

# Marie Curie ITN cQOM

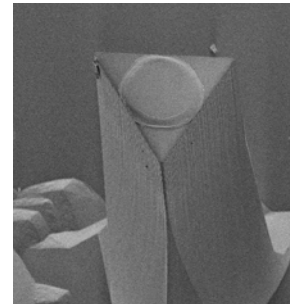
## Summary of the Scientific Achievements

**Name of Fellow:** Leonhard Neuhaus  
**Principal Investigator:** Antoine Heidmann  
**Academic / Industrial Institution:** LKB  
**Start Date of ITN Fellowship:** 1/9/2012  
**End Date of ITN Fellowship:** 31/8/2015  
**Date of Report:** 5/10/2015

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**Goal:** *Prepare and measure quantum states of mechanical motion*

- Fabricated quartz mechanical oscillators with quality factors of a million or above
- Successfully coated high-quality mirrors on the pillars;
- Mechanical properties remain intact
- Developed a stable mechanical mounting for the optomechanical mitigate vibration problems inside the cold dilution Helium boiling
- Developed an FPGA-based cavity lockbox from cheap (<500 Euro) commercially available components. The lockbox performance is superior to analog implementations with respect to scalability, choice of feedback transfer function, cost, DC-offsets and enables full automation of locking and data acquisition
- Implemented optical filter cavities for laser noise reduction in the measurement band
- Observed a Raman instability in Fabry-Perot cavities which sets an upper limit to the product of intracavity intensity and finesse
- Implemented two homodyne detection schemes with high quantum efficiency (>90%)
- Studied the mechanical properties of our samples between room temperature and 100mK
- Encountered thermalisation problems at cryogenic temperatures
- Observed a thermo-mechanical instability
- Designed a controller to counteract the thermo-mechanical instability to enable working at higher intracavity power to increase the measurement and cooling efficiency
- Prepared the experimental device for testing suprafluid film dynamics on our optomechanical system
- Now the quantum regime of optomechanics is in reach and will be exploited during a short postdoctoral stay at LKB



## Publications

- A.G. Kuhn, J. Teissier, L. Neuhaus *et.al.*, "Free-space cavity optomechanics in a cryogenic environment", *Appl. Phys. Lett.* 104, 044102 (2014)
- L. Neuhaus *et al.*, Digital cavity locking with FPGA's – an open source approach, in preparation
- L.Neuhaus *et al.*, Thermal instabilities in optomechanical systems, in preparation
- At least one more paper in preparation

## Conference – Talks

- "Practical limitations of intracavity power in (mechanically compliant) high-finesse Fabry-Perot cavities" at Fiber Fabry-Perot days 2015, Paris, France
- "Custom-tailored real-time DSP in quantum optics experiments" at Zynq days 2015, Paris, France
- "Progress towards cooling a microgram-scale optomechanical resonator to its quantum ground state" at CLEO EUROPE 2015, Munich, Germany
- "Fabry-Perot Cavity Optomechanics with Ultrahigh Mechanical-Q-Factor Quartz micropillars at Cryogenic Temperature" at CLEO Europe 2013, Munich, Germany
- "A versatile scheme for read-out and actuation of nanomechanical motion using silica microspheres" at CLEO US 2012, San José, CA, USA

## Conference – Posters

- "High-mechanical-Q quartz resonators at cryogenic temperatures in a Fabry-Perot cavity" at GRC 2014 on "Mechanical systems in the quantum regime", Ventura, CA, USA\
- "High-mechanical-Q quartz resonators at cryogenic temperatures in a Fabry-Perot cavity" at COLOQ 2013, Villetaneuse, France
- "High-mechanical-Q quartz resonators at cryogenic temperatures in a Fabry-Perot cavity" at Frontiers of Nanomechanics 2013, Trieste, Italy