Marie Curie ITN cQOM
Summary of the Scientific Achievements

Name of Fellow: Sergey Fedorov
Principal Investigator: Prof. Tobias Kippenberg
Academic / Industrial Institution: EPFL
Start Date of ITN Fellowship: 15/09/2015
End Date of ITN Fellowship: 31/05/2016
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1. Description of research work

My research work focused on cavity optomechanics with a hybrid SiN nanobeam – Silica microdisk system. Our study looks into the interaction of light with macroscopic mechanical oscillations in the quantum regime. The focus of my work is towards continuous measurements and feedback control of the mechanical oscillator position.

Quantum effects in an optomechanical system subjecting to linear measurements on the light field manifest when the rate of mechanical position measurements becomes comparable with the thermal decoherence rate. In our experiment the high single-photon cooperativity ~1 of the optomechanical system and operation in cryogenic environment provide access to the ratio of measurement to decoherence rate of 0.05-0.1 and enable robust observation of quantum effects at few-percent level.

2. Goals achieved and/or progress towards them

During the period of 15/09/2015 – 31/05/2016 we succeeded in the demonstration of ponderomotive squeezing of light, which is a manifestation of correlations between the laser shot noise and quantum backaction. This result was presented at the last ITN Workshop at UGENT "From Photonics Research to the CMOS-fab".

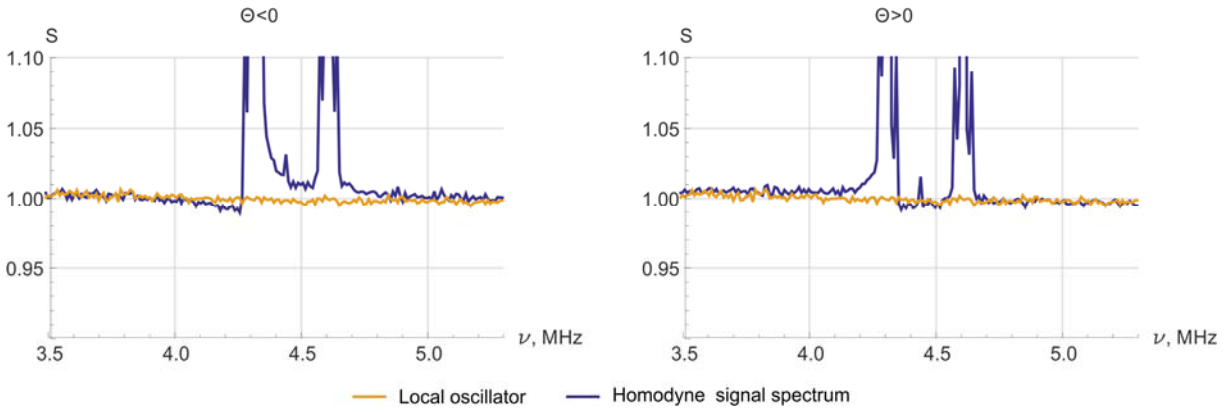

Figure 1. Plots showing ponderomotive squeezing of light – laser noise going below the level of shot noise (local oscillator at the plots). Left and right plots compare the effect measured at different homodyne detection angles and show existence of squeezing in different frequency bandwidths, which is a salient feature in agreement with theory.

After having shown the presence of quantum correlations in our experiment, ongoing work will aim to demonstrate the ability to control these correlations using measurement-based feedback. Currently in the experiment we have shown the persistence of quantum correlations in a

feedback-controlled optomechanical system in a weaker form than squeezing – the mechanical lineshape asymmetry.

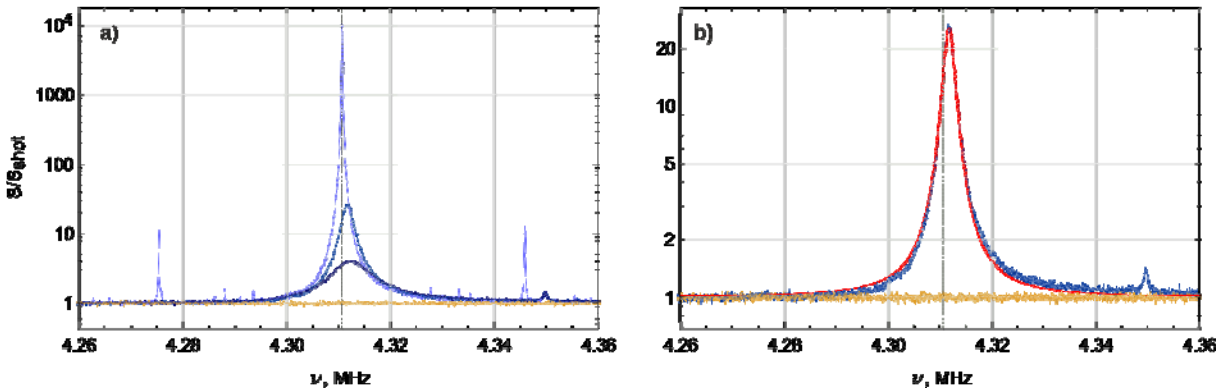

Figure 2. Oscillator motion spectra under the action of linear feedback. a) Blue traces from light to dark show evolution of displacement spectrum with variation of linear feedback gain (starting from 0). b) Fit of one of the feedback-modified displacement spectra with a Lorenzian showing lineshape asymmetry – a signature of quantum backaction-imprecision correlations in the detection. The shaded region shows the bandwidth of feedback.

The latter result is consistent with the previous outcome of our group's work – demonstration for the first time in optomechanics that imprecision-backaction correlations in the form of sideband asymmetry can survive under measurement-based cold damping.

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

1. ITN cQOM workshop: "Taking a Research Idea to a Product", Ruschlikon, Switzerland, 30-November-1 December 2015.
2. Diavolezza annual ITN cQOM Workshop, Switzerland, 31 January – 4 February 2016.
3. ITN cQOM workshop "From Photonics Research to the CMOS-fab", University of Ghent, Belgium, 17-19 May 2016.

4. List of conferences attended

1. Les Houches Summer Physics School on Optomechanics, Les Houches, France, 1-29 August 2016.

5. Publications (with links)

The results on the detection of ponderomotive squeezing of light will be documented in an upcoming manuscript to be submitted to *Physical Review X*.

6. Career plans after ITN

My plan is to complete my PhD in approximately 4 years and then to continue work in academia as a postdoc.