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Optomechanical Technologies Newsletter

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OMT

OPTOMECHANICAL TECHNOLOGIES

Introduction

The OMT newsletters describe new achievements by ESRs (Early Stage Researchers) on their projects. How far they have progressed, what challenges they face and how they manage to overcome those chal-lenges. In the context of OMT newsletters we will also report on workshops that have been or-ganized by different partners of this program in or-der to help ESRs to learn different skills from "the-ory of cavity optomechanics" to "career prospects in industry and academia". We will also see what new steps have been taken by ESRs in the engagement platforms that has been organized in DokuWiki.

Fellows updates

by P. Piergentili (UNICAM)

In the first months of my fellowship at the University of Camerino, I was able to attend two very interesting workshops of the OMT program. The first one was a summer school in Erlangen. It covered the basics of cavity optomechanics, quantum optics and entanglement. The second workshop provided fundamental understanding and practical know-how for performing simulations of mechanical, electromagnetic and thermodynamic properties of optomechanical systems. In the meantime my research project is undergoing in the laboratory of quantum optics, optomechanics and cryogenics of the University of Camerino, high quality factor RLC resonators were designed and realized. The resonators will be coupled with an electromechanical transducer where the vibrations of a Si_3N_4 membrane are optically and electrically measured.

by E. Ivanov (UPMC)

My project topic is the design and fabrication of a transducer, capable of converting a microwave signal produced at cryogenic temperatures into optical photons that can be preserved for a long time at room temperature, via a coupling to the modes of mechanical nanomembrane. For the moment, I am working on the fabrication and optimization of the membranes. To do so, I have split my efforts in three main tasks; all of which, when finished, should allow me to measure and characterize the mechanical properties of SiN nanomembranes, which are patterned with a phononic crystal (and a central defect) to help localize the mode, and reduce as much as possible losses due to clamping and bending. Firstly, I am putting my newly acquired skills from the workshop at EPFL to use: I aim to predict the energy band diagram of my membranes (and hence the location of their quasi-band gaps), their eigenfrequencies, as well as characterize characterize their losses and place an estimate on their quality factors. In parallel to this, I am working on their fabrication, which is done in cleanrooms. Finally, I am working on the optical setup to be ready to characterize the samples once the microfabrication is perfected and the samples are adequate, which for now consists of a simple interferometric setup.

by I. Sanchez (UKON)

This has been my first month as a fellow of the OMT-ETN project and I have been introduced to my new lab and experiment. Previously, during this summer at the OMT workshop in Erlangen, leading experts in optomechanics taught us the theoretical foundations of this field, which made easier my start here with my new project in

Konstanz. This month I attended as well the workshop organized by EPFL within the OMT program about Finite Element Modelling, in which I had the chance to meet for the first time the rest of the ESRs. We learnt about powerful software that we will need during our PhD studies, that in my case will help me to design and understand the properties of my nanomechanical resonators and will complement the experimental results.

by C. GUT (UNIVIE)

Since the start of my Ph.D. I started collaborating on an ongoing project which tries to experimentally create and measure the entanglement between mechanical motion and light. We are studying the features of our data and prepare some fine tuning for the next runs of the experiment. We are exploring our data to make sure that the result is not an artifact of some measurement bias and that the uncertainties are small enough.

by M. BEREYHI (EPFL)

Starting from a different background in electrical engineering and physics makes it challenging to begin research in optomechanics. However getting the chance to have different training opportunities has been very useful for me to get started with theory and simulations in this field. Since the start of my fellowship, I participated in a workshop on theory of cavity optomechanics in Erlangen which was very useful in terms of becoming more familiar with the theory and literature of cavity optomechanics. This workshop was followed by a simulation workshop organized by EPFL which covered the useful simulation skills that I needed to start simulating optomechanical structures in my project. I am now implementing an experimental setup for measurement and characterization of the mechanical structures that I was able to study based on what I have learned in these workshops and which is the first phase of my PhD project.

by S. HOENL (IBM)

My goal is to develop a device that translates high-frequency electrical signals quantum coherently into an optical signal, i.e. an electro-optic quantum transducer. To achieve that, we can exploit optomechanics to create an interface between the optical and the electrical domain. In the past year, we have put a lot of effort into the development of a novel material platform, gallium phosphide (GaP), that may enable us to fabricate transducer devices capable of quantum transduction. Although well known in optoelectronics for its use in LEDs, this material has not been used extensively in the context of nanophotonics due to fabrication challenges. However, it provides a suite of material properties that make it highly suitable for electro-optomechanical applications. So far the fabrication of the samples has been entirely in-house, including epitaxial growth of the device layer. In recent months, I have fabricated the first optomechanical devices as well as waveguide resonators and the preliminary results are very promising.

by G. MODICA (CNRS)

The first part of my Ph.D. project at C2N - CNRS was mainly focused on acquiring skills useful for the fabrication part developed in cleanroom as well as on learning how to simulate such a structure with software. From a fabrication point of view, optimization of the processes to get the desired system, as well as trying new ideas and options, have been the main goals of the first few months. On the other hand, simulations and bibliographic research meanwhile helped to achieve a better understanding of the studied structures. Moreover, I already attended several workshops and summer schools focused on nano-optomechanics and photonic crystals theory and FEM simulations. These have been a good parallel support for the work that I performed in the lab since I had the opportunity to see different points of view and talking with experts in the field as well.

by S. SAARINEN (UCPH)

Thus far, I've been facing a steep learning curve. However, I've started to find comfort working with our setups and my current efforts have been spread on a couple of projects. Firstly, our effort in creating an integrated device to transduce classical signals is advancing despite a few fabrication setbacks and we are now characterizing complete devices. Secondly, we have also started building a fiber cavity and are now figuring out the best practices for eg. the cavity alignment and general handling of the components. In summary, not much to report yet on my part result-wise, but - as always - there are multiple developments that will hopefully lead to interesting findings by the time of the next newsletter.

by B. ANN (TU DELF)

Since May, I have been working as a Ph.D. student in the OMT project in the group of Gary Steele in Delft. In our project, we plan to do quantum optomechanics experiments combining the tools of circuit QED and very light mechanical resonators made from materials such as superconducting 2D materials. I have spent my time in the group learning the basics of microwave measurements, fabrication of superconducting circuits, and the basics of circuit QED. I have also enjoyed attending the workshop in June in Erlangen, which gave me a firm foundation in optomechanics, and the workshop in October at EPFL where I got an introduction into finite-element modeling, a tool I will be using extensively in my project.

by M. ASHOUR (BOSCH)

My project aims at creating CMOS compatible optical modulators. The major target is to be able to control the optical phase shift of light in silicon photonic chips. There are several approaches that have been demonstrated in

literature including: plasma dispersion based modulators and Opto-Mechanical modulators using pump power to exploit optical gradient forces. My early work is focusing on literature review, and acquiring practical material data to build reliable simulation models. Later simulation results will facilitate the design, and eventual realization of such devices. The final step would be testing of the obtained modulators to acquire benchmark figures of their performance.

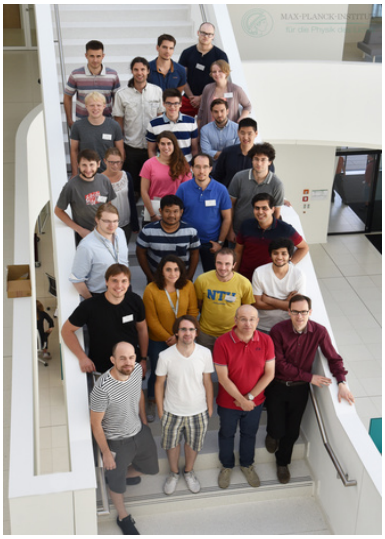
by N. MARTYNOVA (EPFL-IBM)

I've been working in EPFL since two months. In the beginning of my project, I joined the fabrication group in our laboratory which fabricates samples for different purposes. During these months I became familiar with different processes in the cleanroom and in particular learned all the steps in the Photonic Damascene process to fabricate optical chips. The Photonic Damascene process has been developed at our lab, the Laboratory of Photonics and Quantum Measurement in EPFL and it is a fabrication method that enables us to fabricate ultra-low loss optical cavities with a high quality-factor that can be utilized in different photonic circuits. I participated in two OMT workshops: at the University of Erlangen-Nuremberg and at EPFL which organized by our research group. It was very useful for me to start my project with an introduction to the theory of optomechanics, followed by the second workshop on FEM which was helpful to become familiar with simulation tools that I can utilize in my research.

Workshops

by M. BEREYHI

Since the beginning of the OMT program, fellows have been exposed to several workshops, helping them to improve their scientific skills as well as giving them the chance to experience different toolboxes that are available and widely used in today's research. In particular, two workshop have been organized so far in the series of OMT-ETN workshops naming "Theory of Quantum Cavity Optomechanics" at FAU-Erlangen and "Finite Element Simulation" at EPFL-Lausanne. The first workshop was held on 5-7 July 2017 by FAU university on the theory of cavity optomechanics and optical measurement at Erlangen, Germany. In this workshop several lectures were organized on theoretical basics of the field along with exercise sessions in which students were able to see how the lecture materials were related to real scientific problems in the field and be able to discuss with lecturers.



Prof. Marquartd and Prof. Vitali with OMT fellows at 1st workshop at MPL, Erlangen, Germany (July 2017)

This workshop was followed by a finite-element simulation workshop on 15-19 October 2017 at EPFL, Switzerland. In EPFL's workshop, fellows were introduced to and guided through different simulation tools that are widely used in research e.g. COMSOL, Sonnet and ANSYS. Different research problems that were inspired by the recent advances in the field were organized and presented to OMT fellows in the simulation workshop. At the end of each day an exercise session was organized with recent research problems presented as simulation exercises. Students were given the freedom to choose which topic to work on and lecturers assisted the students with their questions.

OMT fellows at 2nd workshop at EPFL, Lausanne, Switzerland (Oct 2017)

Secondment

by M. HAQUE

I am working on optomechanics with superconducting Josephson junctions. I spent the first three month of my secondment at the University of Camerino, Italy. There I learned theoretical aspects of quantum optomechanics as well as interaction between two-level atoms and optical cavity from Prof. David Vitali. So far, I have attended both the OMT workshops and gained introductory skills for theoretical analysis and simulation of optomechanical systems. Outside of the OMT workshops, I have also participated at the school on nanomechanics, held at Trieste, Italy.

DokuWiki

by M. BEREYHI

As early stage researchers we might be stuck with our own problems, thinking that we are the only ones facing that issue and no one can help us solve it. But many problems give rise to experience and skills if we discuss them with others who are probably dealing with the same problem!

In a nutshell, sharing scientific and technical issues with other colleagues may save minutes or hours, since others may have faced them already and know how to solve them or at least share some useful experience with us. This is why in the OMT project, a platform for ESRs was created to share and communicate about their projects, workshops, ideas and new discoveries in the field. Hopefully we'll also be part of those new discoveries...