

Marie Curie ITN cQOM

Summary of the Scientific Achievements

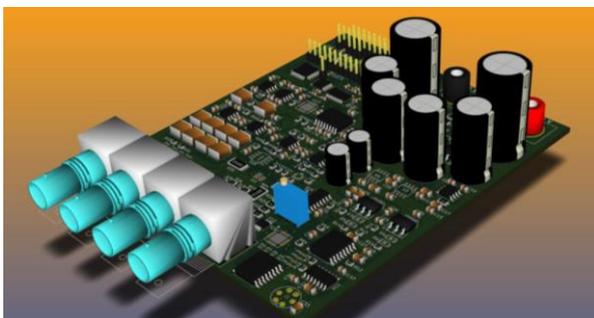
Name of Fellow: Hans Hepach
Principal Investigator: Markus Aspelmeyer
Academic / Industrial Institution: University of Vienna
Start Date of ITN Fellowship: 03.12.2015
End Date of ITN Fellowship: 30.05.2016
Date of Report: 28.06.2016

1. Description of research work

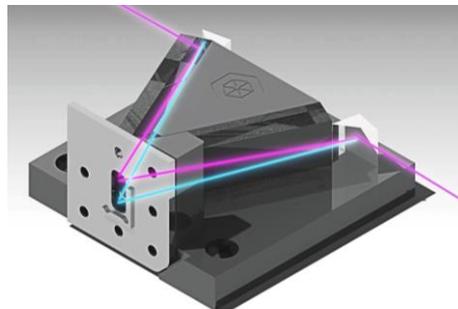
The experiment I am helping to set up is described in the publication linked below. It aims at demonstrating gravitational attraction between small test masses by combining experimental techniques from quantum optics and micromechanics. Although related experiments have already been conducted, this will be the first time where source as well as test mass are equally small (around 80mg). The main challenge for the detection of the gravitational attraction is the perturbation of the test mass by noise sources. Keeping the technical noise sources such as vibrational noise under control is certainly challenging, but avoiding fundamental noise sources such as shot noise in laser beams due to the statistical nature of the photon emission in the laser itself is much more difficult.

Reducing the relative laser shot noise is possible by increasing the overall power in the laser beam, as the shot noise increases slower than the signal and thus reducing the relative noise level. The standard solution for this problem consists in using a cavity, which increases the laser power by making the light bounce back and forth between a set of mirrors. However, such a configuration may prove difficult to align. On the other hand just increasing the laser power by using a more powerful laser presents the problem of detecting a large amount of laser power while adding a minimal amount of noise.

My project during the ITN fellowship has been to design and implement a new low noise detector design, which will be able to handle large amounts of power. This proved surprisingly difficult. The final version seems to meet the project requirements, which is therefore nearly completed.



3D view of the final detector



Sketch of the final optical setup

2. Goals achieved and/or progress towards them

It has been my main goal during the past six months to complete and finalize the development of the new low noise high power homodyne detector for frequencies in the audio band. This required delving into electronics, which has not been part of my training prior to this project. I do now have the necessary skills needed for the final steps in completing the project, which in itself is but a building block of the experiment we are working to set up. There is still a lot of work to do before we will be able to actually measure the gravitational attraction between small test masses, but the progress made during the duration of this project is promising.

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

During the past six months I have attended the ITN workshops in Diavolezza in January / February 2016 as well as the final workshop in Ghent in May 2016. These have given me the possibility to present our group's work and results to fellow scientists. Especially the last workshop with its visit of the cleanroom facilities of IMEC has demonstrated the relevance of quantum optics techniques to recent advances in (computer) chip production.

In between the workshops I have completed an introductory course to our workshop, which enables me to fabricate simpler parts for the experiment myself.

The following ITN workshops have been attended:

- 2016 cQOM Annual Diavolezza Workshop
Diavolezza, Switzerland, January 31 – February 4 2016
- From Photonics Research to the CMOS-fab
University of Ghent, Belgium, May 17 – 19 2016

4. Participation and role in dissemination and outreach activities

I have not participated in any outreach activities, yet, a part from occasional lab tours. Starting from the beginning of July I will supervise the internship of a student and prospective undergraduate student of physics.

5. List of conferences attended

- DPG Frühjahrstagung
Hannover, Germany, February 29 – March 4 2016

6. Publications (with links)

J. Schmöle, M. Dragosits, H. Hepach and M. Aspelmeyer. *A micromechanical proof-of-principle experiment for measuring the gravitational force of milligram masses*, Classical and Quantum Gravity, Vol. 33, No. 12 (2016)

<http://iopscience.iop.org/article/10.1088/0264-9381/33/12/125031>

7. Career plans after ITN

There is still a lot to be set up before the experiment can be successfully run. Therefore, I will continue working on the experiment. I am still in the beginning of my PhD, which means I will probably stay with my current group for the next years. Currently it is still my plan to continue working in research, but that will be decided once my PhD is finished.