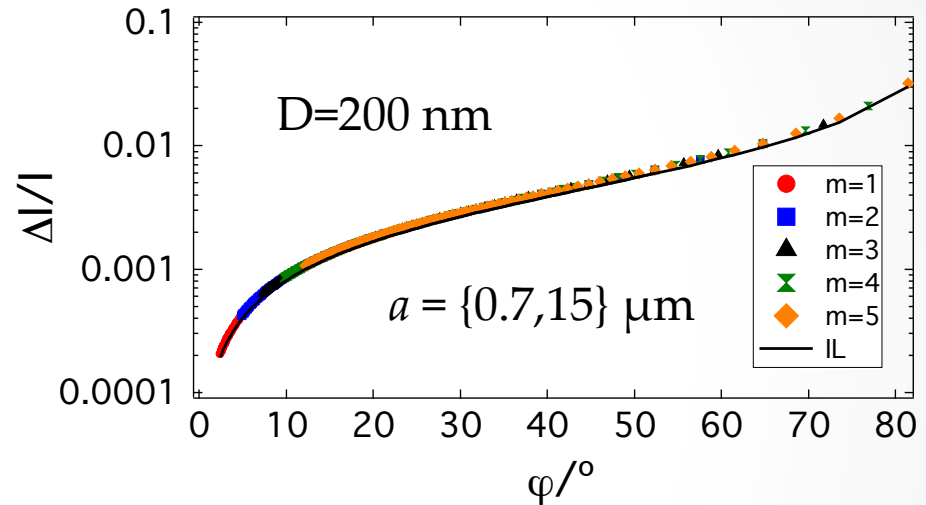
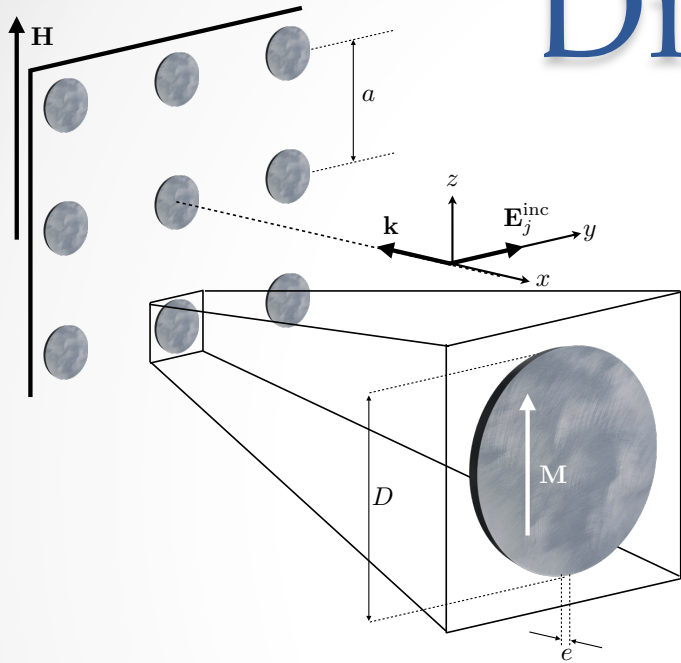
$D=1000$ nm



- FP converges to IL as D increases
- I and ΔI scale in an almost identical fashion

— FP
- - - IL

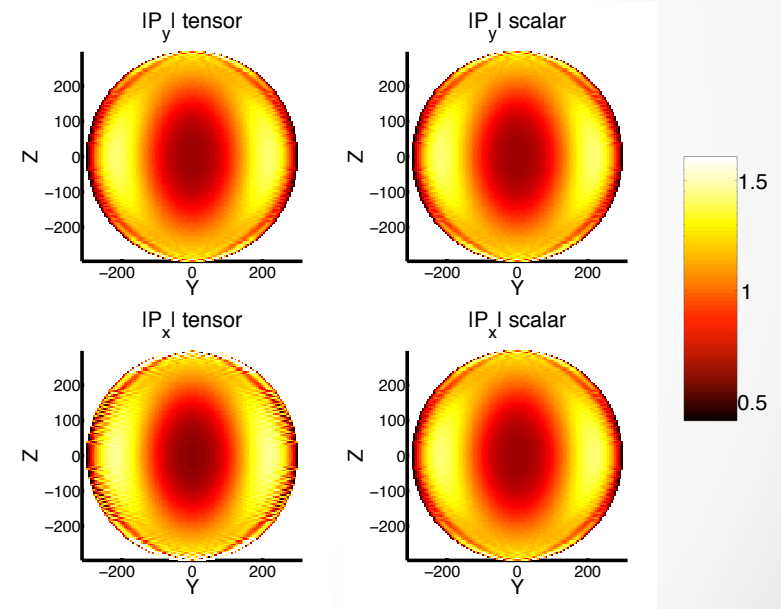
Disk lattice



- Almost **perfect match** between FP and IL
- Geometric confinement **does not affect** $\Delta I/I$
- Results for all **other sizes** look nearly **identical**

Conclusions

- The experimentally accessible T-MOKE $\Delta I/I$ -ratio seems virtually unaffected by the geometric confinement of the disks.
- Local T-MOKE response is perturbative



interaction factor

$$P_{x_{\text{scalar}}} = \frac{\alpha_{xx_{\text{eff}}}}{\alpha_d} \frac{\alpha_{\text{off}}}{\alpha_d} P_{y_{\text{scalar}}}$$

single dipole factor

Thank you for your attention

Acknowledgments

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