

M2 / Final-Year Engineering Internship Offer

Spectral control of radiative thermal diodes

Host laboratory: PROMES, CNRS / Université de Perpignan Via Domitia

Duration: 4–6 months

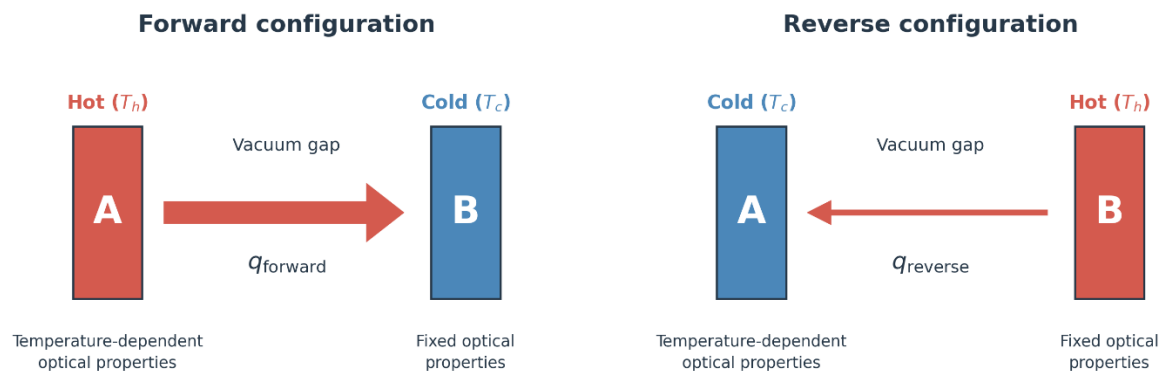
Location: Perpignan and Odeillo, France

Supervisors: François Vernay, Maxime Giteau and Hamid Kachkachi

Starting date: Flexible (between February and May 2027)

Background

Can heat be transmitted preferentially in one direction? Thermal diodes achieve this by transferring different amounts of heat when the temperatures at their two terminals are reversed. Radiative thermal diodes exploit spectral selectivity and temperature-dependent optical properties to control heat exchange between bodies separated by a vacuum gap.



Strong rectification—the contrast between forward and reverse heat flows—is often the main measure of performance. However, a device that blocks heat in both directions may exhibit high rectification while transmitting little useful heat. Understanding how to combine directional control with substantial heat transfer is therefore essential for evaluating radiative diodes and identifying promising designs.

This internship will explore this balance using simple physical models and spectral optimization. The project connects fundamental questions in nonlinear thermal transport with applications in thermal management and thermophotovoltaic energy conversion.

Research objectives and work programme

The central question is: **how should radiative exchange be engineered to maximize transmitted heat flux while maintaining a prescribed level of rectification?**

The work will be primarily theoretical and numerical, focusing on far-field radiative exchange between two surfaces, at least one of which has temperature-dependent optical properties. The intern will:

- **Develop and validate a reference model:** review selected diode concepts, calculate forward and reverse spectral heat fluxes, and reproduce a representative published result.
- **Investigate performance limits:** identify spectral contributions that favour forward transfer while limiting reverse leakage, and optimize transmitted heat flux at a prescribed rectification level.
- **Assess simple configurations:** compare idealized benchmarks with selective surfaces or simplified temperature-dependent optical responses, examining the effects of temperature, spectral bandwidth and incomplete optical switching.

Analytical developments will be pursued where tractable, supported by numerical integration and optimization in Python or MATLAB. The scope will be adapted to the internship duration and the student's background. Expected outcomes include a validated computational model, performance maps, and a physical interpretation of the mechanisms governing the balance between rectification and heat transmission.

Further reading

For an introduction to the physical concepts and performance questions underlying the project:

- E. Nefzaoui, J. Drevillon, Y. Ezzahri and K. Joulain, **"A simple radiative thermal diode,"** *Applied Optics* **53**, 3479–3485 (2014). Introduces radiative rectification using selective emitters with temperature-dependent optical properties. [Open-access preprint](#).
- S. Khandelwal, M. Perarnau-Llobet, S. Seah, N. Brunner and G. Haack, **"Characterizing the performance of heat rectifiers,"** *Physical Review Research* **5**, 013129 (2023). Explains why rectification and transmitted heat current should be considered jointly. [Open-access article](#).
- B. Li, L. Wang and G. Casati, **"Thermal Diode: Rectification of Heat Flux,"** *Physical Review Letters* **93**, 184301 (2004). Introduces thermal rectification in nonlinear lattice models, providing a complementary perspective on temperature-dependent spectral matching. [Open-access preprint](#).

Research environment and location

The internship will take place within the **Materials for Energy and Space (MEE)** team at PROMES, bringing together expertise in theoretical physics and thermal transport in Perpignan, and radiative heat transfer and thermophotovoltaic conversion in Odeillo.

The intern may be based at either Perpignan or Odeillo, with regular visits to the other site. The arrangement will be agreed with the supervisors according to scientific needs and practical constraints. The student will interact with researchers at both sites throughout the project.

Candidate profile

We welcome applications from students completing a Master's degree or equivalent in physics, thermal sciences, energy engineering or applied mathematics. A background in heat transfer, electromagnetism or statistical physics would be valuable, together with experience in scientific programming using Python or MATLAB. We particularly value curiosity, scientific rigour and an interest in understanding physical mechanisms through modelling.

Possible PhD continuation

The internship may lead to a PhD application to the **Énergie et Environnement doctoral school (ED305)** on radiative thermal diodes and their role in energy-conversion systems. Continuation will depend on mutual interest and successful doctoral funding.

How to apply

Please send a **CV, a brief motivation letter and recent academic transcripts** to:

Maxime Giteau: maxime.giteau@cnrs.fr

François Vernay: francois.vernay@univ-perp.fr

Hamid Kachkachi: hamid.kachkachi@univ-perp.fr

Please indicate your availability and preferred internship duration.