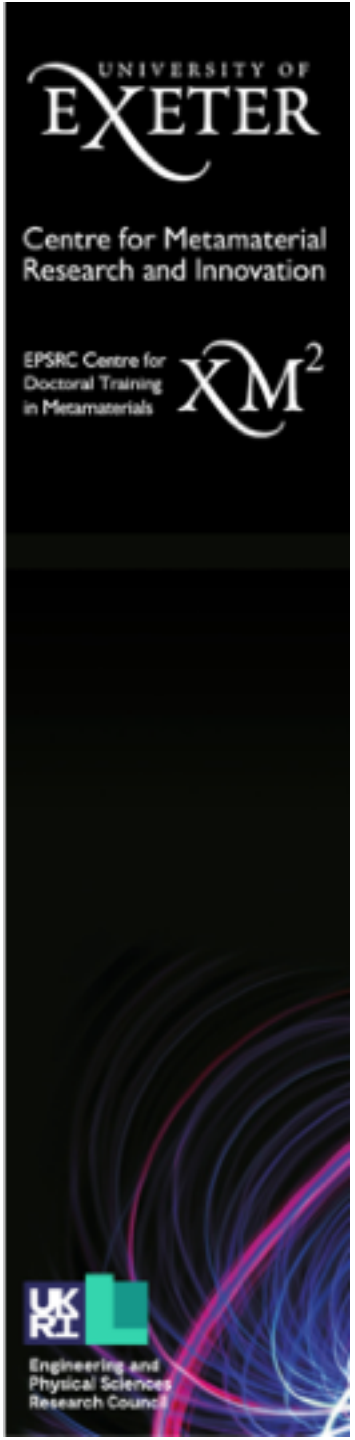
UNIVERSITY OF EXETER

Centre for Metamaterial Research and Innovation

EPSRC Centre for Doctoral Training in Metamaterials

XM²



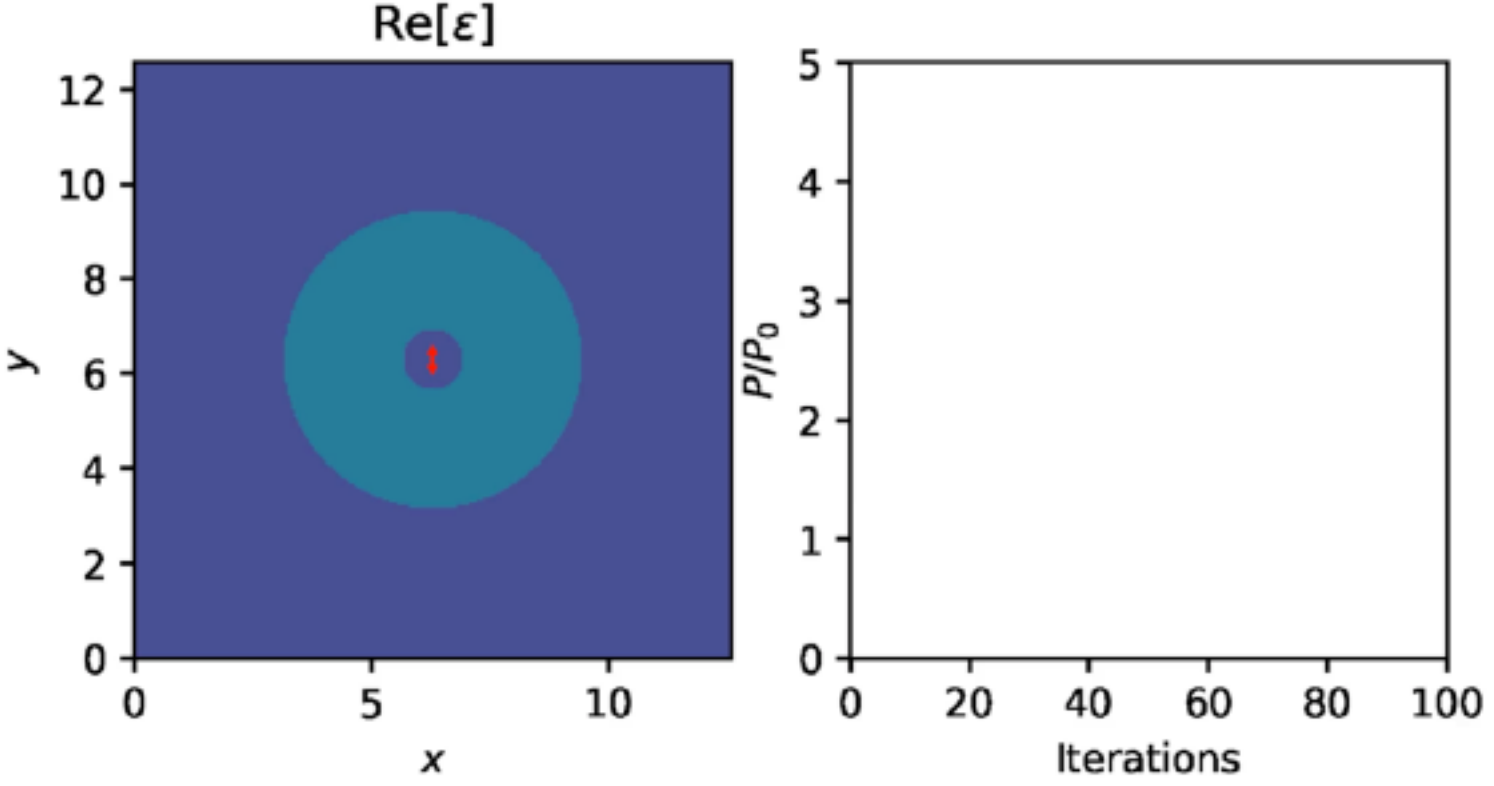
UKRI Engineering and Physical Sciences Research Council

www.metamaterials.center

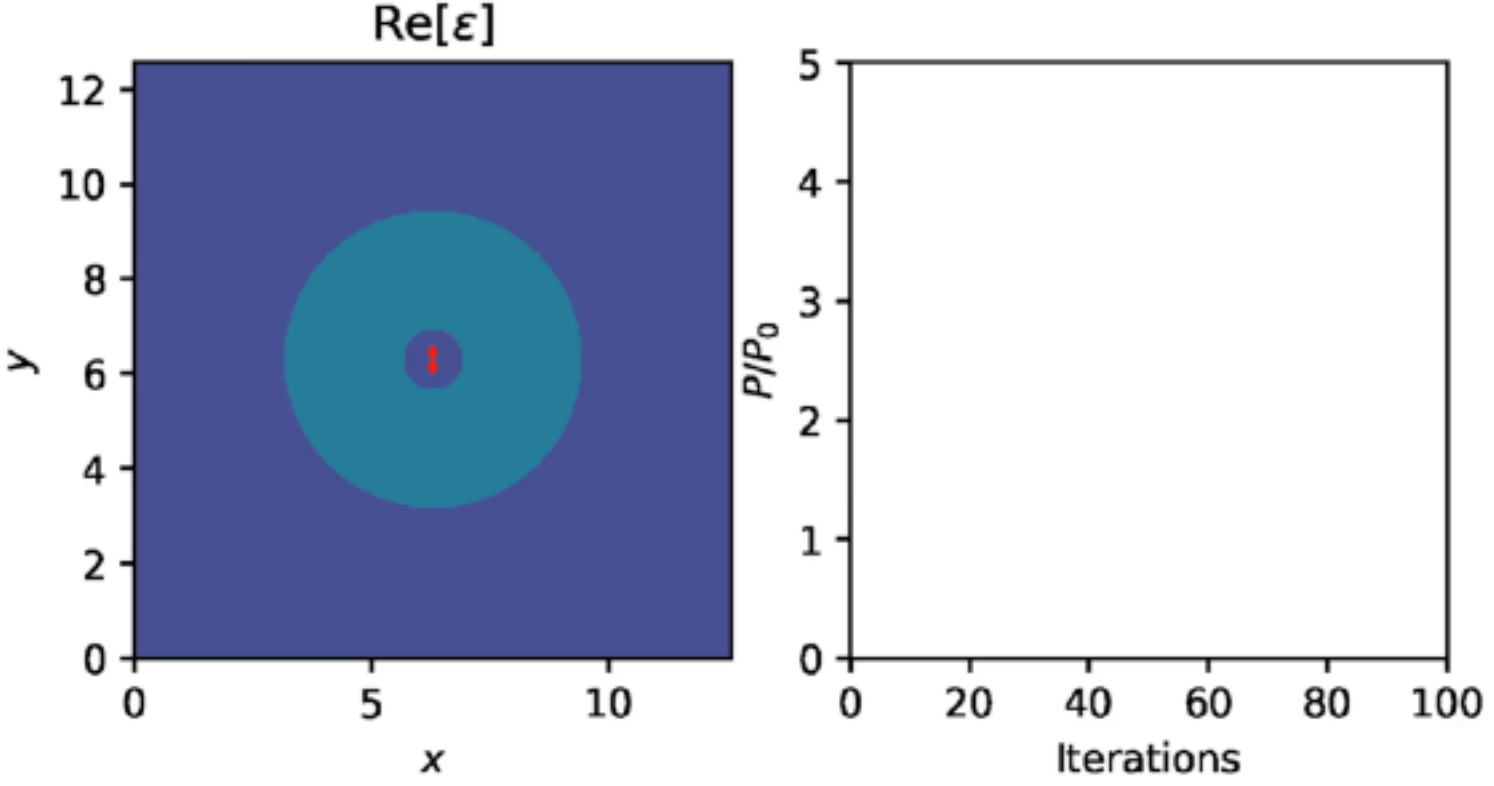
The Adjoint Method

6

- Sandro Mignuzzi, Stefano Vezzoli, Simon A. R. Horsley, William L. Barnes, Stefan A. Maier, and Riccardo Sapienza “Nanoscale Design of the Local Density of Optical States”, Nano Lett. 19, 3, 1613–1617 (2019)
- Owen Miller, “Photonic Design: From Fundamental Solar Cell Physics to Computational Inverse Design”, PhD thesis (2012)


Re[ε]
y
x
P/P0
Iterations
0
2
4
6
8
10
12
0
5
10
1
3
20
40
60
80
100

$$\delta P = \frac{1}{2}\mathrm{Im}\left[\boldsymbol{E}_*(\boldsymbol{r}) \cdot \boldsymbol{E}(\boldsymbol{r})\right] \delta\varepsilon$$


Re[ε]
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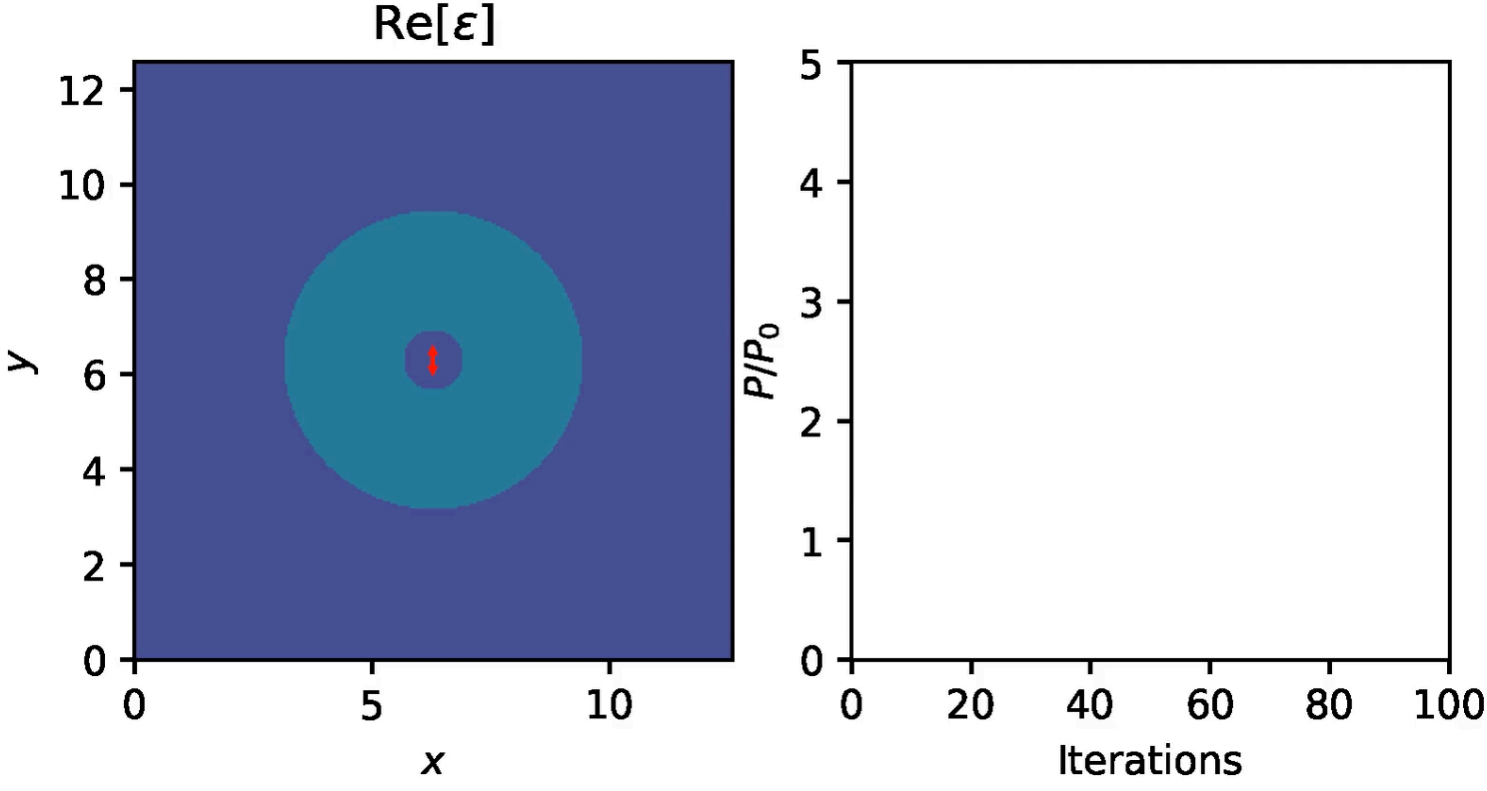
Re[ε]
y
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10
P/P0
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2
3
4
5
0
20
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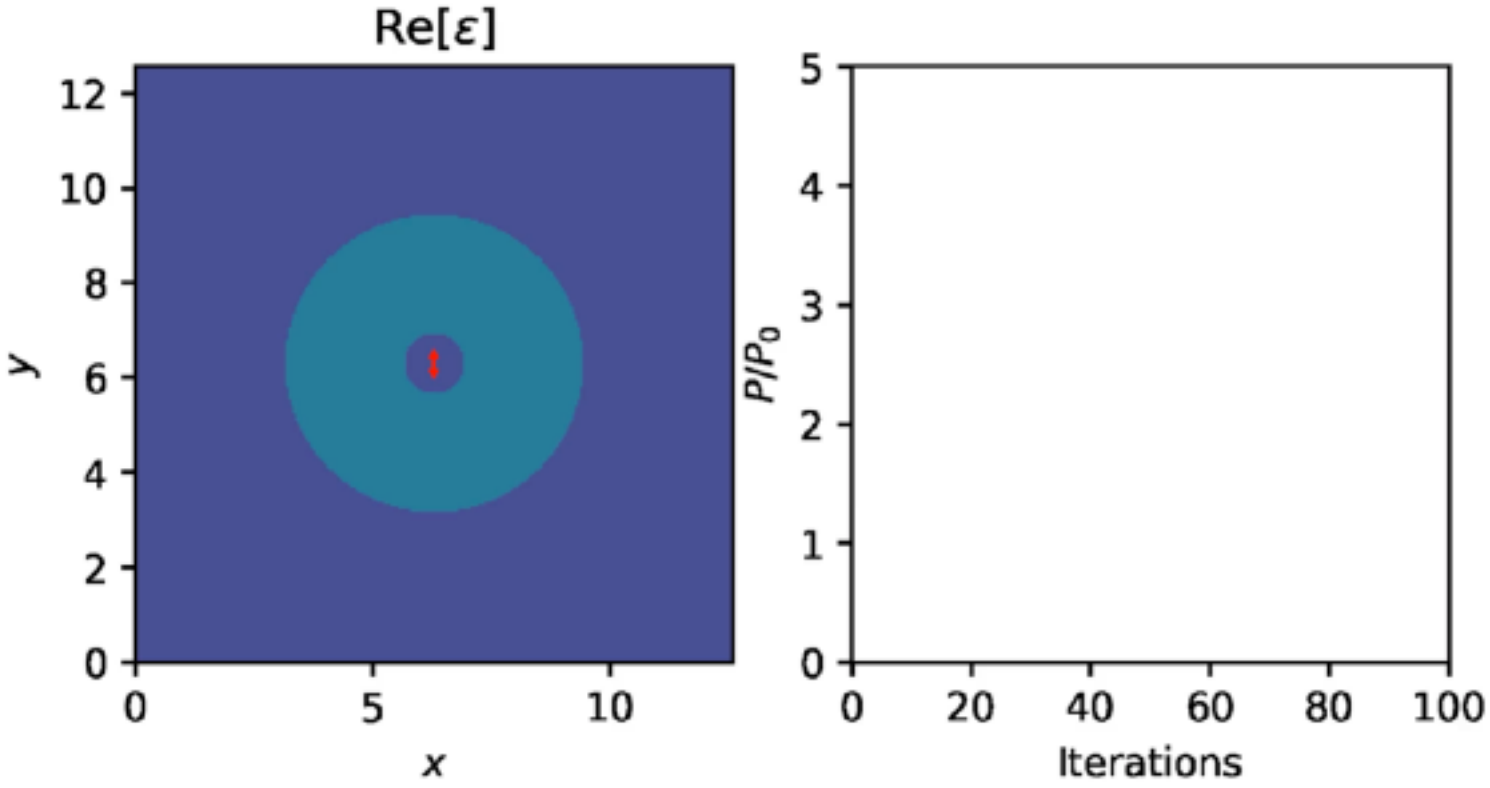
60
80
100
Iterations

The Adjoint Method

$$\delta P = \frac{1}{2}\mathrm{Im}\left[\boldsymbol{E}_*(\boldsymbol{r}) \cdot \boldsymbol{E}(\boldsymbol{r})\right] \delta\varepsilon$$



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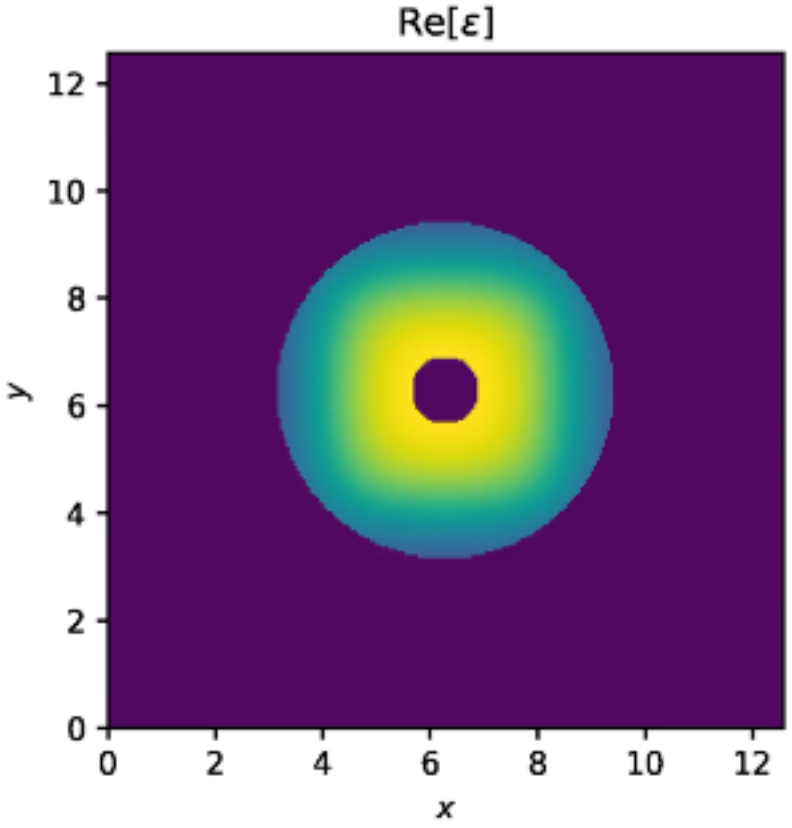
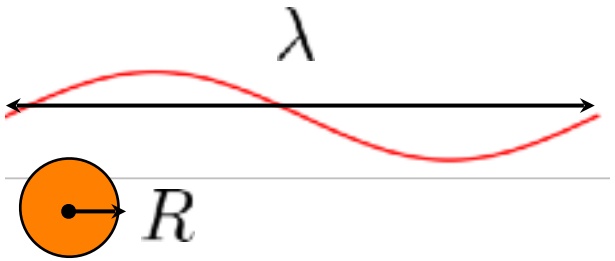
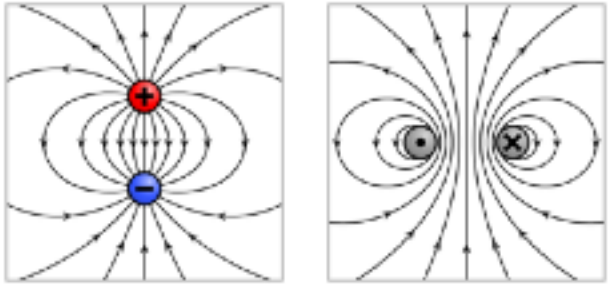
Continuous → Discrete





$$kR \leq 1$$



$$\begin{pmatrix} \boldsymbol{p} \\ \boldsymbol{m} \end{pmatrix} = \begin{pmatrix} \boldsymbol{\alpha}_E & 0 \\ 0 & \boldsymbol{\alpha}_H \end{pmatrix} \begin{pmatrix} \boldsymbol{E} \\ \boldsymbol{H} \end{pmatrix}$$

$$\begin{pmatrix} \boldsymbol{E}(\boldsymbol{r}) \\ \boldsymbol{H}(\boldsymbol{r}) \end{pmatrix} = \begin{pmatrix} \boldsymbol{E}_s(\boldsymbol{r}) \\ \boldsymbol{H}_s(\boldsymbol{r}) \end{pmatrix} + \sum_n \begin{pmatrix} \xi^2 \boldsymbol{G}(\boldsymbol{r}, \boldsymbol{r}_n)\boldsymbol{\alpha}_E & i\xi\nabla \times \boldsymbol{G}(\boldsymbol{r}, \boldsymbol{r}_n)\boldsymbol{\alpha}_H \\ -i\xi\nabla \times \boldsymbol{G}(\boldsymbol{r}, \boldsymbol{r}_n)\boldsymbol{\alpha}_E & \xi^2 \boldsymbol{G}(\boldsymbol{r}, \boldsymbol{r}_n)\boldsymbol{\alpha}_H \end{pmatrix} \begin{pmatrix} \boldsymbol{E}(\boldsymbol{r}_n) \\ \boldsymbol{H}(\boldsymbol{r}_n) \end{pmatrix}$$

Total = Source + Scattered

$$\delta\mathbf{E}(\mathbf{r}) = -\left[\xi^2 \mathbf{G}(\mathbf{r}, \mathbf{r}_n)\alpha_E \nabla \mathbf{E}(\mathbf{r}_n) + i\xi\nabla \times \mathbf{G}(\mathbf{r}, \mathbf{r}_n)\alpha_H \nabla \mathbf{H}(\mathbf{r}_n)\right] \delta \boldsymbol{r}_n$$

- Purcell, E. M. and Pennypacker, C. R., "Scattering and absorption of light by nonspherical dielectric grains" Astrophysical Journal 186 705 (1973)