MAnipulating heat CArriers: from the Classical to the QUantum regime (MaCaCQu)

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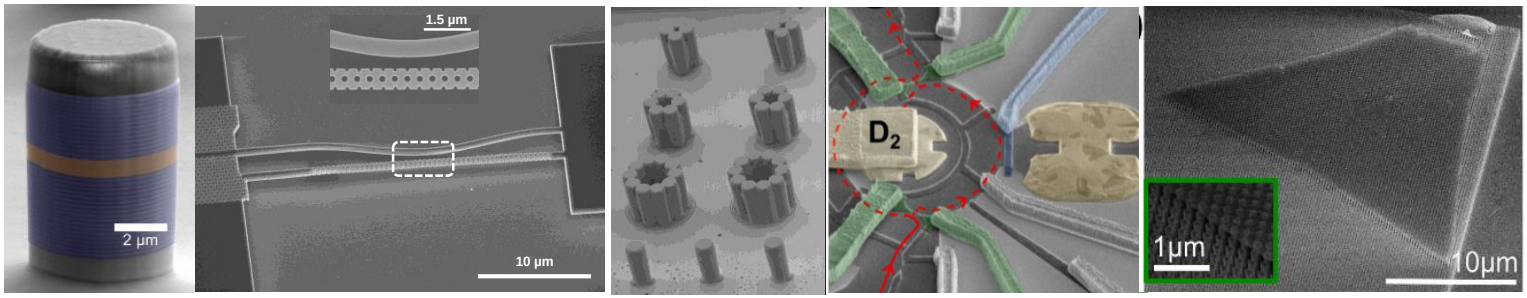
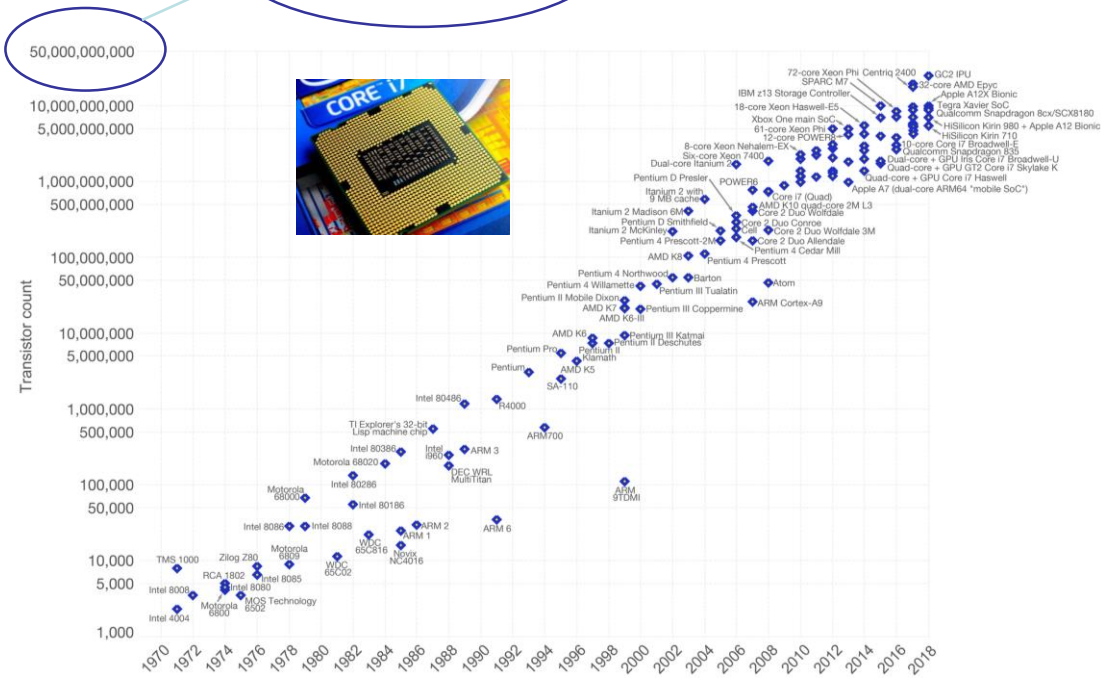
3 communities, 11 teams working to reach the ultimate control of heat carriers
Never worked together before, no common workshops, no common projects



Motivation

50 000 000 000 It doubles every 2 years



Transistor count vs. year

Coherence properties of heat carriers

Control of the mutual interactions

Heat carriers in complex systems

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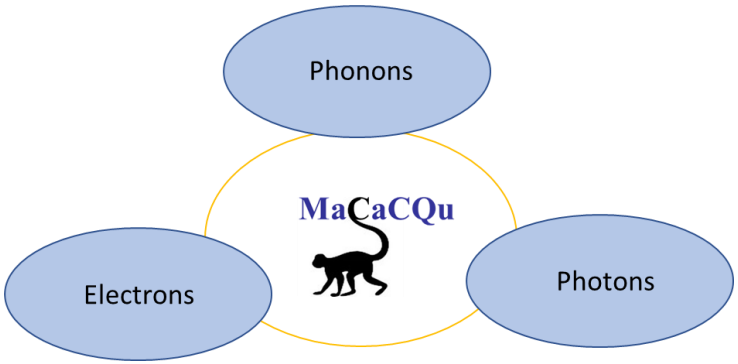
Need for novel strategies and models
Access to novel operation regimes and phenomena

Objective



Coherence

Thermal transport

Complex dynamics

To develop methods and strategies to control and manipulate heat carriers to tackle these key challenges

To structure a new and strong scientific community
around the ultimate control of photons, phonons, electrons and their interactions

Our objective:

To reach an ultimate control of heat carriers and their interactions

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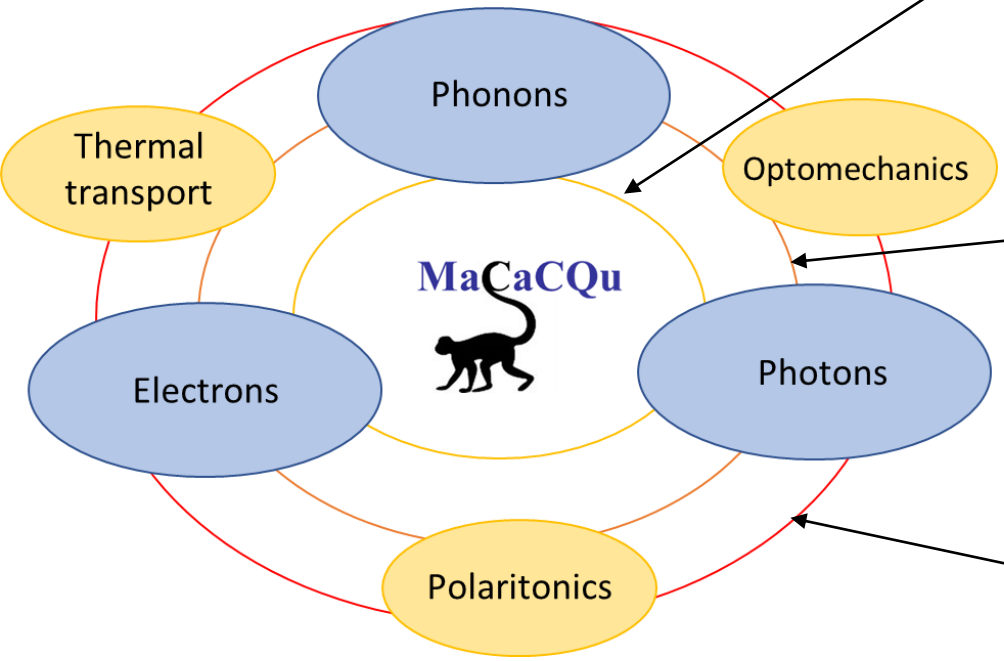
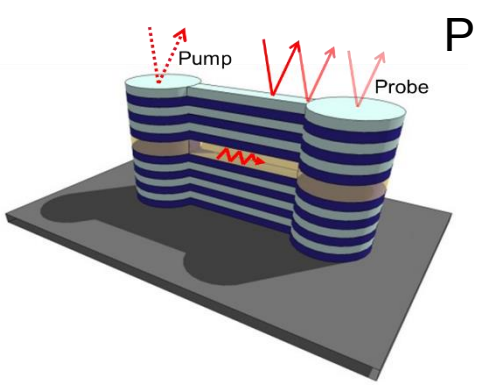


1 Fundamental heat carriers

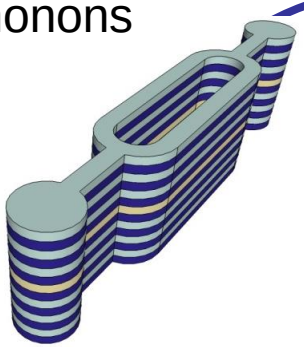
2 Transport regimes and transduction mechanisms

3 Complexity-enabled phenomena

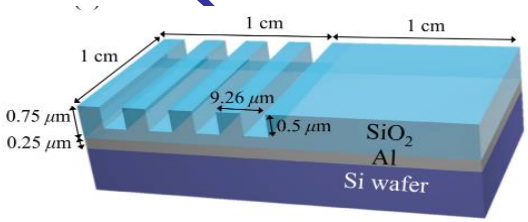
Axis 1: Coherence properties of heat carriers

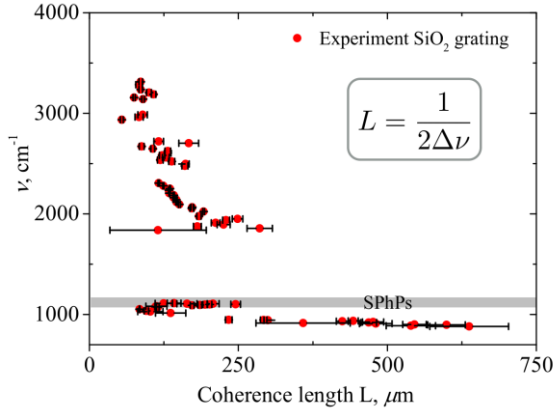


Phonons

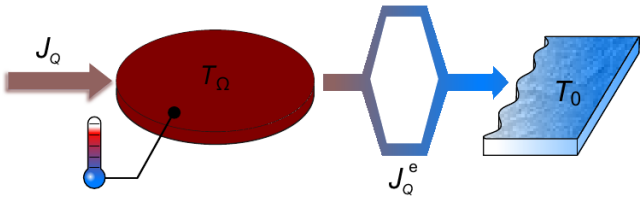


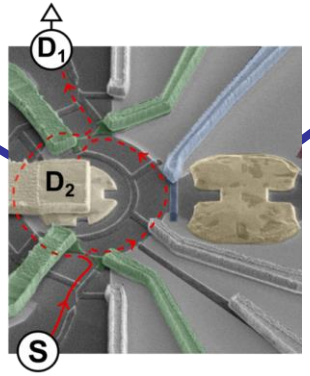
Photons





Electrons





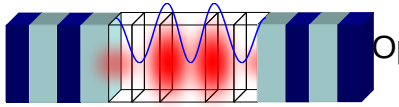
Fundamentally different particles

Similar physical principles

Quantum and classical interferences

Axis 2: Heat transport and transduction

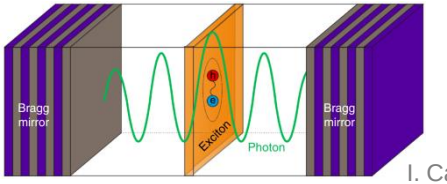
Nanophononics



Optomechanical interactions (amplification, cooling).

M. Aspelmeyer, *et al.*, RMP **86** (2014)

Polaritonics



Nonlinear physics (BEC, superfluidity), Topology.

I. Carusotto and C. Ciuti, RMP **85** (2013)

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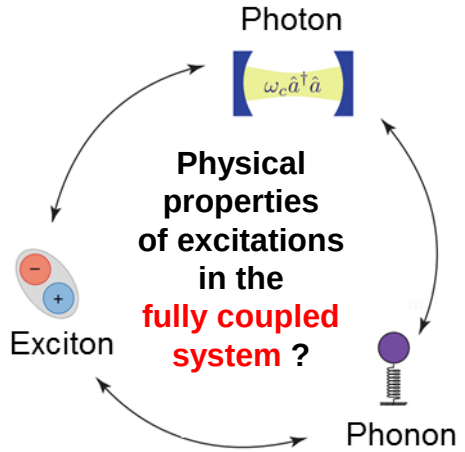
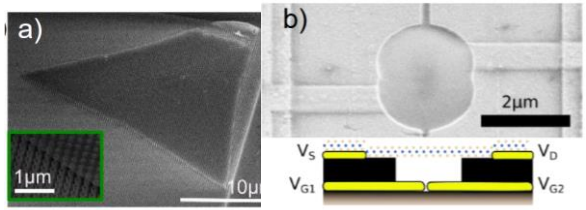
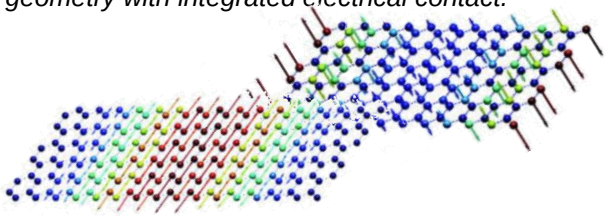


Fabrication & experiments



monolayer MoS2 on nanopillars b) another geometry with integrated electrical contact.

Theory & modeling



Comprehensive thermoelectric models based on nanostructured 2D materials

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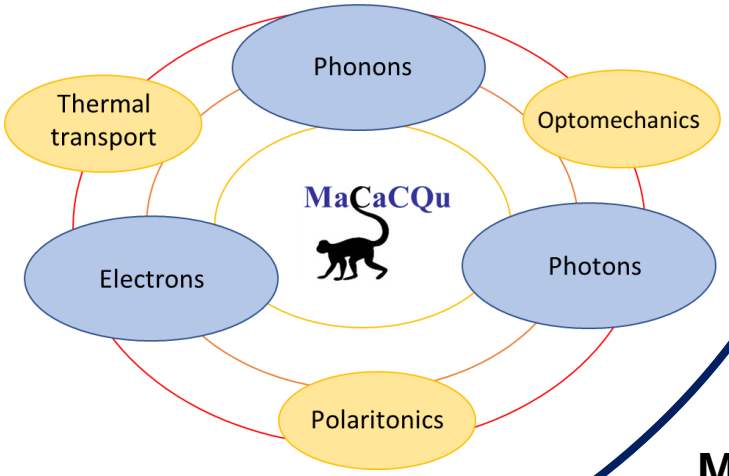
Raman **thermometry experiments**

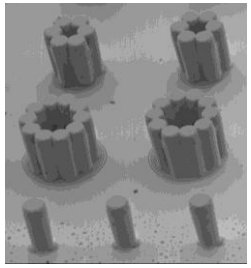
Fabrication of suspended 2D devices MoS2 and SnS2

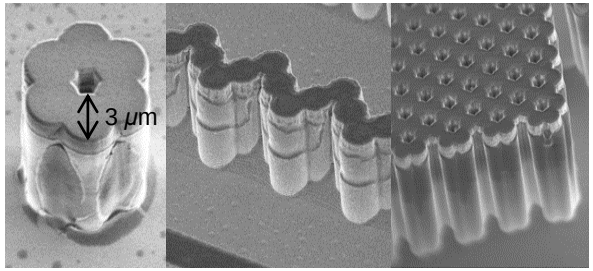
Multi-scale modeling

Axis 3: Complexity-enabled phenomena

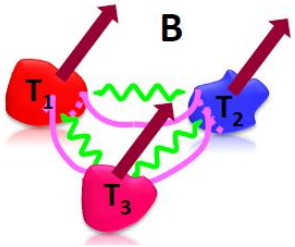


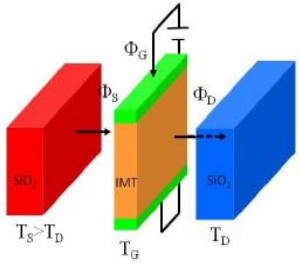
Topological transport and nonlinearities



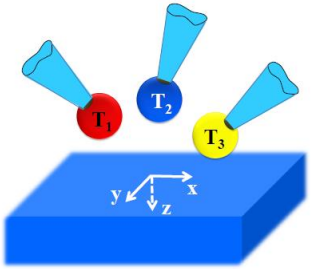


Many body radiative heat transfer



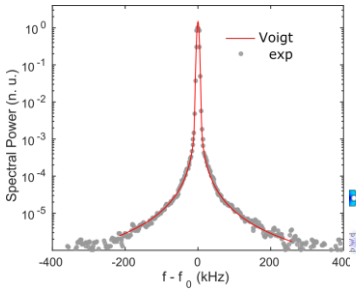


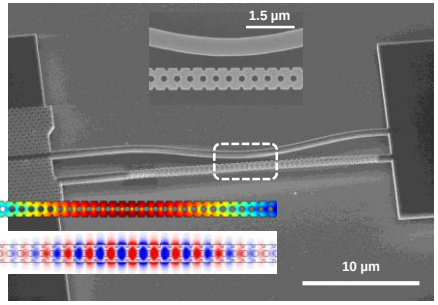
Thermal transistor

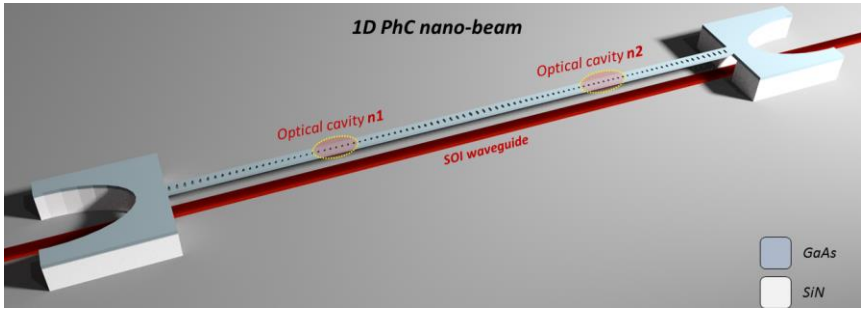


Multi-tips SThM

Chaos and synchronization







Our objective:

To reach an ultimate control of heat carriers and their interactions

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1 Fundamental heat carriers

- Phonons
- Photons
- Electrons

2 Transport regimes and transduction mechanisms

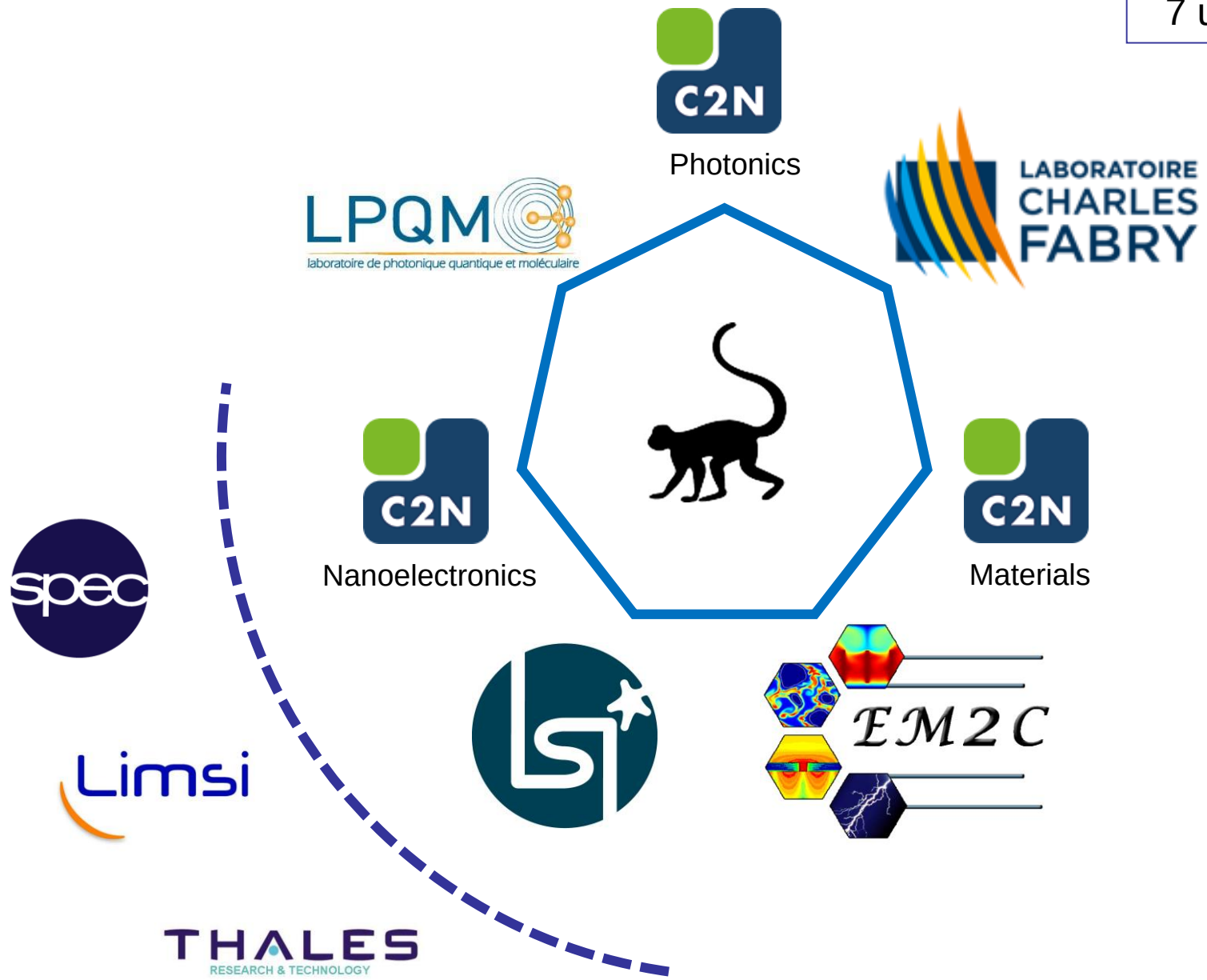
- Contact resistance (e-ph)
- Heat transfer in 2D materials
- Phonon-polaritonics

3 Complexity-enabled phenomena

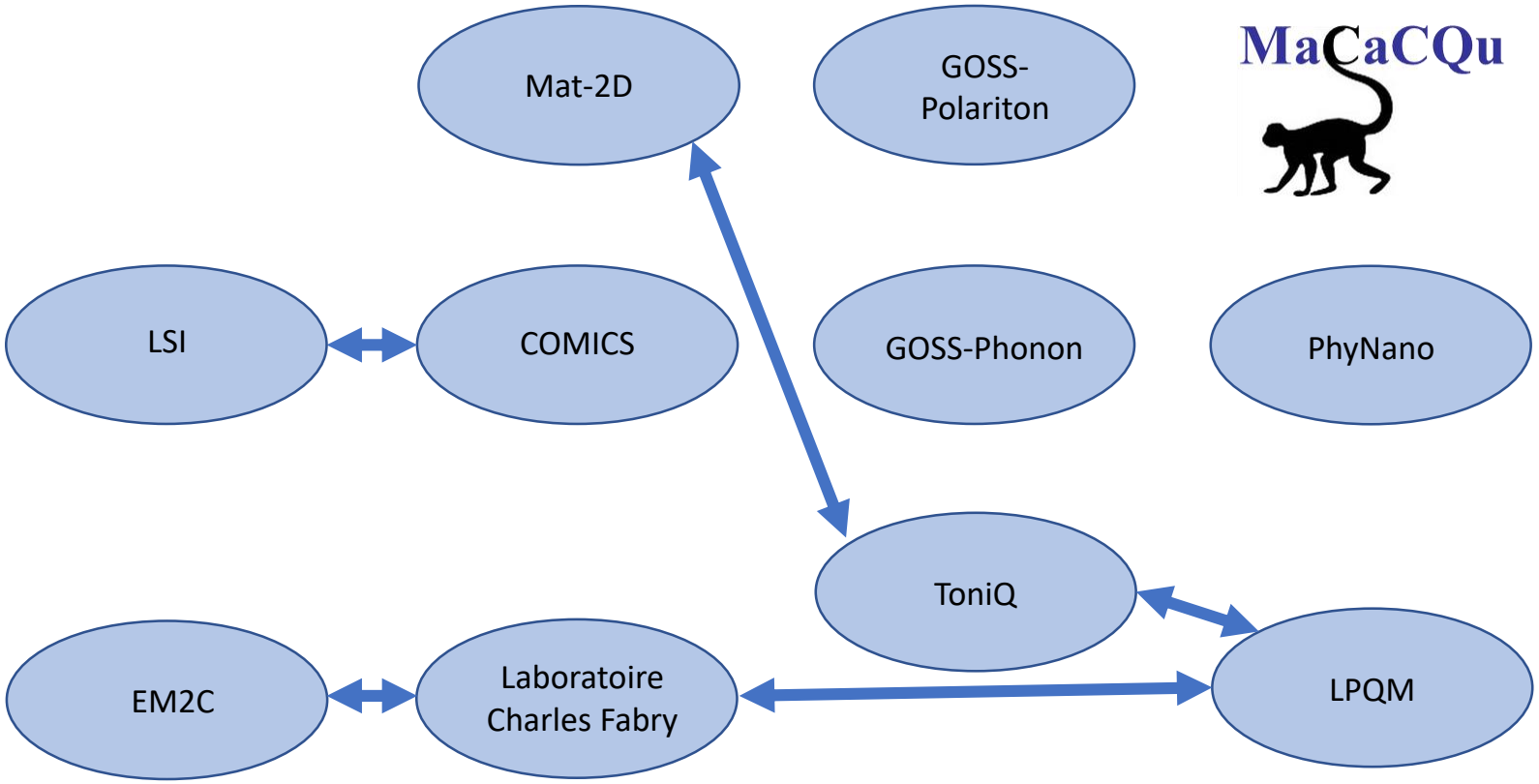
- Coupled optomechanical resonators
- Many body thermal radiation
- Topology and non-linearities

Structuring the community

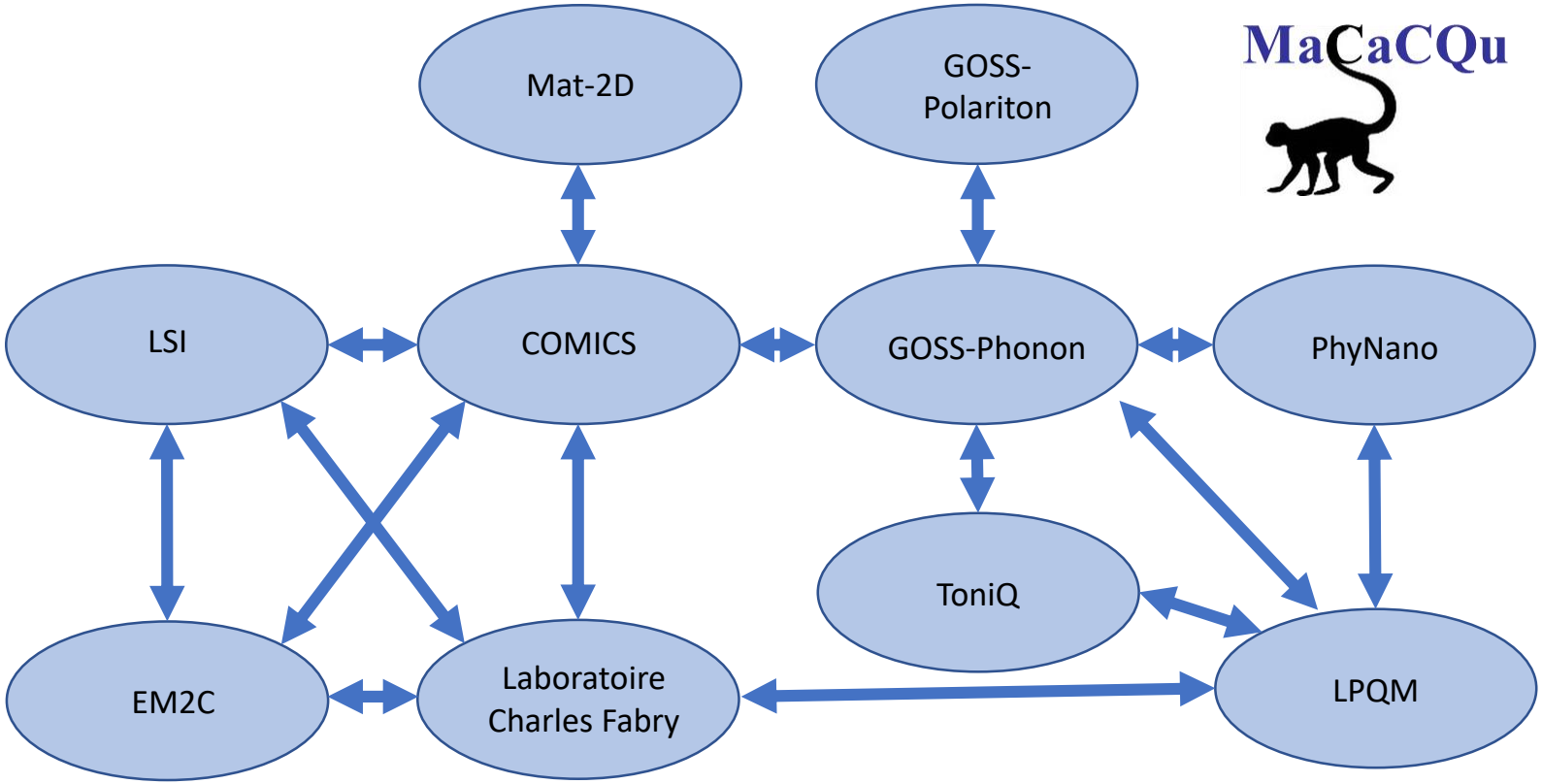
25 researchers
11 teams
7 units NanoSaclay



Structuring the community

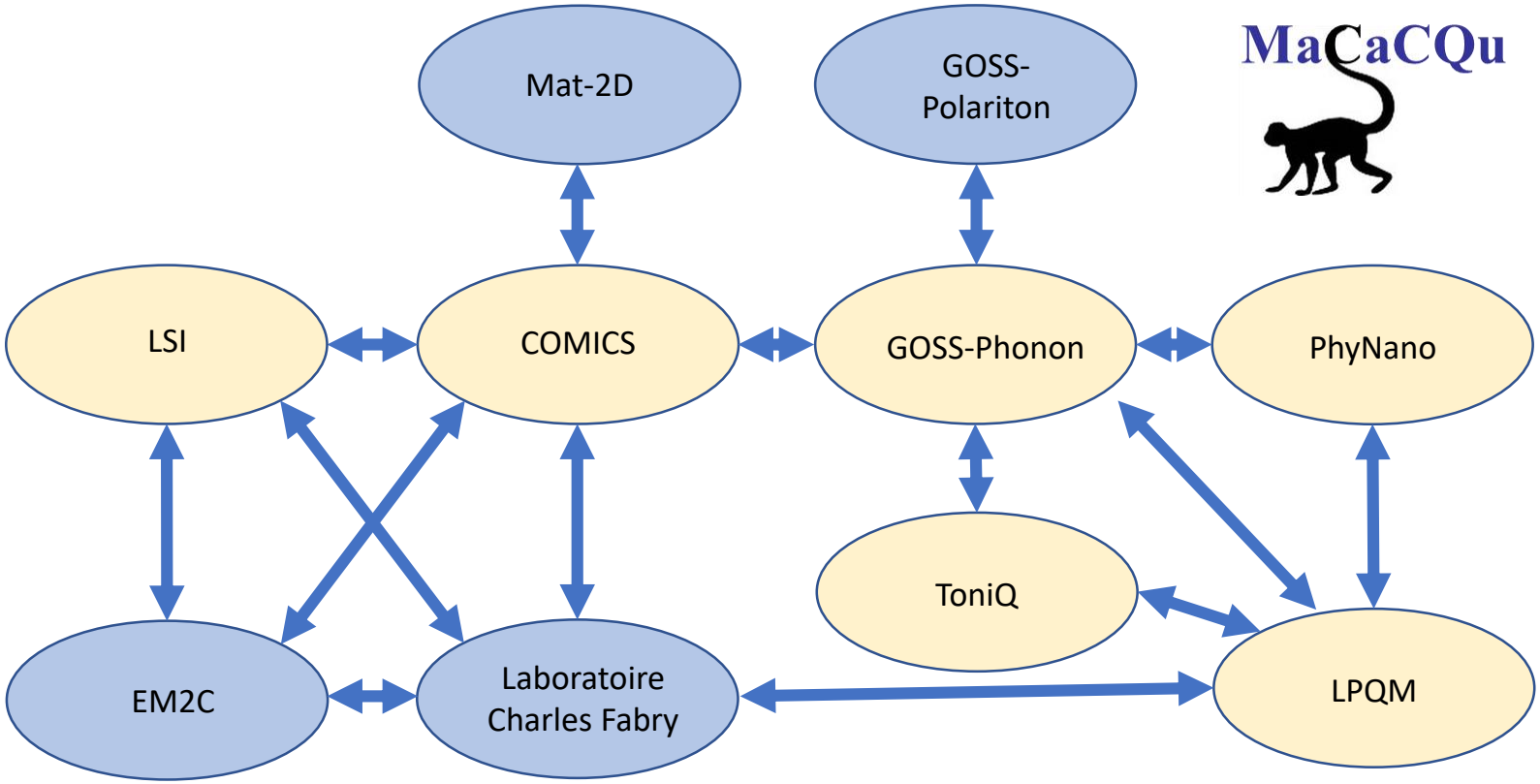


Structuring the community



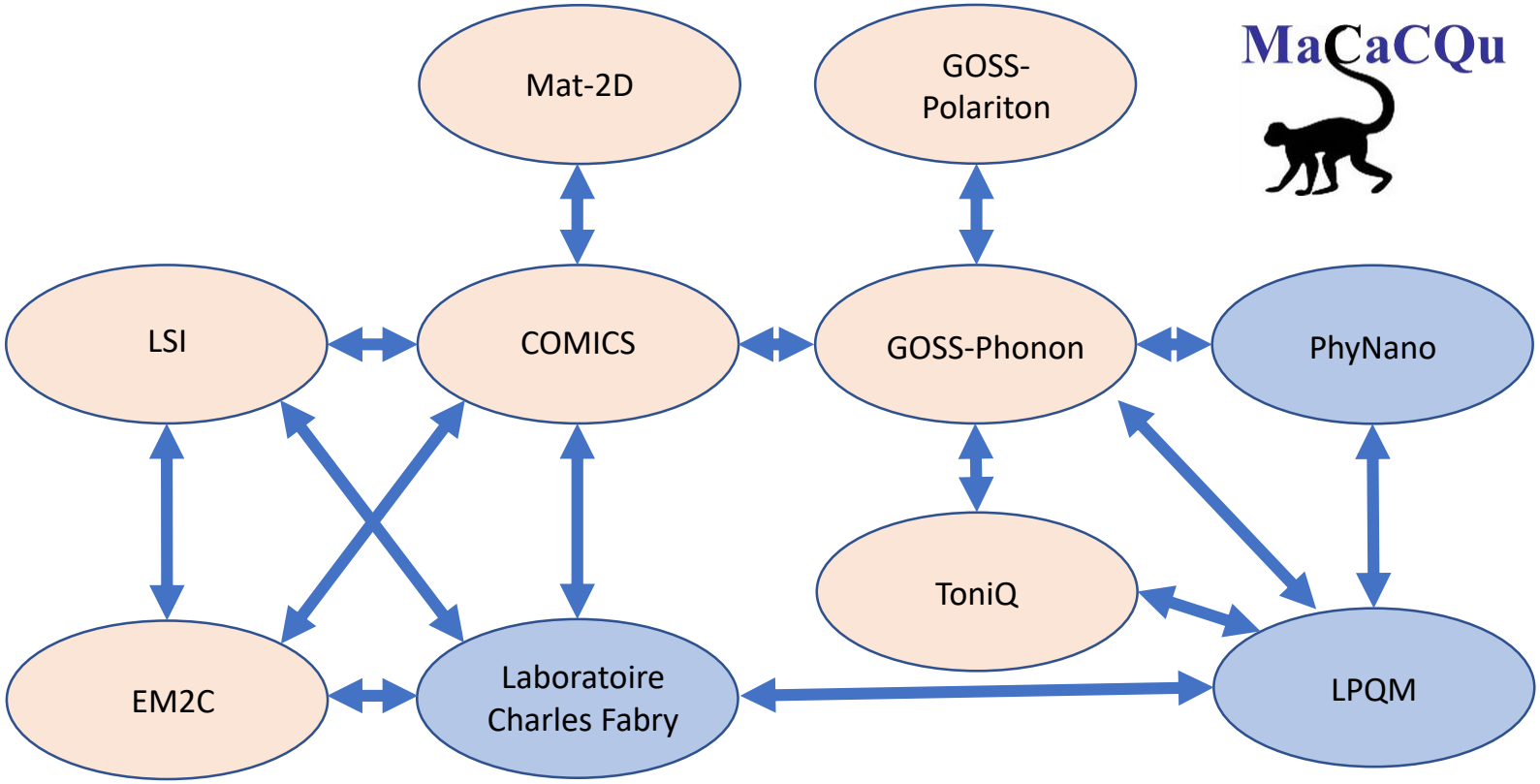
Structuring the community:

1. Fundamental heat carriers



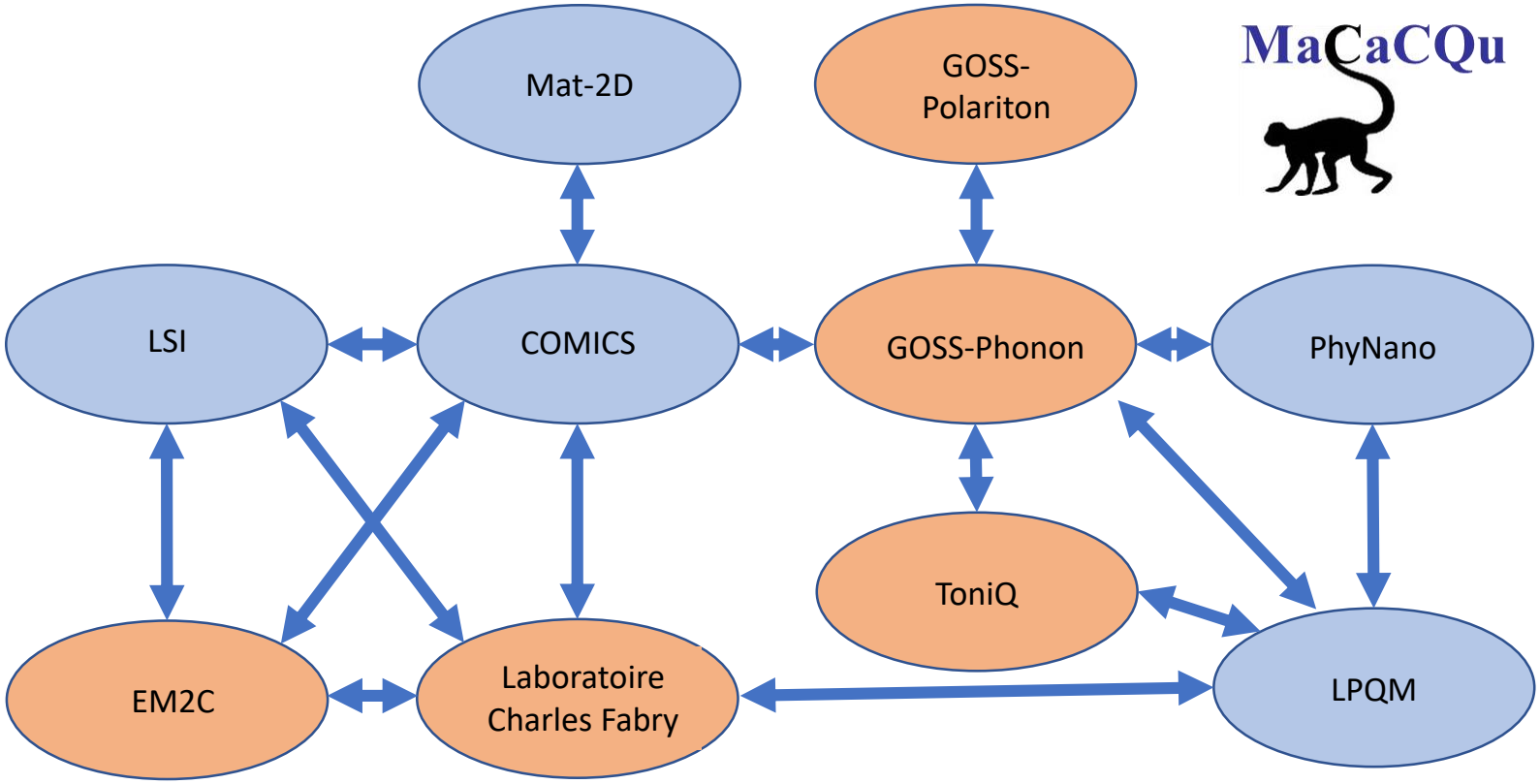
Structuring the community:

2. Transport regimes and transduction mechanisms



Structuring the community:

3. Complexity enabled phenomena



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Common thread

- Heat carriers engineering

Potential breaktrough

- Coherence: quantitative understanding and control
- Transport & Transduction: novel strategies
- Complex dynamics: new platforms and bedtests

Structuring effect

- Explore the same concepts from **different communities**
- Continuous feedback between **theory and experiments**
- System of **secondments** for PhD and postdocs
- **Young diverse community** (CR, DR, MC, PR, IE, IR)