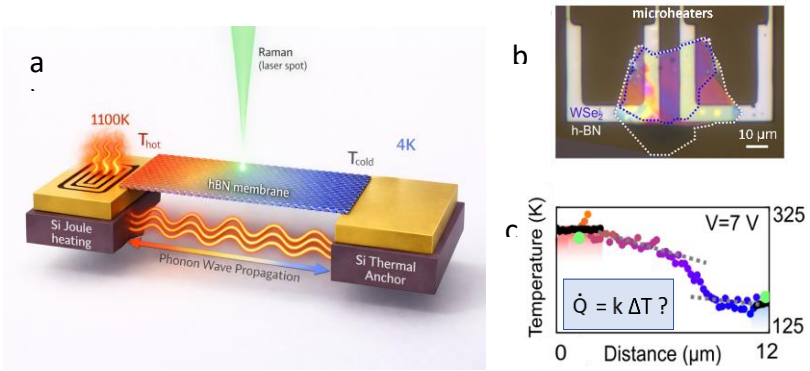
Master thesis proposal

10,bd Thomas Gobert
91120 Palaiseau
Dir : Arnaud Bournel

Title: **Shaping heat flow in two-dimensional materials: geometry and phonon hydrodynamics**

Keywords: 2d materials, condensed matter, heat transport, phonons

Scientific description: Can heat flow through a solid like a fluid through a narrow channel? In very clean crystals, collective phonon motion can produce hydrodynamic heat transport, opening possibilities for controlling heat through device geometry. Recent experiments on thermal Tesla valves in graphite [1] and non-diffusive transport in isotopically enriched hexagonal boron nitride (hBN) [2] (**ref from the group)** motivate this approach.



This internship aims to determine how a constriction modifies heat transport in suspended hBN membranes. The student will compare uniform and variable-width channels using spatially resolved temperature measurements and thermal conductance measurements. Comparison with Fourier heat-diffusion models will help identify non-diffusive behavior and assess possible hydrodynamic contributions. Electronic de Laval nozzles [3] provide further inspiration for exploring geometry-controlled collective transport. **The expected outcome is a quantitative comparison of temperature profiles and thermal conductance in reference and constricted devices**, providing a basis for future studies of nonlocal and nonlinear heat transport. The internship offers training in nanofabrication, optical spectroscopy, cryogenics and low-noise instrumentation. A continuation towards a PhD is envisaged.

Techniques/methods in use: The student will participate in 2D material exfoliation and transfer, and cleanroom nanofabrication. Raman spectroscopy and photoluminescence (PL) from integrated semiconductor monolayers will provide local thermometry, with calibration to distinguish temperature shifts from strain effects. Second-harmonic generation (SHG) may complement the structural and crystallographic characterization of selected heterostructures. The experimental program will combine low-temperature measurements, targeting 3–300 K, with low-noise electrical techniques for controlled Joule heating and electrical readout. The student will develop automated temperature mapping and analyses the results using thermal-transport models.

References

[1] X. Huang et al., "A graphite thermal Tesla valve driven by hydrodynamic phonon transport", *Nature* **634**, 1086–1090 (2024).
[2] C. Brochard-Richard et al., "Extreme longitudinal thermal conductivity and non-diffusive heat transport in isotopic hBN", *Nature Communications* (2026).
[3] J. Geurs et al., "Supersonic flow and hydraulic jump in an electronic de Laval nozzle", *arXiv:2509.16321* (2025).

Applicant skills: Good students
Industrial partnership: No
Internship supervisor(s) (Julien chaste, Julien.chaste@universite-paris-saclay.fr 0649956047
Internship location: C2N Univ. Paris Saclay
Possibility for a Doctoral thesis: Yes, By ANR