Marie Curie ITN cQOM
Summary of the Scientific Achievements

Name of Fellow: ESR Ramon Moghadas Nia
Principal Investigator: Prof. Markus Aspelmeyer
Academic / Industrial Institution: University of Vienna
Start Date of ITN Fellowship: 01.07.2013
End Date of ITN Fellowship: 31.05.2016
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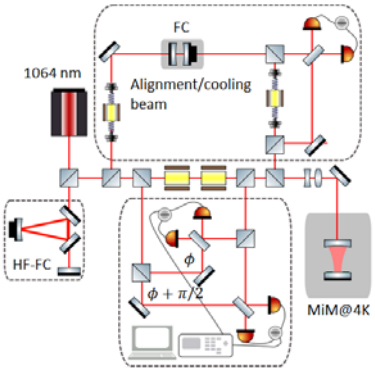
1. Description of research work

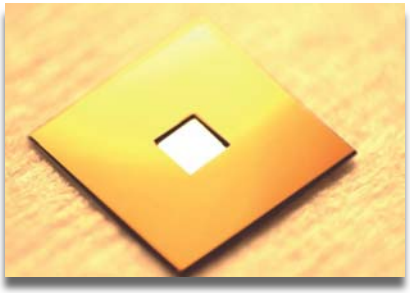
My work concentrated at the deep heart of this ITN's topic, namely exploiting the opto-mechanical coupling of a micro-mechanical oscillator (a Silicon Nitride membrane) inside an optical (membrane-in-the-middle) cavity to observe quantum opto-mechanical effects. My project focused on the generation and verification of quantum entanglement between a (many) mechanical mode of a SiN membrane and an optical mode of the cavity.

2. Goals achieved and/or progress towards them

Great progress has been made on the way to the generation of quantum entanglement. A high finesse membrane-in-the-middle cavity is operational inside a 4 Kelvin Helium flow cryostat. The SiN membranes are reliably suspended inside the cavity with quality factors of above ten million. Also a quantum shot noise limited laser drive has been proven to reach the necessary noise levels. This lifts the system in the regime of cooperativity larger than unity and thus into the quantum regime, necessary to generate entanglement. Entanglement of such a (macroscopic) device is not only of great interest in fundamental science but also a key component for quantum information and computing.

The next step is to be able to tune the membrane position/frequency (and with that the opto-mechanical coupling) to reach the values necessary to generate an observable amount of entanglement.





Top: SiN membrane used as the opto-mechanical resonator.
Left: Schematic of the experimental setup.

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

During the course of my project I had the opportunity to travel and visit many different groups within the ITN network (Paris, Hannover, Lausanne), giving insight into routines, techniques, equipment, hardware and software implemented and used by other scientists. The ITN workshops helped me to acquire additional skills in the following topics: simulations with COMSOL, programming with Python, 3d printing and others.

ITN CQOM WORKSHOP ATTENDED:

- Finite Element Modelling, Lausanne, Switzerland, 21 July – 23 July 2014
- Laser Stabilisation and high sensitivity displacement sensing, Paris, France, 2 - 4 April 2014, Informal research presentation
- Fundamental Noise Sources, Mardorf, Germany, 16-20 June 2013
- Taking an idea to a product, Munich, Germany, 09-10 October 2013
- Diavolezza First Workshop, Switzerland, 10-14 February 2013, Talk

4. Participation and role in dissemination and outreach activities

My outreach activities were mostly limited to a great number of lab-tours to a diverse audiences, from events to get school kids interested into natural sciences up to other students and professors from in- and out-of-topic groups all over the world.

5. List of conferences attended

- Frontiers in Nanophotonics, Monte Verità, Switzerland, 31 August - 4 September 2015
- Quantum Nano- and Micromechanics, Monte Verità, Switzerland, 21-25 July 2013

6. Publications (with links)

A. Sawadsky, H.Kaufer, R. Moghadas Nia, S. P. Tarabrin, F. Ya. Khalili, K. Hammerer, R. Schnabel. *Observation of generalized Optomechanical Coupling and Cooling on Cavity Resonance*. Physical Review Letters, Vol. 114, Iss. 4 (2015)
http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.114.043601

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

I will stay with my current host institution and supervisor to complete my PhD research by summer 2017. After that I plan to switch to industry because of poor salary and contract conditions in science and because companies can also offer interesting work in research and development.