Confinement of light in realistic 3D cavity superlattices

Marek Kozon[1,2], Sjoerd A. Hack[1,2], Jaap J.W. van der Vegt[2], Ad Lagendijk[1], and Willem L. Vos[1]

[1] *Complex Photonic Systems (COPS), MESA+, University of Twente, Enschede, The Netherlands*

[2] *Mathematics of Computational Science (MACS), MESA+, University of Twente, Enschede, The Netherlands*

e-mail: m.kozon@utwente.nl

UNIVERSITY OF TWENTE. MACS cops MESA+ INSTITUTE FOR NANOTECHNOLOGY

Motivation

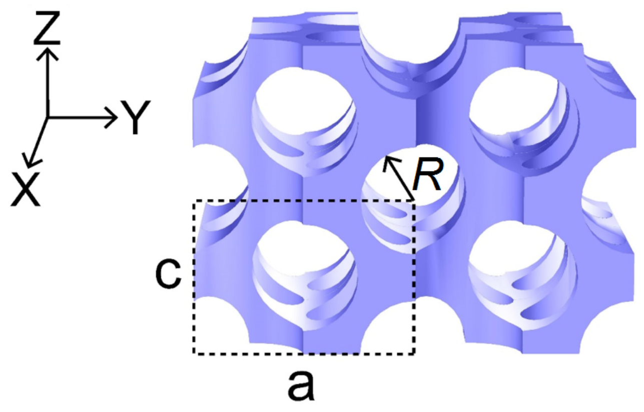
Goal: Trap photons and manipulate their behavior.

Relevant for Anderson localization of light [1], photonic computing [2], …

3D inverse woodpile photonic crystal

Omnidirectional photonic band gap [3, 4] .

Band gap width depends on the reduced pore radius $\frac{R}{a}$.

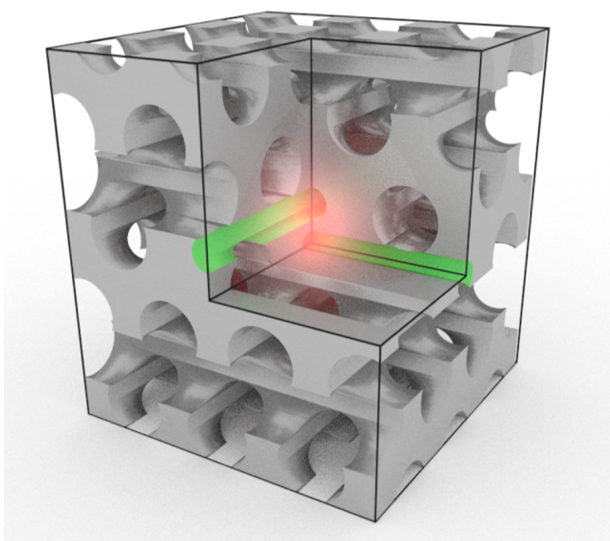


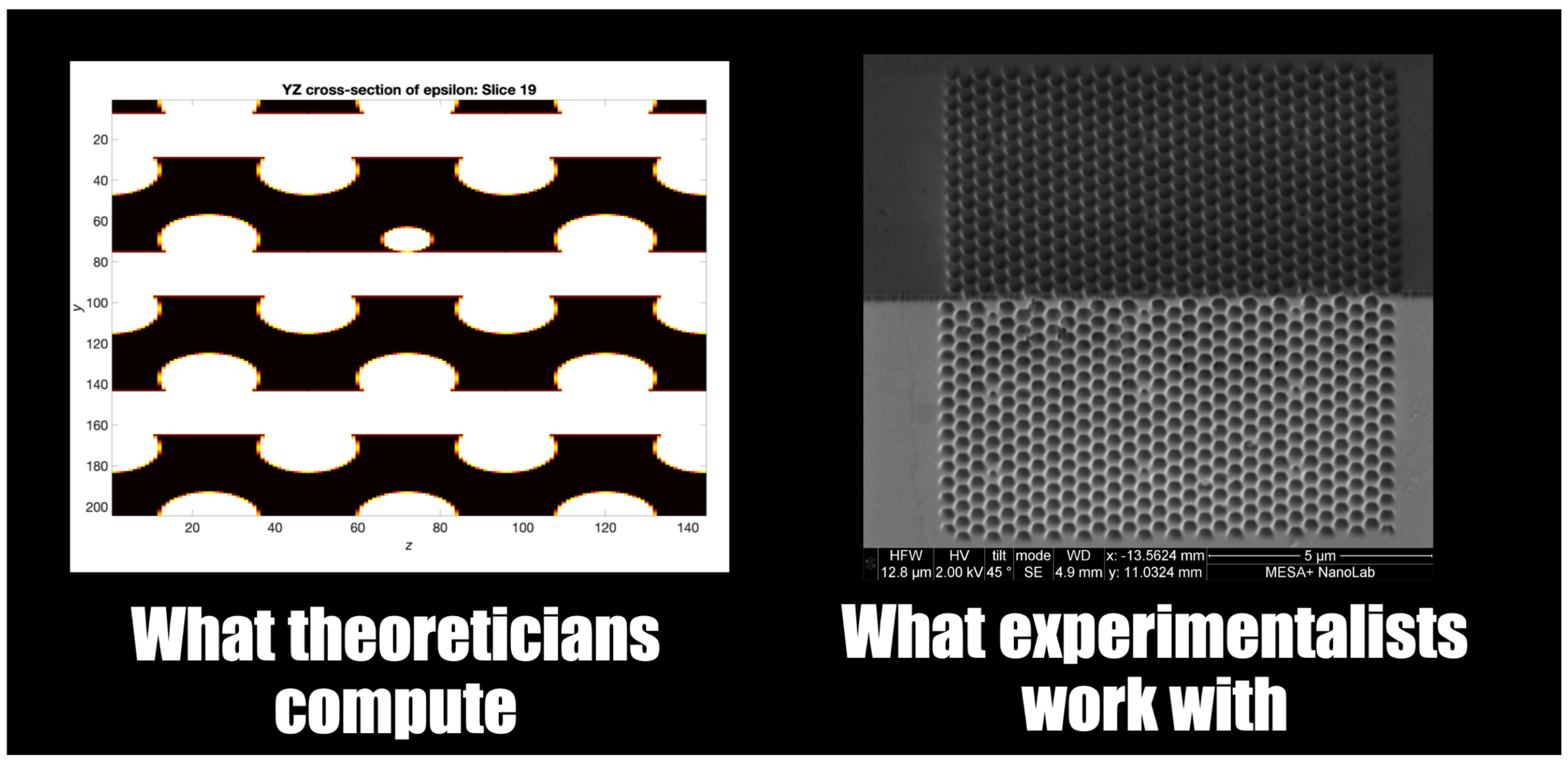
Crystal with a cavity

Two perpendicular defect pores with $R' < R$ [5, 6].

Cavity superlattice results in Cartesian light [7].

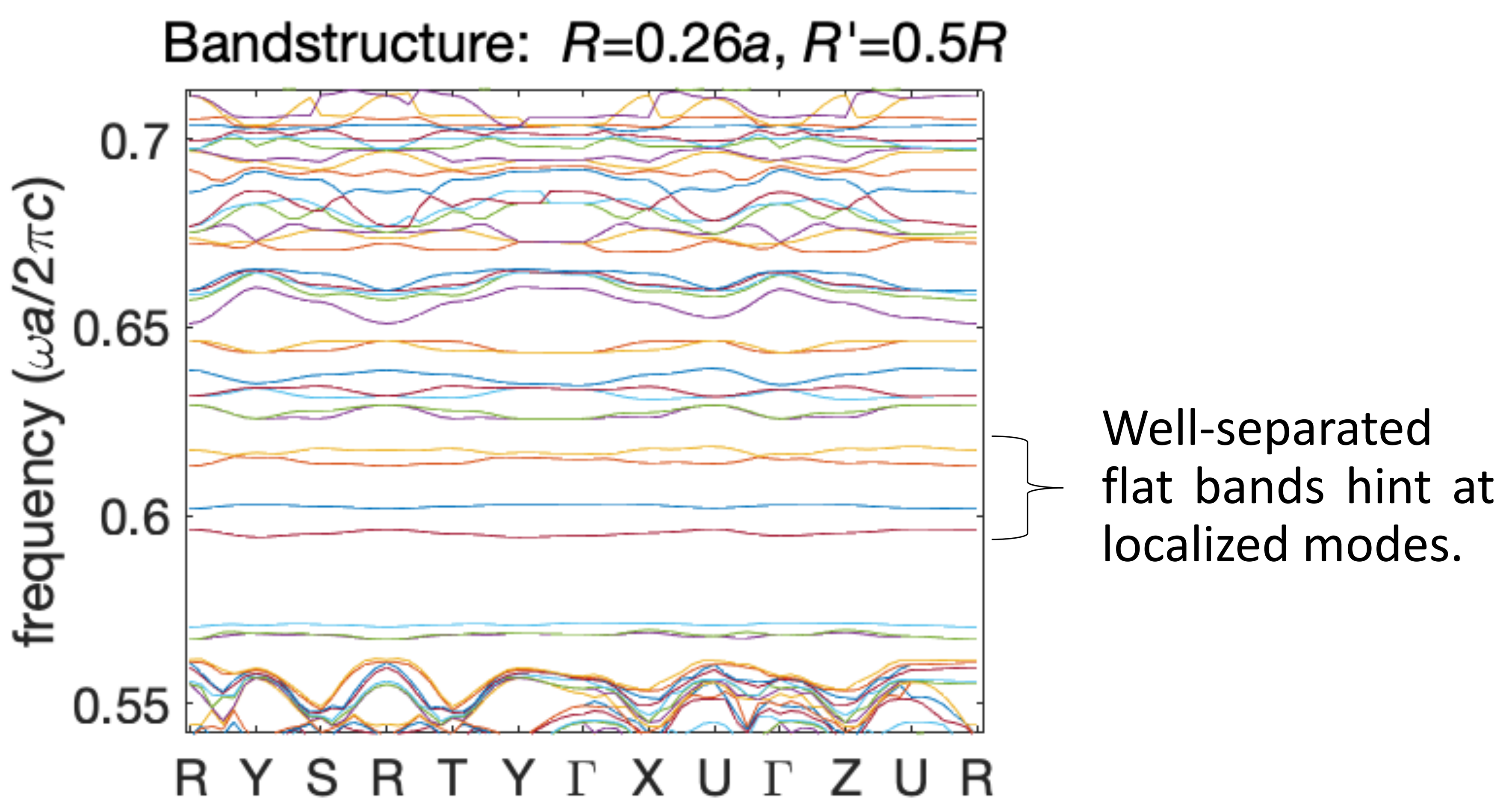
Properties strongly depend on both R and R'.





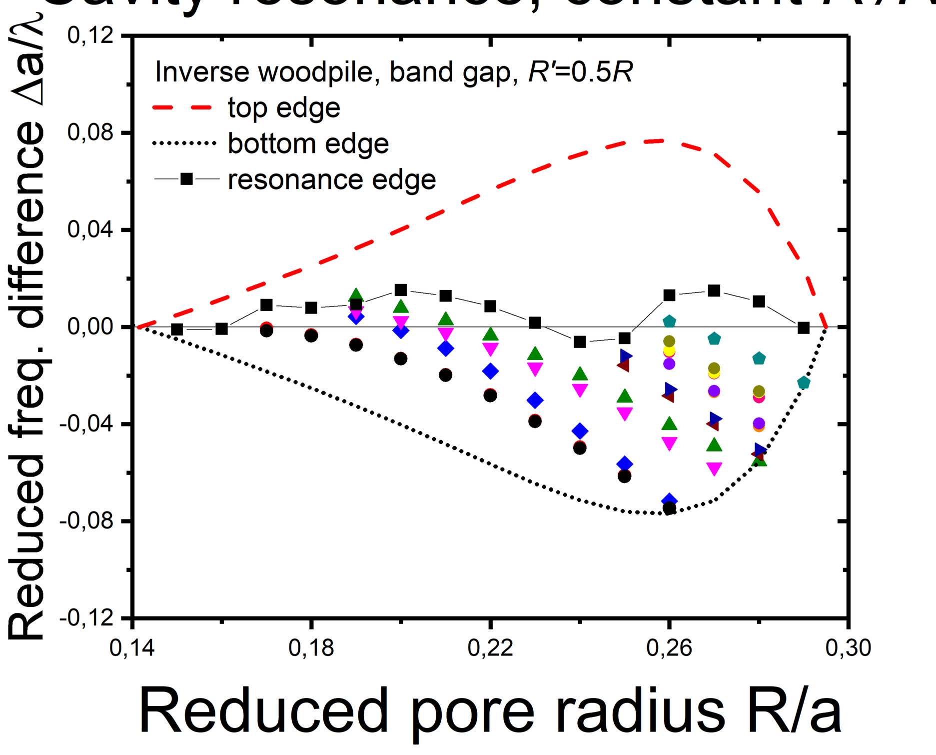
We investigate the behavior of the resonance with respect to variations of structural parameters (R,R'), as they appear in experiment.

Parameter map

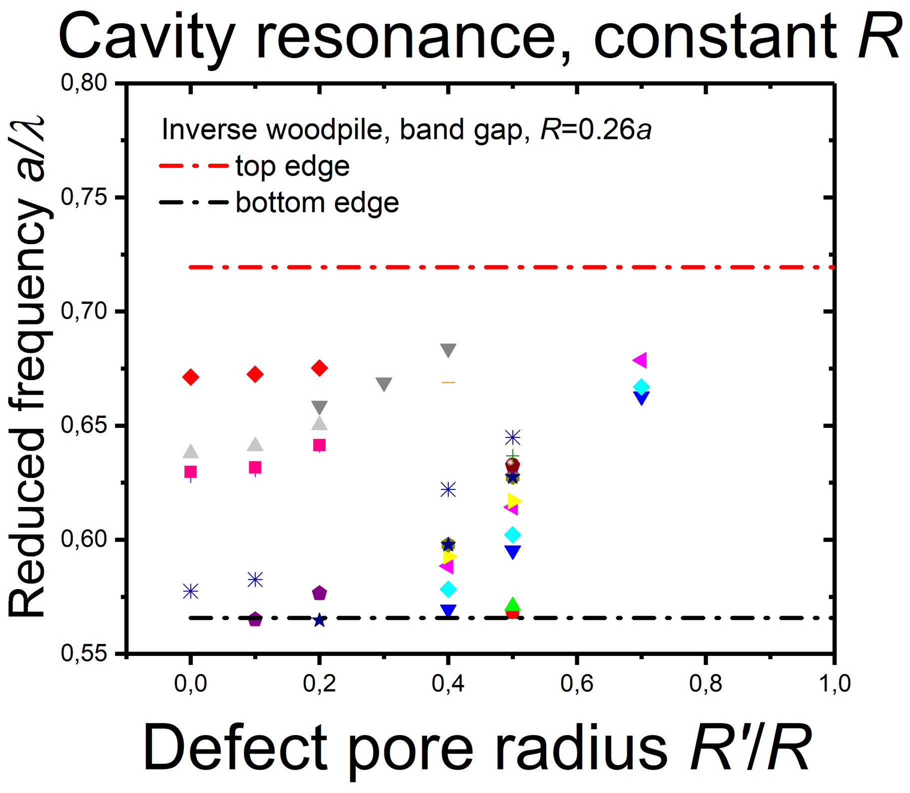


As the pore sizes (R,R') change, various resonances sweep the lower half of the band gap and disappear at its bottom.

Cavity resonance, constant R'/R



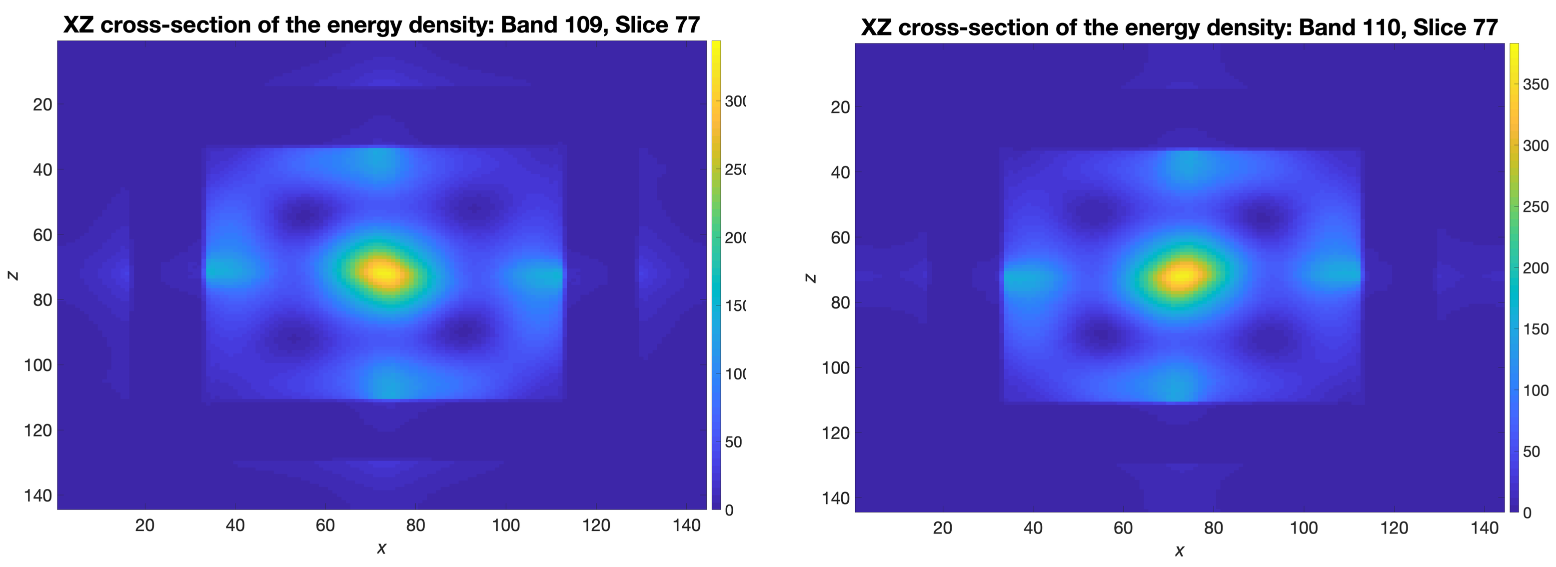
Cavity resonance, constant R



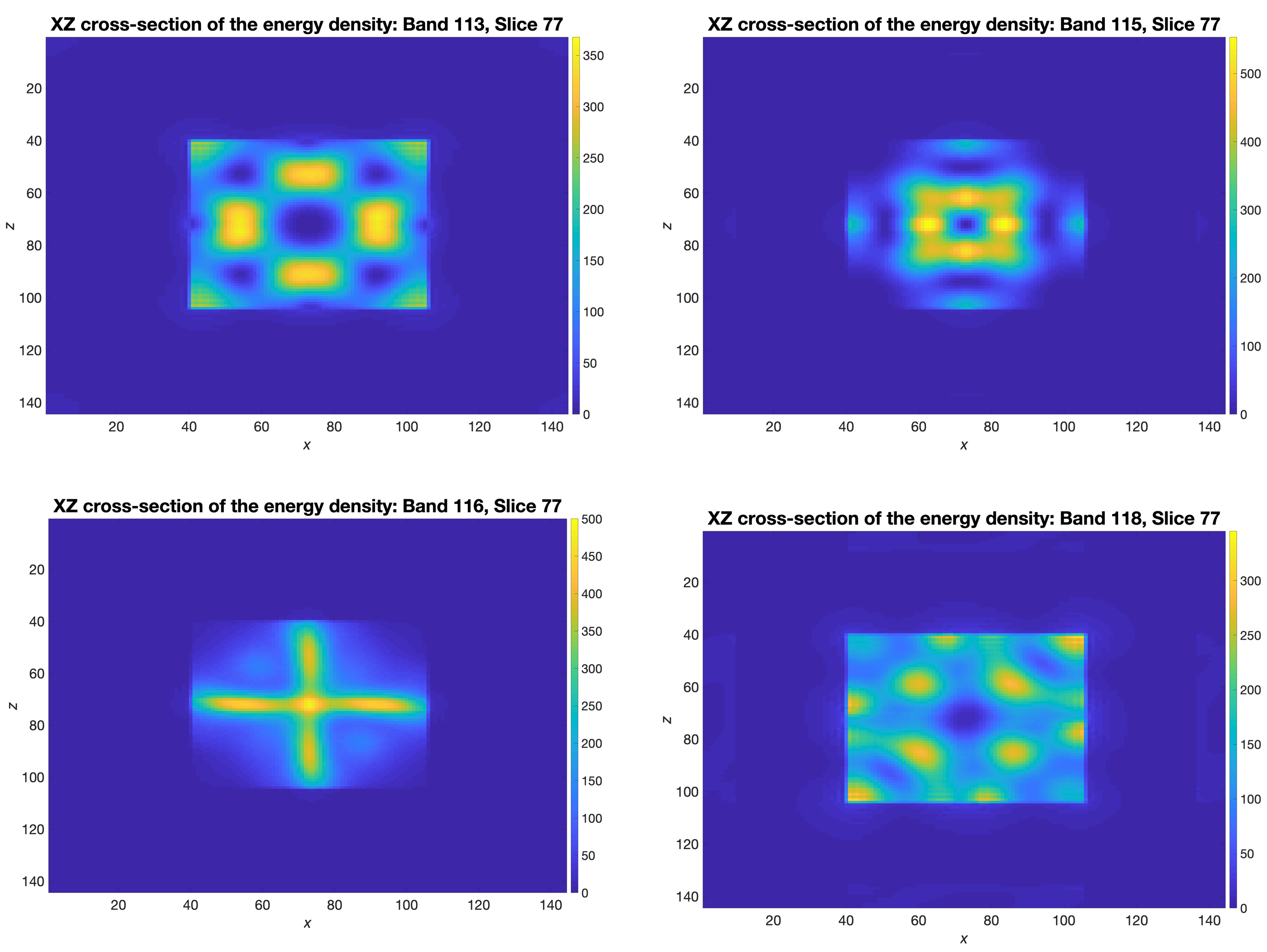
Resonance symmetry

Resonances exhibit various multipolar symmetries.

$R = 0.18a,\ \ R' = 0.5R,\ \ \omega \in (0.40, 0.41)$: **Dipolar**



$R = 0.26a,\ \ R' = 0.4R,\ \ \omega \in (0.565, 0.615)$: **Quadrupolar**



References

[1] P.W. Anderson, Phys. Rev. **109**, 1492 (1958)
[2] M.J. Hartmann, F.G.S.L. Brandao, and M.B. Plenio, Laser & Photon. Rev. **2**, 527 (2008)
[3] K. Ho, C. Chan, C. Soukoulis, R. Biswas, M. Sigalas, Solid State Commun. **89**, 413 (1994)
[4] M.D. Leistikow, *et al.*, Phys. Rev. Lett. **107**, 193903 (2011)
[5] D. Devashish, *et al.*, Phys. Rev. B **99**, 075112 (2019)
[6] L.A. Woldering, A.P. Mosk, and W.L. Vos, Phys. Rev. B. **90**, 115140 (2014)
[7] S.A. Hack, J.J.W. van der Vegt, and W.L. Vos, Phys. Rev. B **99**, 115308 (2019)