2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Reconfiguring the Boundaries of a 3D-Microwave Cavity within the Photon Lifetime

Philipp del Hougne*(1), Gabriele Gradoni(2), Jean-Baptiste Gros(1), Mathias Fink(1), and Geoffroy Lerosey(1)
(1) Institut Langevin, CNRS UMR 7587, ESPCI Paris, PSL Research University, 1 rue Jussieu, 75005 Paris, France
(2) School of Mathematical Sciences and George Green Institute for Electromagnetics Research,
University of Nottingham, University Park, NG7 2RD, United Kingdom
* email: philipp.delhougne@gmail.com

Time-domain shaping of cavity eigenmodes and photons during their lifetime offers the unique opportunity to experimentally explore exciting non-equilibrium physics, such as the dynamical Casimir effect, the wave Fermi accelerator and breaking time reversal symmetry. In optics, these possibilities are out of reach with current wavefront shaping devices whose maximum frame rate is on the order of a few hundreds of kHz. In the microwave regime, the (electrical) tuning of a *one*-dimensional resonator within the photon lifetime was reported for a transmission line terminated with a SQUID [1], as well as using a variable capacity [2].

Here, building on recent advances in spatiotemporal wavefront shaping of microwaves trapped in large cavities [3], we introduce a simple (room-temperature) setup consisting of a *three*-dimensional microwave cavity ($f_0 \sim 2.6$ GHz; $Q \sim 500$) with boundary conditions that are partially tunable, at rapid rates (~5% of the photon lifetime). A simple 2x4 reflectarray, as depicted in Fig. 1(a), covers one wall of the microwave cavity. Each of its elements is individually reconfigurable via the bias voltage of a PIN diode to act either like a Neumann or Dirichlet boundary condition. With an arbitrary wave generator (10 GHz sampling rate), we impose a time-varying bias voltage on the diodes (see Fig. 1(c)), thereby controlling at wish the cavity boundary conditions in time.

To begin with, we work with a single-mode cavity to avoid over-complicating the initial problem through the presence of overlapping resonances. Under continuous wave excitation, we analyse the transient field both in space and time for a single as well as periodic change of the boundary conditions of one cavity wall. We compare the experiments with analytical and numerical results [4]. For certain parameter configurations, as exemplified in Fig. 1(b), we observe pronounced overshooting of the detected signal during the transient.

Then, we go on to explore how simple periodic wall oscillations of a regular cavity may yield chaotic behaviour. We probe the wave field in space to analyse the corresponding wave dynamical phase-space via a Wigner function formalism and consider the effect of an increased cavity volume (changing the modal density). Moreover, we explore the possibility of realizing wave Fermi acceleration by switching the wall patches coherently in time, and whether under certain conditions oscillating cavity walls may break the time reversal symmetry.

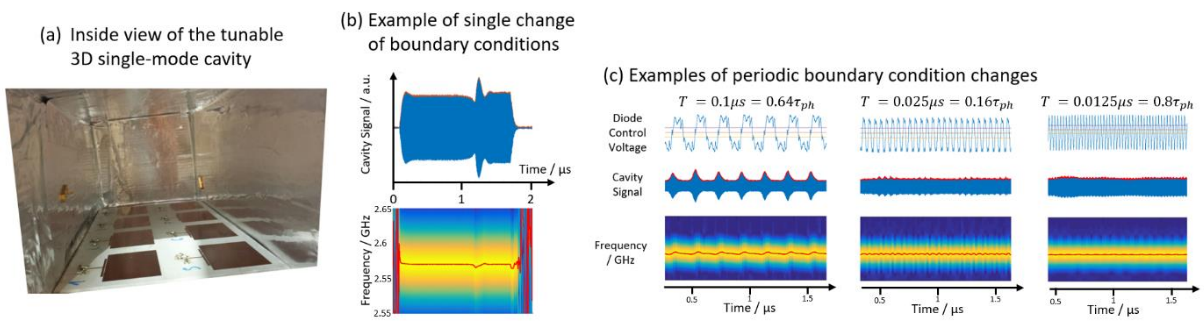

Figure 1. (a) Setup. (b) Single change. (c) Periodic changes.

1. Sandberg, Martin, et al. "Tuning the field in a microwave resonator faster than the photon lifetime." *Appl. Phys. Lett.* 92.20 (2008): 203501.
2. Gehler, S., et al. "Microwave realization of a periodically driven system." *New J. Phys.* 15.8 (2013): 083030.
3. del Hougne, P., et al. "Spatiotemporal Wave Front Shaping in a Microwave Cavity." *Phys. Rev. Lett.* 117.13 (2016): 134302.
4. Gradoni, G., Arnaut, L. R. "Transient evolution of eigenmodes in dynamic cavities and time-varying media." *Radio Sci.* 50.12 (2015): 1256-1270.