Marie Curie ITN cQOM
Summary of the Scientific Achievements

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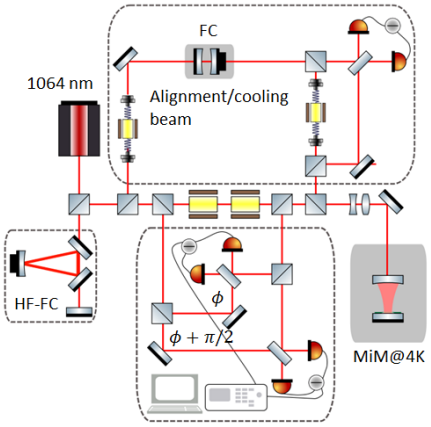
1. Description of research work

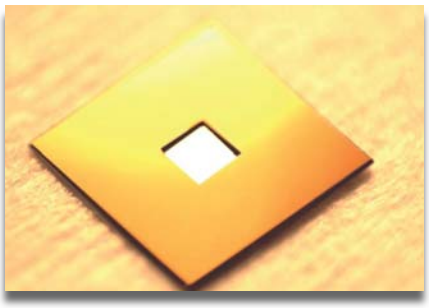
The tasks of my work covered both work in the optical lab as well as in fabricating mechanical resonators in a cleanroom environment. During the first half of my research, I focused on working on the optical setups with which we can measure and perform all kinds of optomechanical experiments. The heart of our experiment is a membrane-in-the-middle setup, which comprises a high finesse optical cavity that holds a membrane within. We started working with commercially available silicon nitride membranes. These membranes show decent optical and mechanical properties which are crucial for more sophisticated optomechanical experiments. However, they lack the flexibility of custom made resonator designs that reach even higher qualities which turned out to be important to achieve our main goal of generating and detecting quantum entanglement between mechanical resonator and optical cavity modes. This is the reason why I also focused on working afterwareds in the field of nanofabrication to deliver custom made resonators and designs for our experiments.

2. Goals achieved and/or progress towards them

There has been made great progress on the way to generate and eventually detect quantum entanglement. We could build up a full working optical setup that allows us to manipulate and detect not only entanglement but also other optomechanical quantum effects. Our high finesse cavity operates at cryogenic temperatures still with SiN membranes in the middle that show reliable good mechanical quality factors. Our lasers are filtered such that they meet the noise level requirements in terms of shot noise which gives us a complete toolbox to work with. We can still improve on the optomechanical coupling strength to eventually reach cooperativities that exceed the minimum value necessary to successfully verify quantum entanglement in our system. This would not only be of great relevance for fundamental research but also a key success on the way to a quantum information technology since optomechanical systems might act as nodes in a quantum network to store the information in the mechanical element that was imprinted in the optical light field before.

We keep on working with great effort to finally reach the coupling strengths necessary by optimizing our cavity designs and by fabricating membranes of higher qualities.





Top: commercially available SiN membrane used as the opto-mechanical resonator.
Left: Schematic of the experimental setup.
(shared work with Ramon Moghadas Nia)

3. Training received (complementary/soft skills, ITN workshops attended)

The ITN cQOM project provided me with many useful workshops that had and will have great influence on my future career whether it will be in academia or in economy. I had the chance to be in contact with many qualified co-workers within the entire project and could share knowledge and information between various institutes during the regular meetings. The trainings have not only been very useful in that sense but we also learned how to use useful tools in our field of research such as Python, COMSOL, 3D printing or just insights in the work of all the other research groups within the project that I probably would have never learned about without their help.

Following ITN workshops I have attended:

- Theory of Cavity Optomechanics
- Erlangen, Germany, 7 – 9 September 2013
- Finite Element Modeling Workshop
  Lausanne, Switzerland, 21 July – 23 July 2014
- Laser Stabilisation and high sensitivity displacement sensing
  Paris, France, 2 - 4 April 2014, Informal research presentation
- Levitation in (Quantum) Physics
- Vienna, Austria, 14 May - 15 May 2015
- From Photonics Research to the CMOS-fab
- University of Ghent, Belgium, May 17 – 19 2016

4. Participation and role in dissemination and outreach activities

The main contribution to outreach activities took place within the university itself by organizing lab tours for external visitors as well as school kids and students being interested in the field of physics. It is actually a good feeling trying to bring natural sciences a bit closer to those who probably can't imagine how physics in a research lab is like at its core. It was always an uplifting experience to see many exciting and stunned faces when showing them the optical setups but also a very good task of trying to explain very complex topics as easy as it can be and to light a spark of excitement for a broad spectrum of non-physicists.

5. List of conferences attended

- Frontiers in Nanophotonics , Monte Verità, Switzerland, 31 August - 4 September 2015
- The International Conference on Quantum Physics of Nature, QuPoN 2015, Vienna, Austria, 18 May - 22 May 2015

6. Publications (with links)

G. D. Cole, P.-L. Yu, C. Gärtner, K. Siquans, R. Moghadas Nia, J. Schmöle, J. Hoelscher-Obermaier, T. P. Purdy, W. Wieczorek, C. A. Regal, M. Aspelmeyer. *Tensile-strained InxGa1-xP membranes for cavity optomechanics*. Applied Physics Letters, Vol. 104, No. 20, 201908 (2014)
http://aspelmeyer.quantum.at/docs/82/downloads/apl-104-201908-2014-tensile-strained.pdf

7. Career plans after ITN

Since there is still our outstanding goal of generating and detecting quantum entanglement, I will continue working in my current group to finish my PhD. Staying in my group provides me with a perfect work environment to add my contribution to the entire team that I am working with. After finishing my PhD thesis which is aimed for the end of 2017, I can imagine staying in the group as a postdoc or working in other areas of research. There are far too many options as it is impossible to already know where my path is leading me. All I know is that being a researcher in a challenging field does suit my interests very well, whether it will be in R&D in a company, being a researcher in academia or a totally new experience in a working environment not related to physics at all.