Two-membrane cavity optomechanics

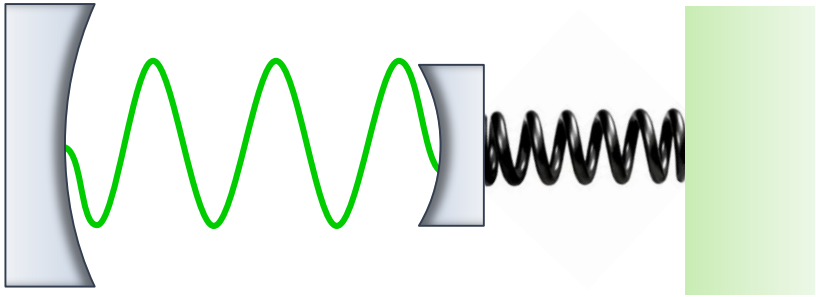
Paolo Piergentili

28/09/2020

Young IQIS 2020

This work is supported by the EU H2020 research and innovation programme under grant agreements No 722923 (OMT) and 732894 (HOT)

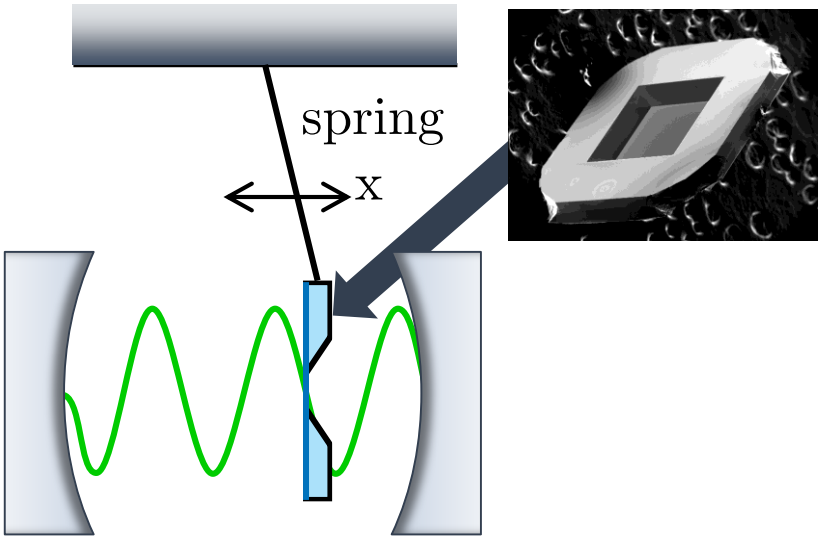
Introduction

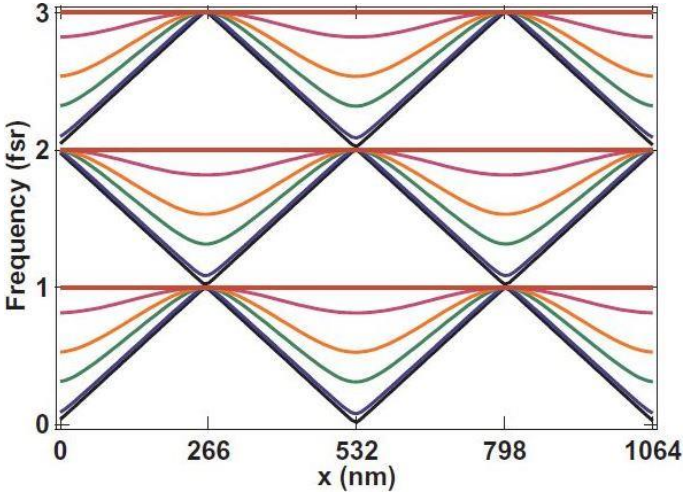


$$\omega_{cav} = \omega_0 \left(1 - \frac{\hat{x}}{L}\right)$$

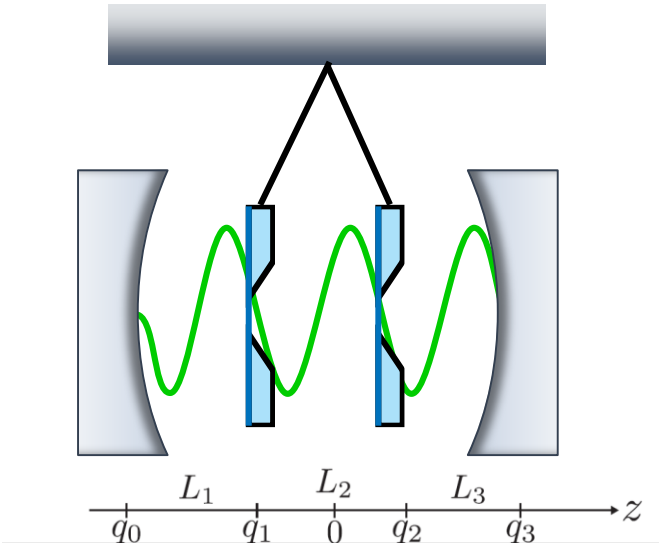
Radiation pressure couples the cavity radiation field to the mechanical motion.

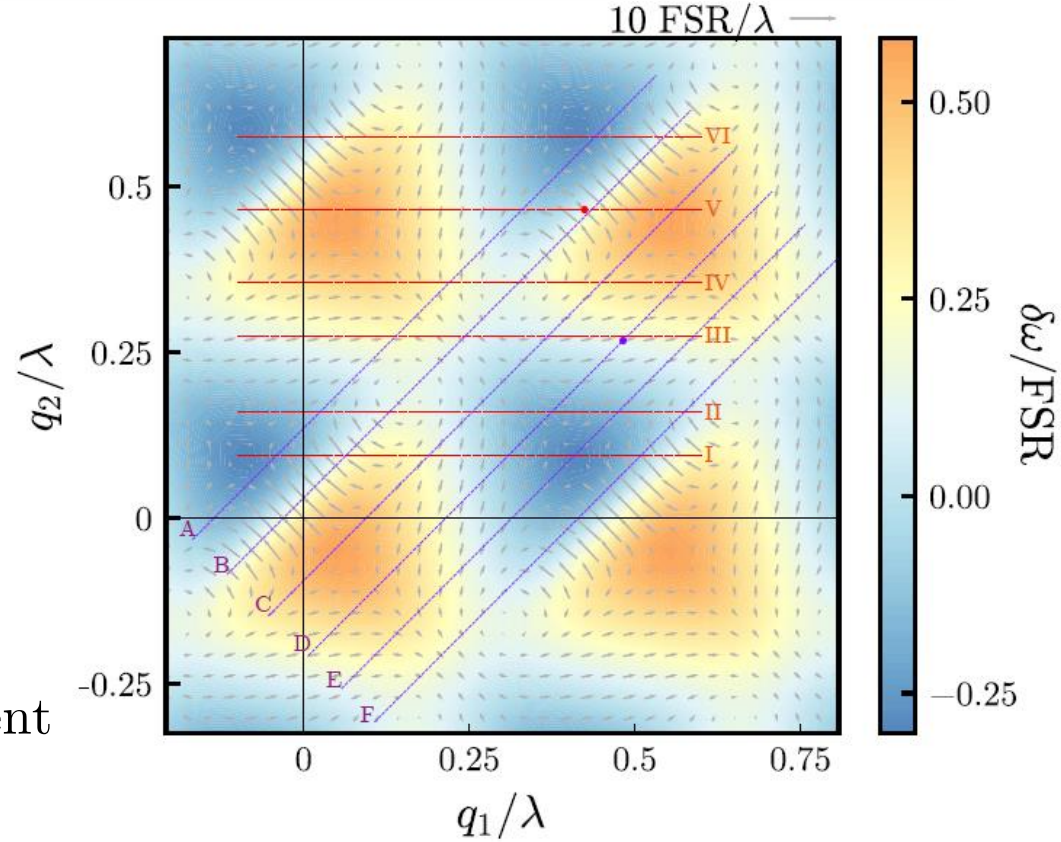
$$G = \frac{d\omega_{cav}}{dx} = \frac{\omega_0}{L}$$





Two-membrane cavity optomechanics





Advantages:

- Strong coupling regime
- Energy transfer and entanglement
- Synchronization

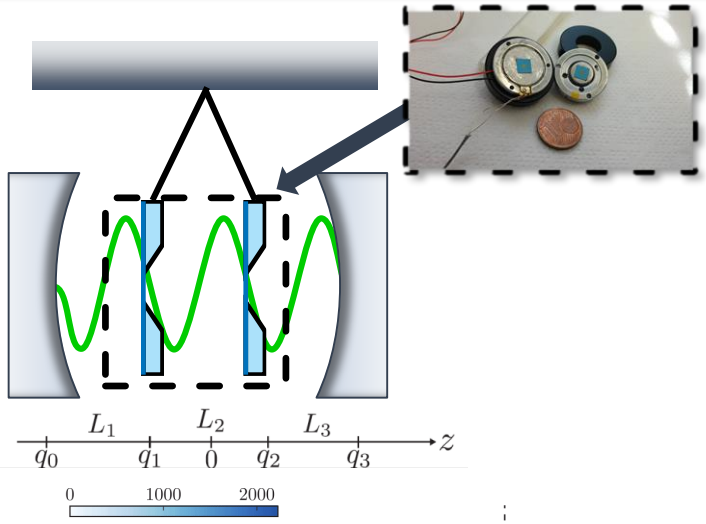
$R_m < 1 \longrightarrow |G_j^{max}| = \frac{1}{1-\sqrt{R_m}} |G_{sing}^{max}|$

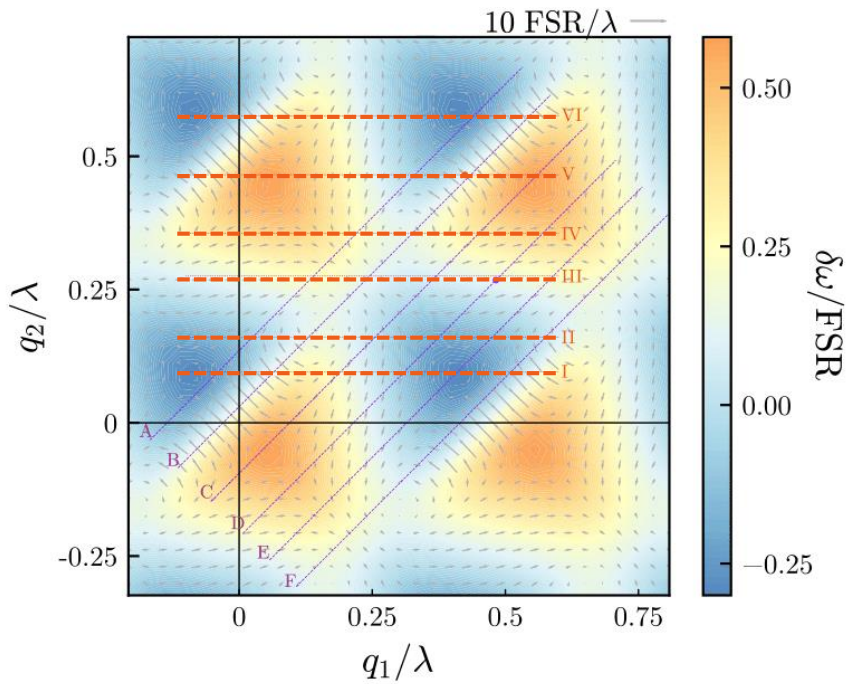
$R_m \sim 1 \longrightarrow |G_j^{sat}| = 2\pi c/(\lambda L_c)$

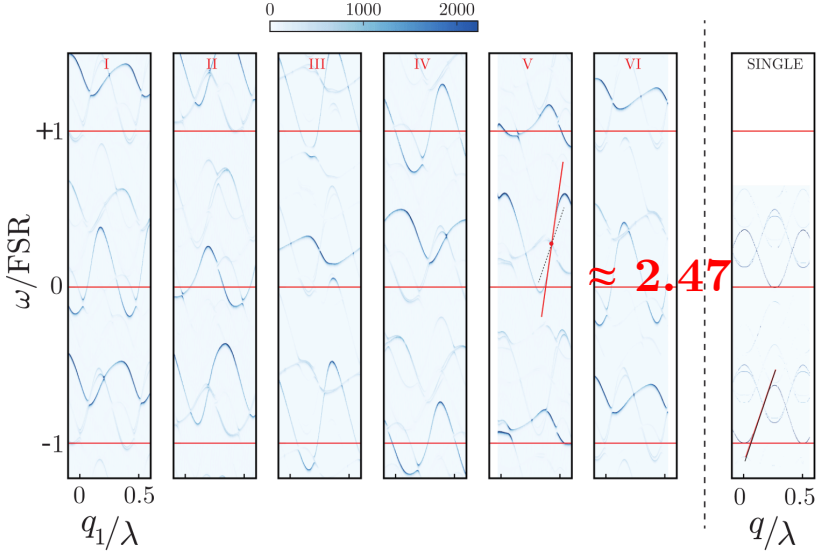
$R_m \sim 0.4 \longrightarrow |G_j^{max}| \sim \mathbf{2.72} |G_{sing}^{max}|$

- **Piergentili P. et al., Two-membrane cavity optomechanics, New J. Phys. 20 083024, 2018, https://doi.org/10.1088/1367-2630/aad85f**
- **Perspective: Jan Gieseler, New J. Phys. 20 101001, 2018, https://doi.org/10.1088/1367-2630/aae3c0**

Optomechanical coupling strength





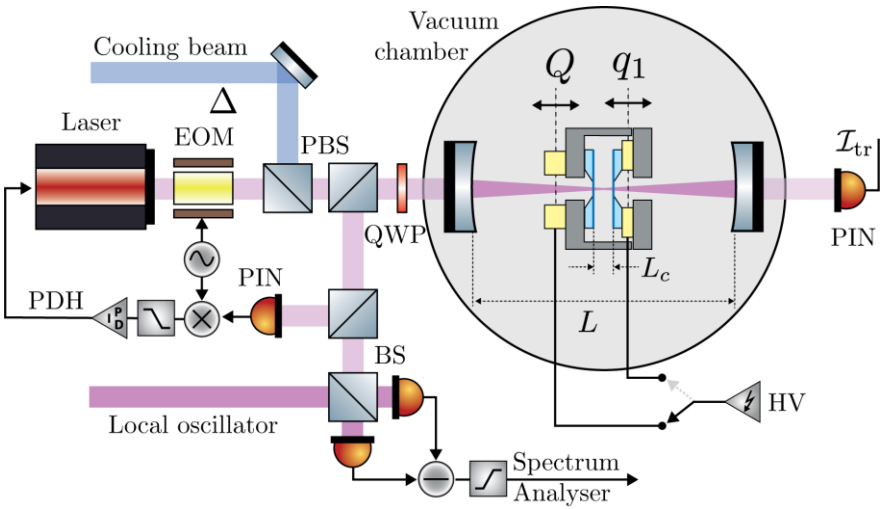


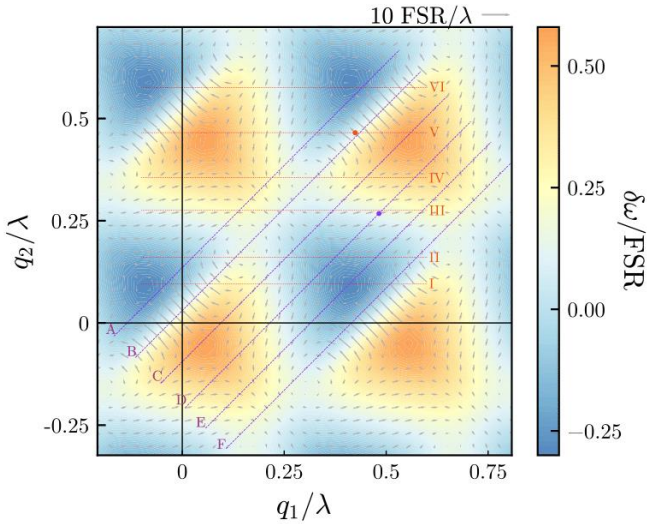
Advantages:

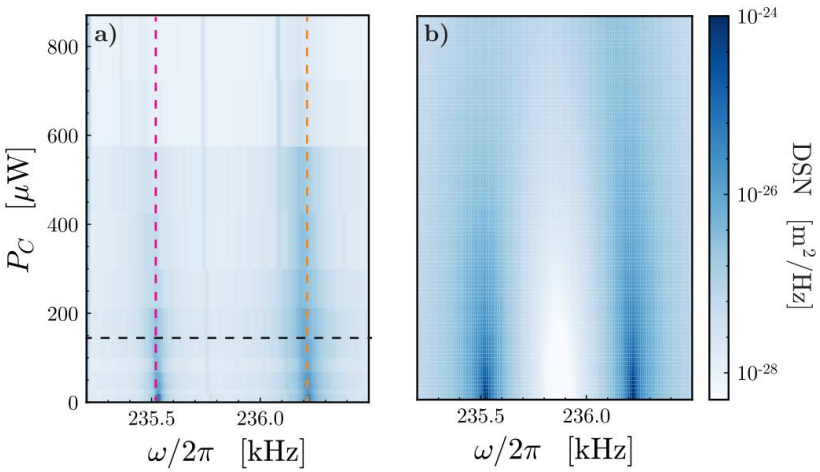
- Strong coupling regime
- Energy transfer and entanglement
- Synchronization

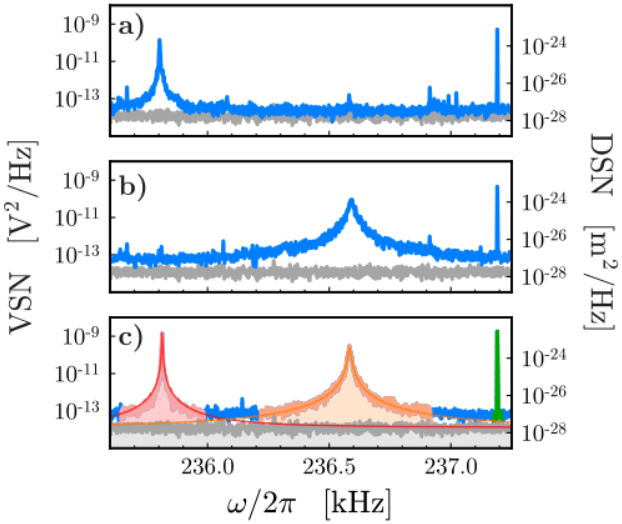
- **Piergentili P. et al., Two-membrane cavity optomechanics, New J. Phys. 20 083024, 2018, https://doi.org/10.1088/1367-2630/aad85f**
- **Perspective: Jan Gieseler, *New J. Phys.* 20 101001, 2018, https://doi.org/10.1088/1367-2630/aae3c0**

Tunable coupling - laser cooling

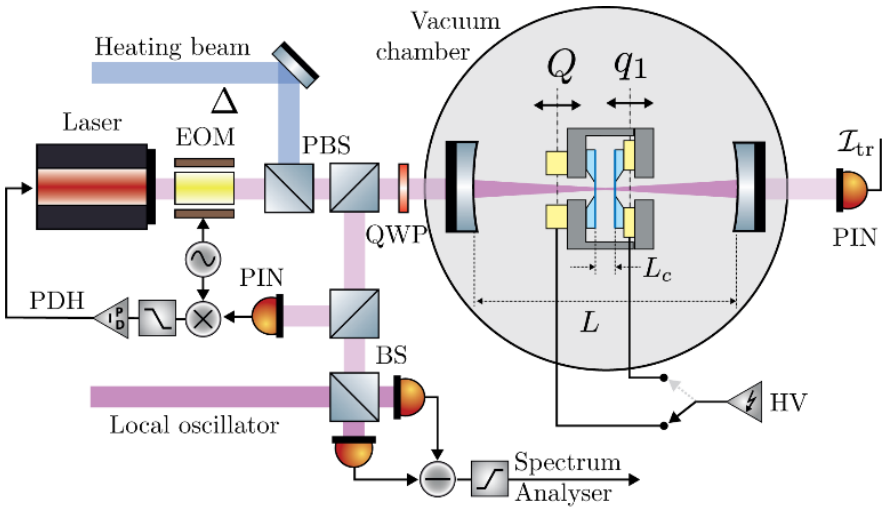


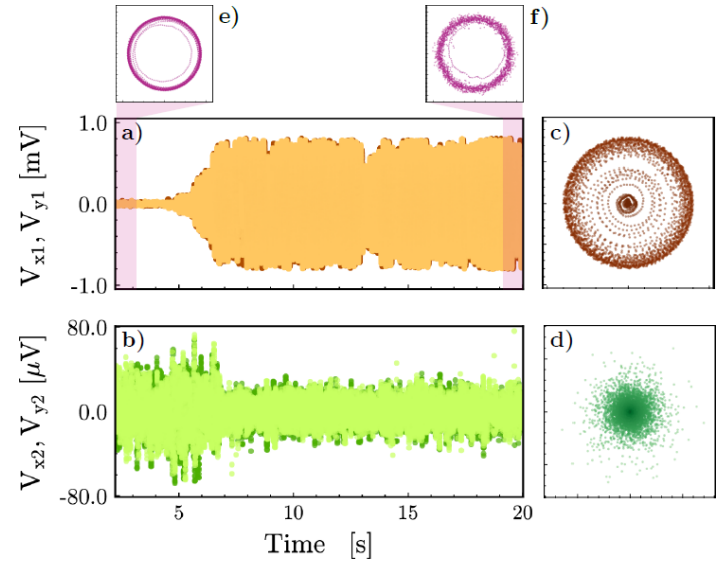


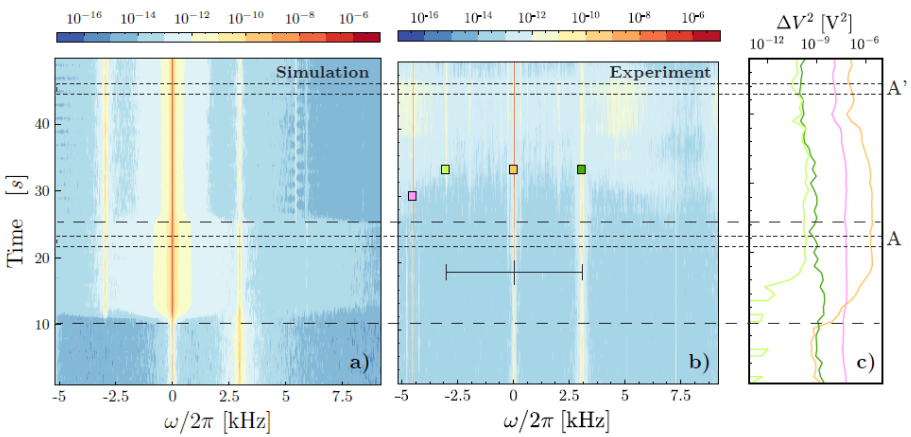


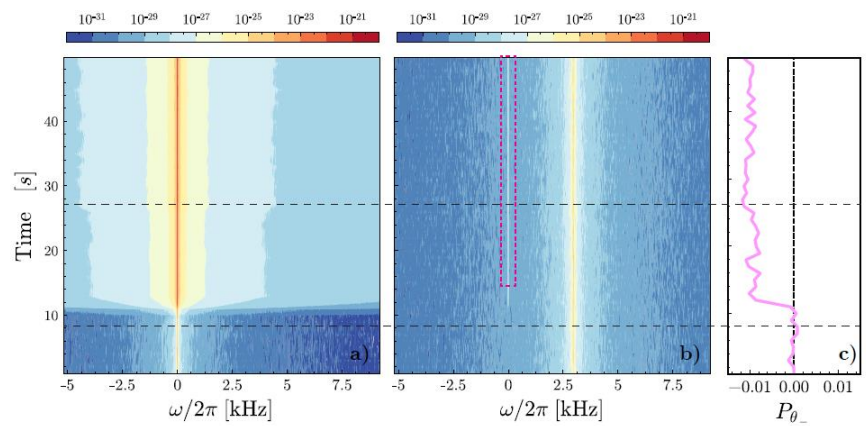


Laser heating - onset of synchronization





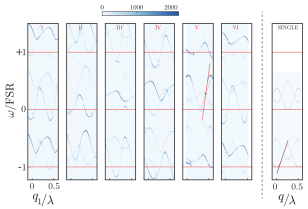




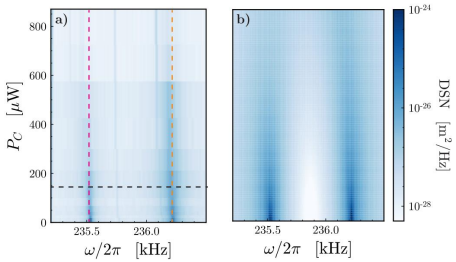
- **Piergentili P. et al., Two-membrane cavity optomechanics: non-linear dynamics, arXiv:2009.04694**

Conclusions

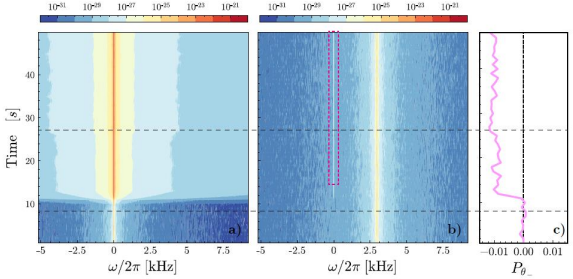
- Enhanced the optomechanical coupling strength by a factor ≈ 2.47 respect to the single membrane case.



- Optical cooling and heating of the fundamental modes of the membranes.



- Onset of synchronization.



- Non-linear dynamics of the optomechanical system.