Inverse Design of Optimal Photonic Structures with Nonlinear Properties

B. Allen ,[1] Z. Lin,[2] A.W. Rodriguez[2]

1 – Washington University St. Louis

2 – Princeton University

$$\nabla \times \frac{1}{\mu} \nabla \times \mathbf{E}(\mathbf{r}) - \omega^2 \epsilon(\mathbf{r}) \mathbf{E}(\mathbf{r}) = i\omega \mathbf{J}(\mathbf{r})$$

$$\mathbf{J}(\mathbf{r}, \mathbf{r}') = \hat{\mathbf{e}}_j \delta(\mathbf{r} - \mathbf{r}')$$

$$\text{Objective: } \operatorname{Re}\left[\int \mathbf{J}^* \cdot \mathbf{E}\, d\mathbf{r}\right]$$

Liang, X. D. and Johnson, S. G. Opt. Express 21(25) 30812 (2013)

Linear Optics

- Induced polarization of material is linearly proportional to strength of the incident optical field
- P = XE

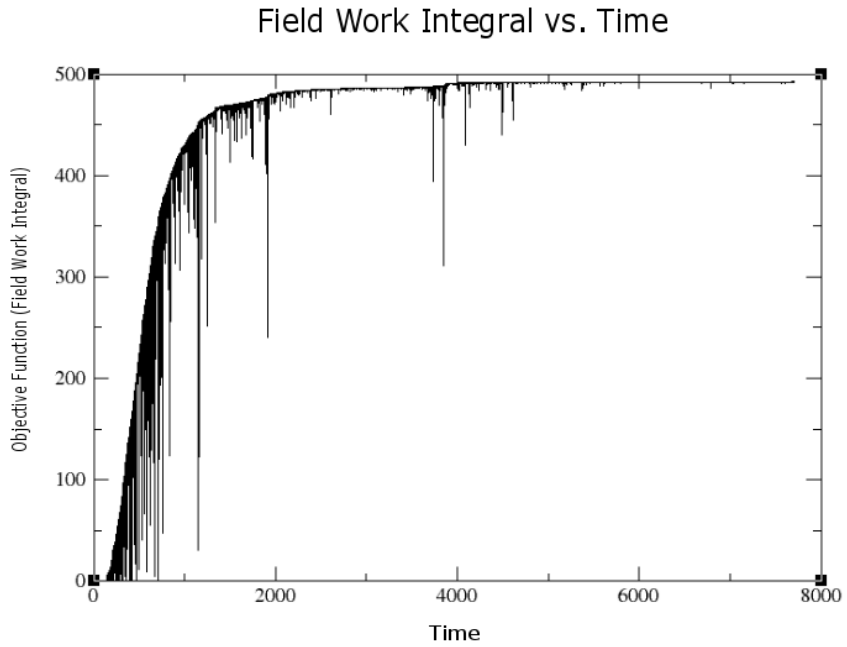
Nonlinear Optics

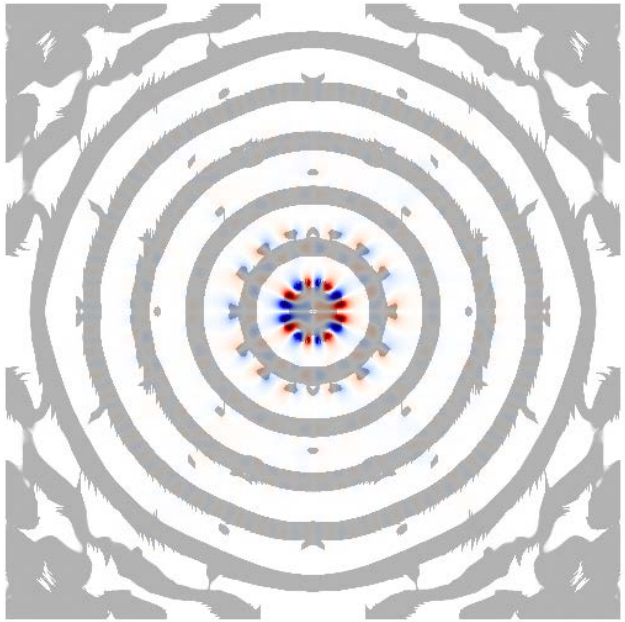
- Induced polarization is proportional to some nonlinear combination

  P = X1E + X2E + … + XnE
- Nonlinear components represent harmonic generation within material

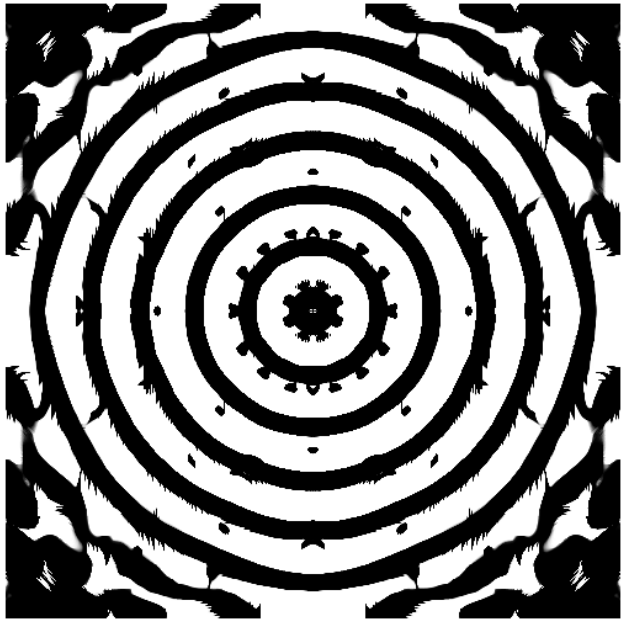
Mode Confinement in Nonlinear Materials

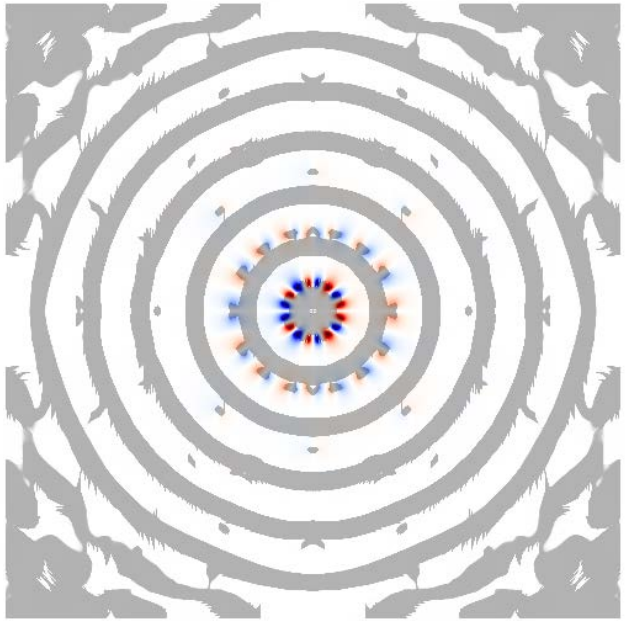
- Structure must confine both X1 and Xn mode
- So-called “intuitive” structures typically only confine one mode
- De novo optimization enables design of structures capable of confining multiple modes



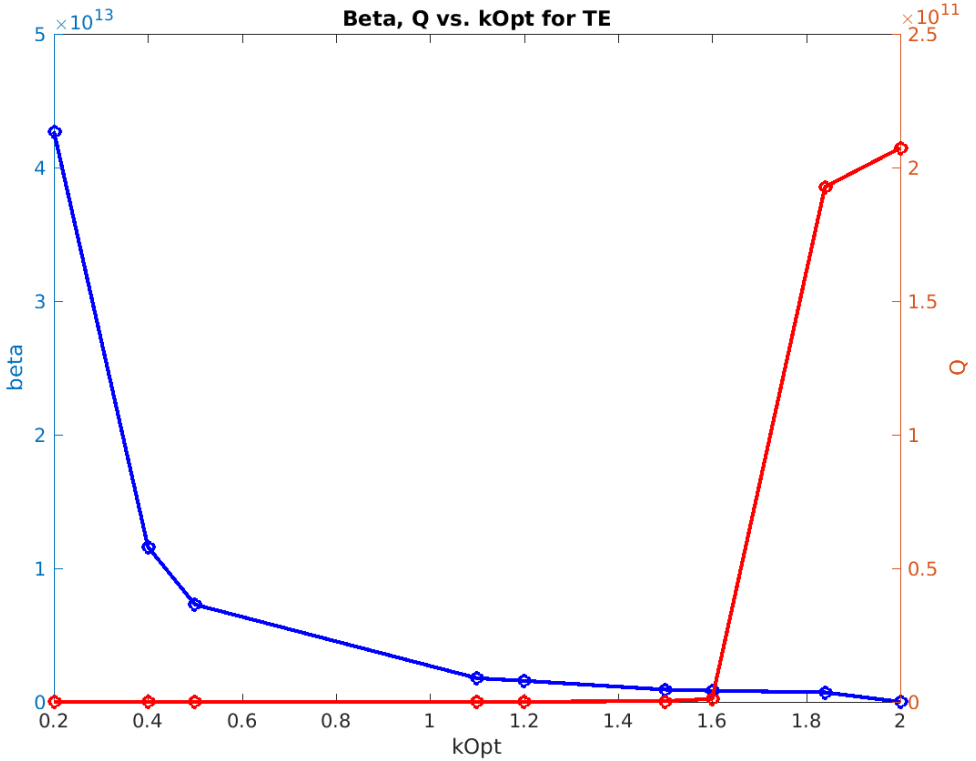


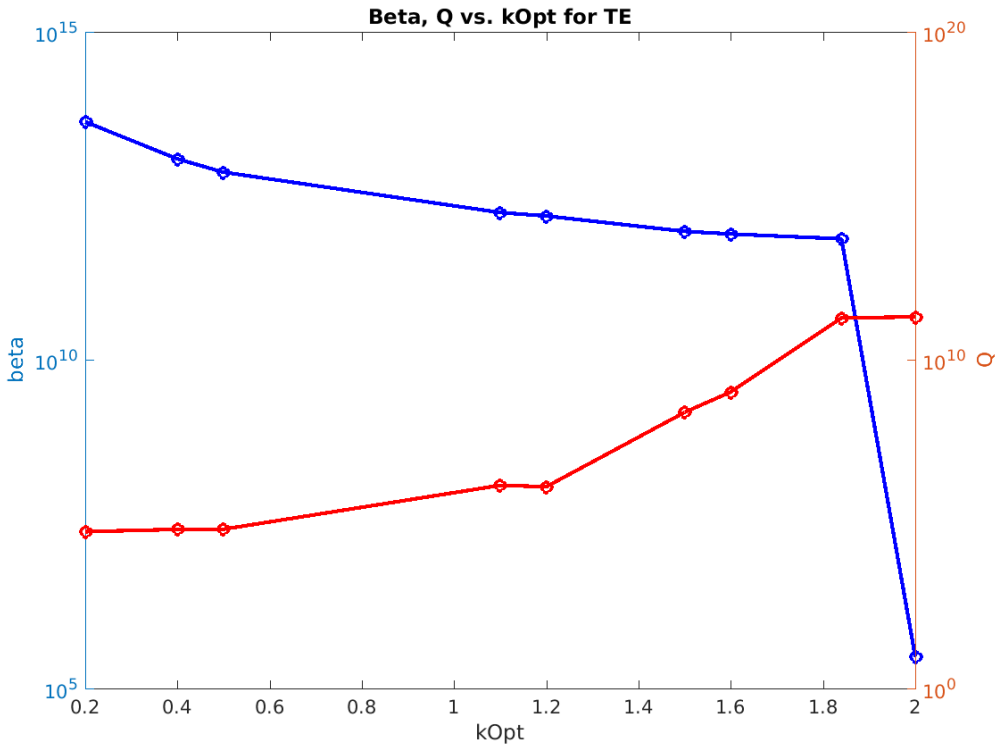
f1 mode





f3 mode





Figures of Merit