Photonic Arrays for Microwave Hidden Sector Photon Search

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-PHARAOH

- Our 2014 paper discussed a microwave LSW experiment using a photonic lattice.
- PHARAOH - PHotonic ARrays for Axions Or HSPs.

Hidden-sector photon and axion searches using photonic band gap structures

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J. Phys. G: Nucl. Part. Phys. 41 (2014) 035005(10pp)
doi:10.1088/0954-3899/41/3/035005

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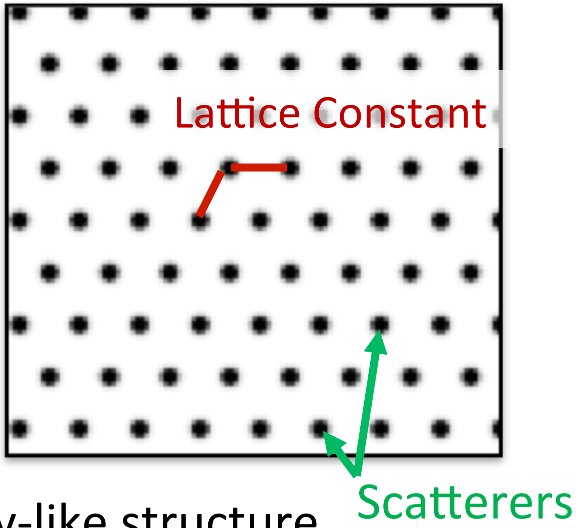
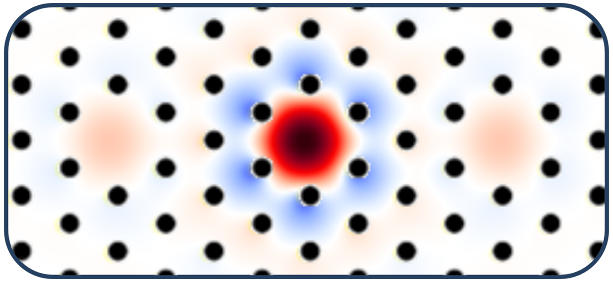
- Photonic structures are formed from a periodic lattice of materials with contrasting permittivity.
- The lattice structure controls the flow of light through the material.

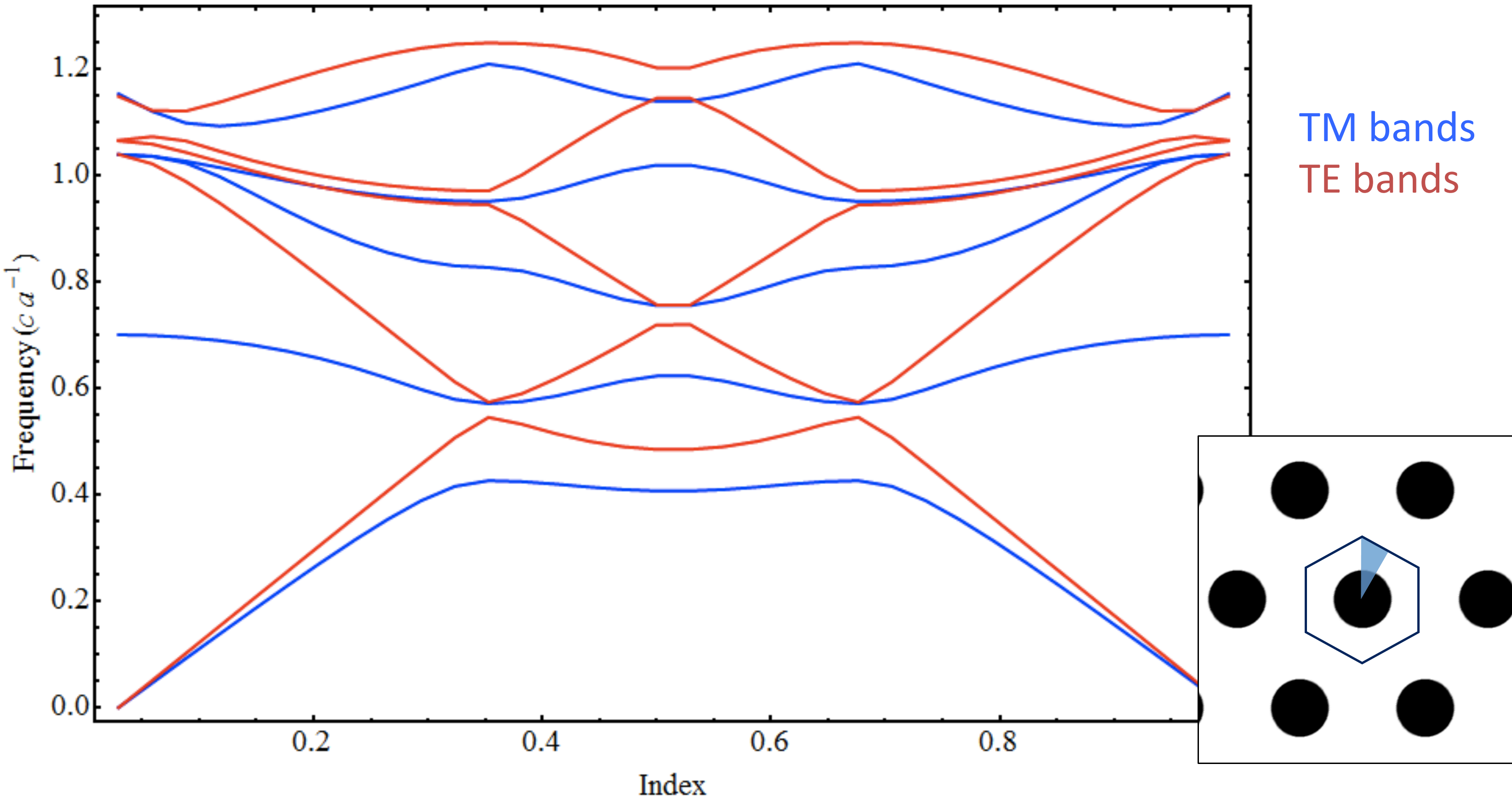


- The removal of a scatterer creates a cavity-like structure.
- Varying the permittivity contrast, scatterer radius and lattice constant tunes the frequency of the 'localised' Bloch state associated with the defect.



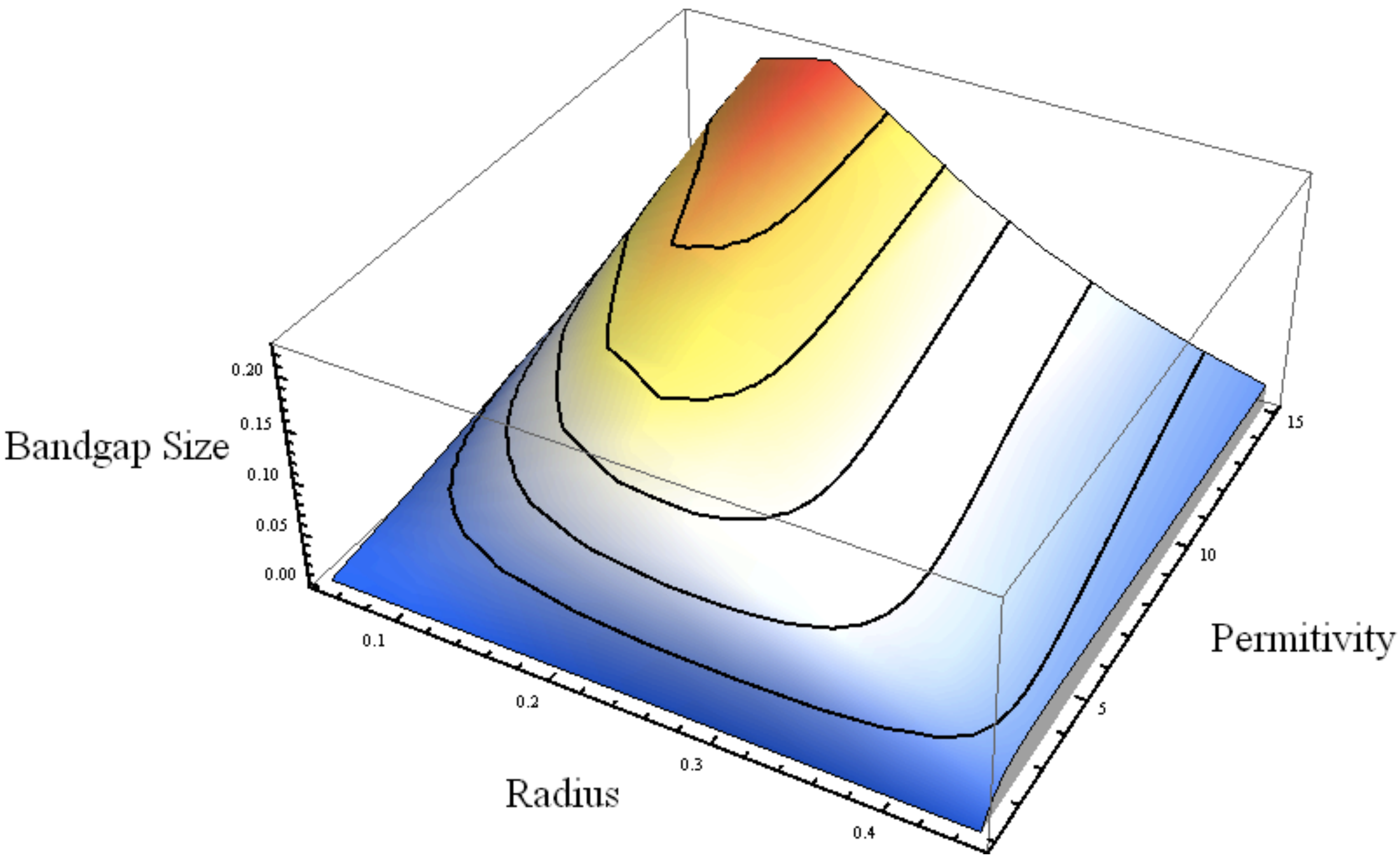
Images courtesy of N. Woollett

Photonic Band-Gap

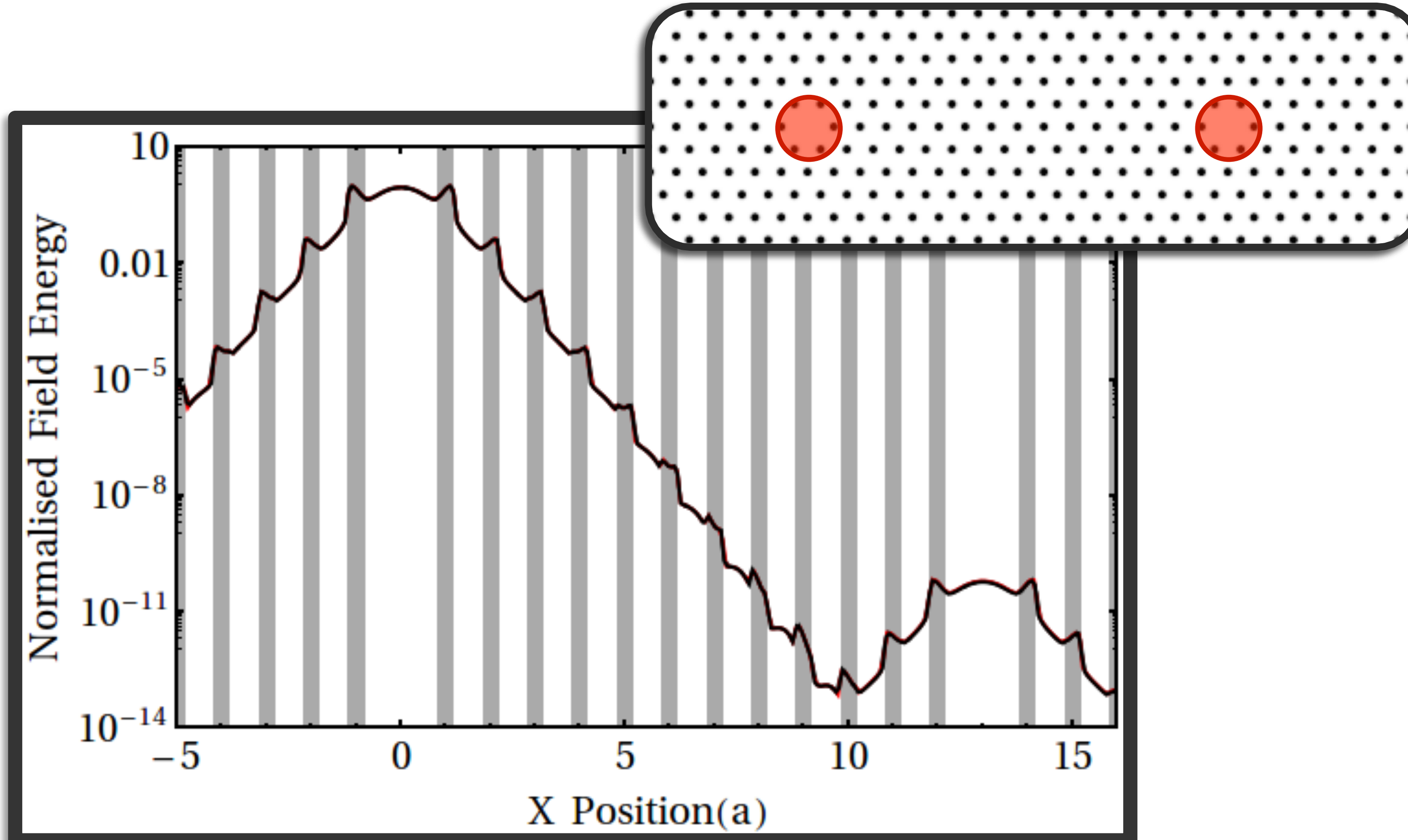


MEEP/MPB simulation of triangular lattice of cylindrical scatterers wih a radius of 0.1 lattice constants and a relative permittivity of 9 corresponding to sapphire in air.

Optimising the Band-Gap

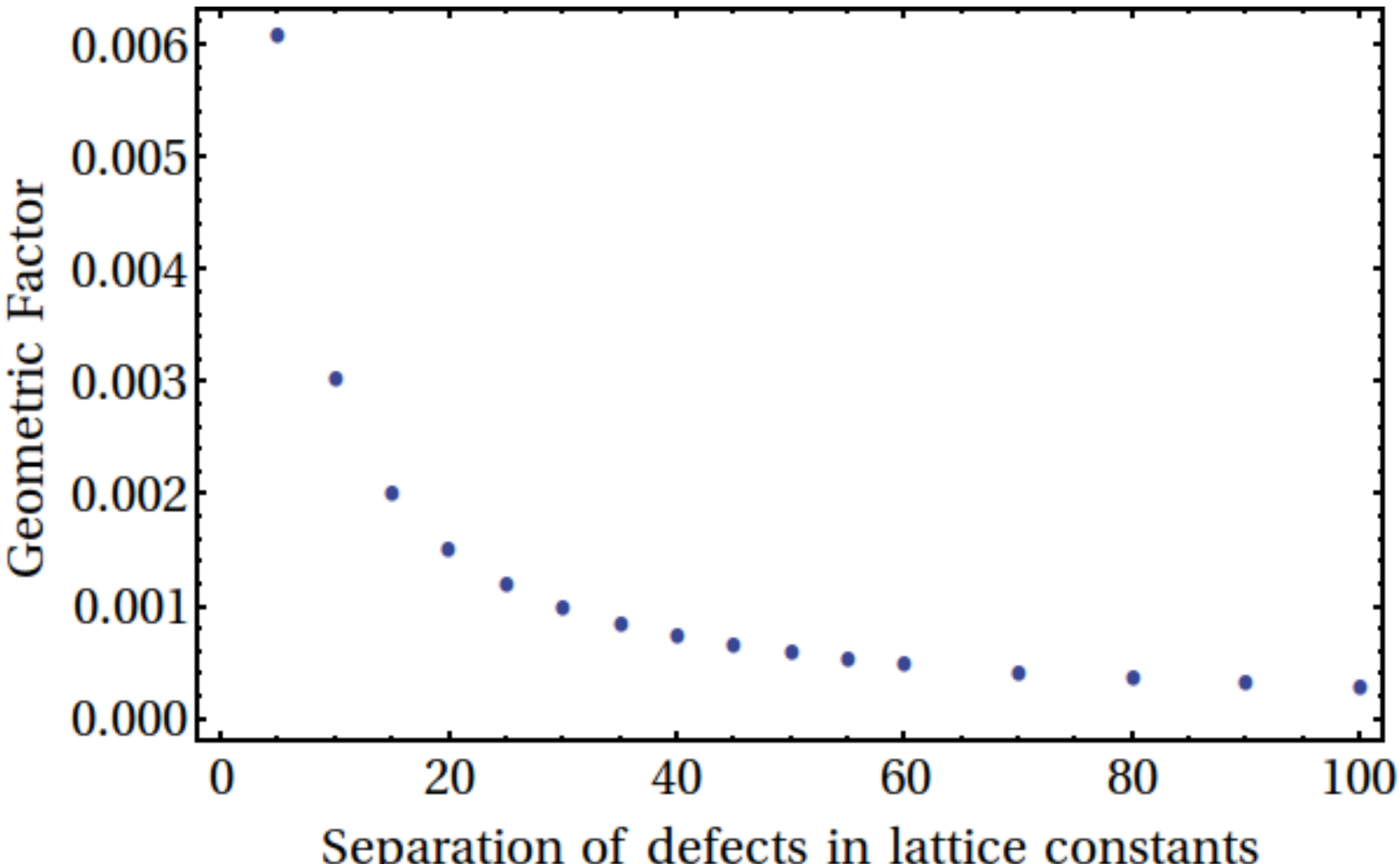


PHARAOH Isolation Simulations

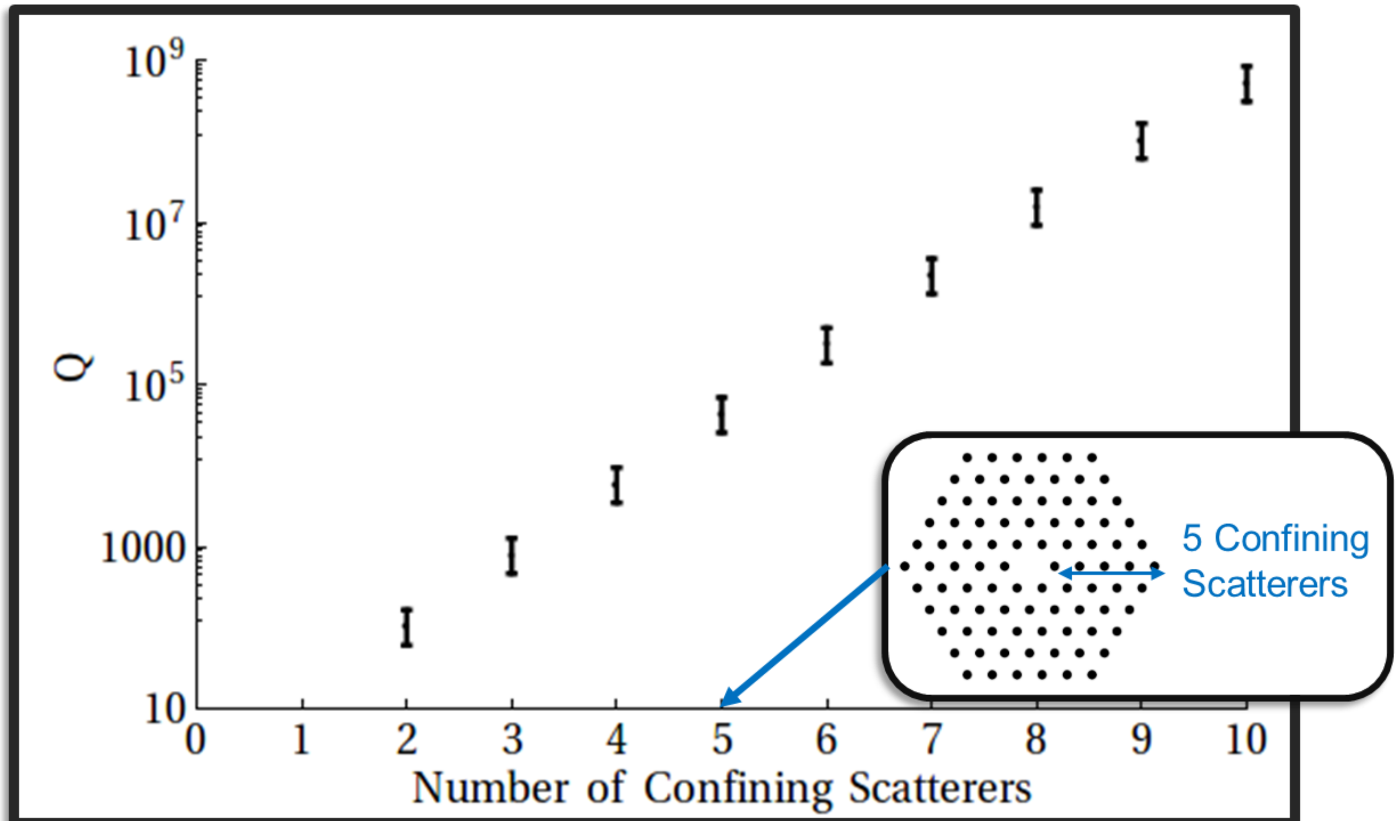


We can form a LSW experiment by introducing a second defect.

Geometric Factor

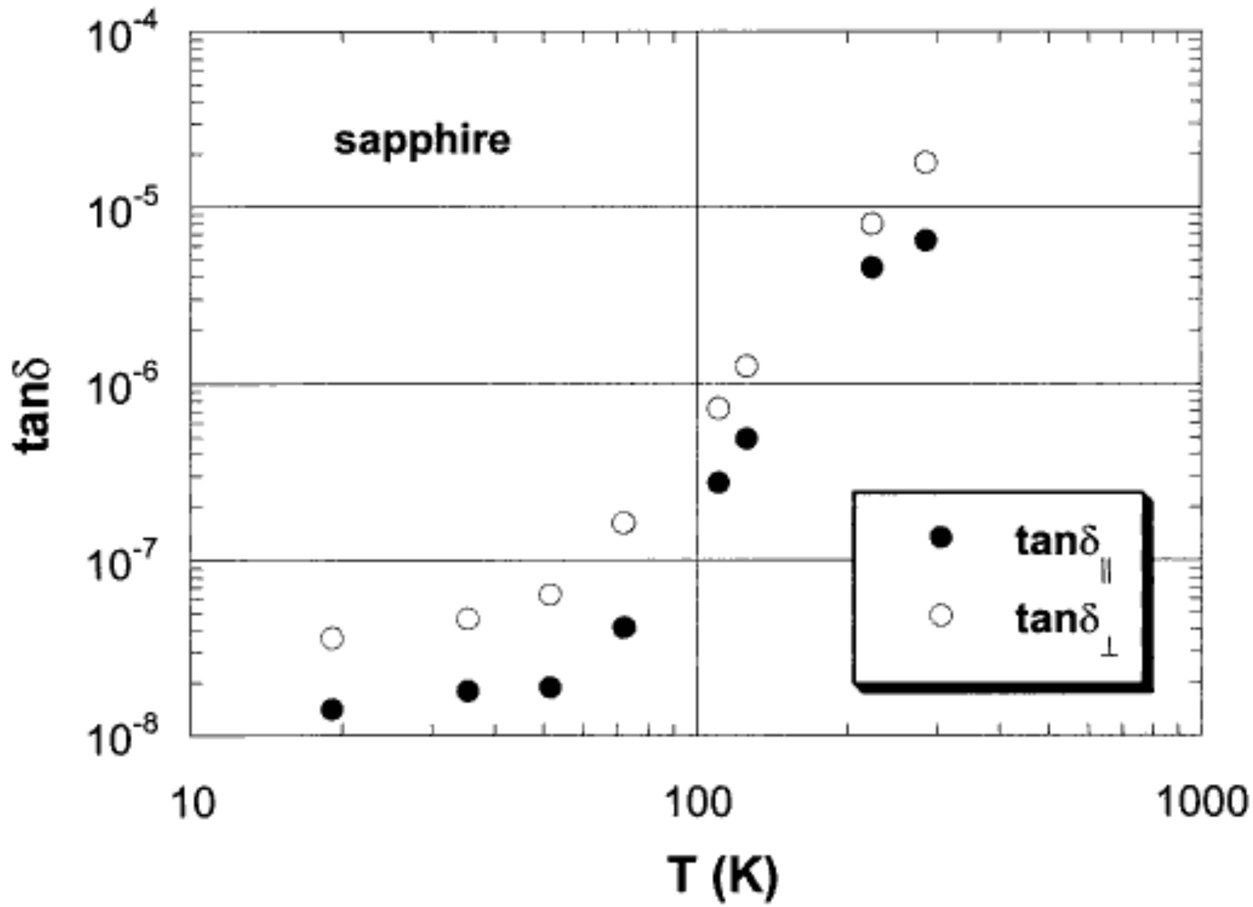


PHARAOH Quality Factor Simulations



The Q of the cavity is a strong function of the size of the lattice, which by construction is self-shielding in the frequency range of interest.

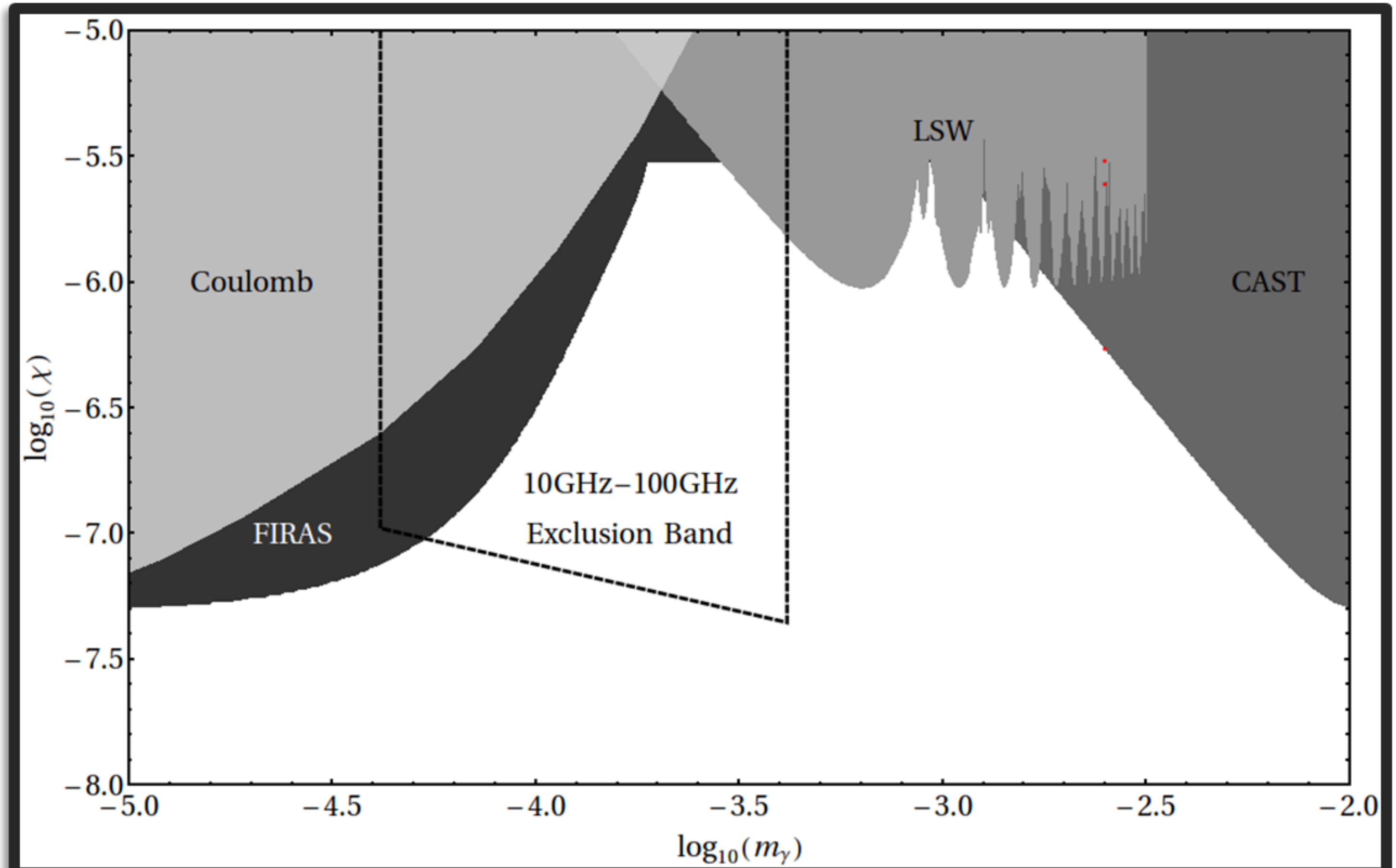
Effect of loss tangents



J. Krupka, K. Derzakowski, M. Tobar, J. Hartnett, R.G. Geyer, Measurement Science and Technology 10 (1999).

Artificial sapphire grown using Czochralski (Cz) process or edge-defined film-fed growth (EFG).

PHARAOH - Possible Exclusion



Assuming 30 lattice spacings between defects so that thermal noise dominates leakage in detector defect and 7 defects in total.

Summary

- Photonic lattices provide an alternative to high-Q cavities in some regimes.
- Can function as an LSW experiment for hidden-sector photons.
  - And axions? Requires near-field calculation.
- Possible funding route through EPSRC due to technology?