

Master 2 Internship

Title: Phase synchronization and neuromorphic computing in arrays of nanoelectromechanical oscillators

Supervisor(s): Fabio Pistolesi: Fabio.Pistolesi at u-bordeaux.fr and Rémi Avriller: remi.avriller at u-bordeaux.fr

PhD funding (if any): + PhD fellowship (founded by ANR)

Project: Context. Recent progress in micro and nanofabrication enabled to design mechanical micro and nano-resonators with properties well controlled by external gate voltages and electronic currents. In particular, SiN drum resonators [1] (see Fig.1) were shown to have large capacitive coupling to the gate electrode and high-quality factors, thus making them ideal candidates for further integration in complex electronic circuits. Indeed, arrays of such micro and nano-resonators, have been predicted to synchronize due to their large mechanical non-linearities [2,3], low dissipation rate, and mutual mechanical and optomechanical coupling. *This suggests to use them in innovative devices as elementary building blocks for performing neurocomputing calculations* [4,5].

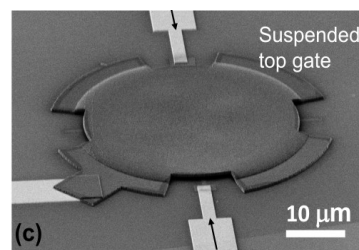


Figure 1: Image of a suspended SiN membrane, forming a nano-mechanical drum resonator

In this M2 internship, we propose to investigate from the theoretical point of view, the mechanism of phase synchronization of arrays of SiN drum resonators, coupled to a single microwave optomechanical circuit.

The internship will first focus on the effect of non-linearities and of how they affect the dynamics of a single opto-mechanical resonator. Then, we will investigate the conditions of phase synchronization to occur when many such resonators couple to the same microwave cavity [3]. *The final goal of this work is to investigate how this system can perform neurocomputing tasks (for instance, pattern recognition).*

The candidate profile. The candidate for the Master 2 internship should have a background and interest in the following disciplines: quantum physics, statistical physics, condensed matter. Good skills and tastes in analytical methods, scientific computing and English would be appreciated. The candidate will be supervised by **Fabio Pistolesi** and **Rémi Avriller** in *LOMA, a laboratory of CNRS and of the University of Bordeaux*. He (she) will benefit from a dynamic scientific environment, and the possibility to continue in PhD (available fellowship financed by ANR).

References:

- [1] X. Zhou, et al., Nano Letters, 21, **13**, 5738-5744 (2021)
- [2] M. H. Matheny, et al., Phys.Rev.Lett. **112**, 014101 (2014).
- [3] G. Heinrich, et al., Phys. Rev. Lett. **107**, 043603 (2011).
- [4] M. Romera, et al., Nature **563**, 230–234 (2018)
- [5] Frank C. Hoppensteadt, et al., IEEE Transactions, 48, 2, 133-138, (2001).