Postdoctoral Position: Infinite Embedding Methods for Control and Analysis of Partial Differential Equations (PDEs)

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Scientific Context

The ANR project **PIVOINE** aims to unify infinite embedding techniques (moment-SoS hierarchies, kernel methods, Koopman operators) for the **control and safety certification of high-complexity dynamical systems**, with applications to energy networks, nuclear fusion, and learning algorithms. **Work Package 2** focuses on extending these methods to **infinite-dimensional systems**, with a dual emphasis:

- **Moment-SoS hierarchies formulated in reproducing kernel Hilbert spaces** to combine algebraic geometry with kernel-based learning.
- **Measure-valued solutions** for nonlinear PDEs, including stochastic extensions and shape optimization (e.g., stellarator coil design).

Infinite embedding methods for PDE control combine algebraic and functional approaches: moment-SoS hierarchies address nonlinear PDEs via convex relaxations [1], and physics-informed kernel learning enables data-driven solutions by integrating physical constraints into kernel methods [2]. Measure-valued solutions [3] provide weak formulations for hyperbolic PDEs, but they are currently limited to searching solutions: control, optimization and invers problems remain open challenges, requiring unified frameworks for scalability and certification.

The postdoc will contribute to **bridging finite-dimensional control theory and infinite-dimensional systems**, with a focus on numerical efficiency and real-world applicability.

References

[1] S.P. Chhatoi et al. Optimizing quasi-dissipative evolution equations with the moment-sos hierarchy. *Discrete and Continuous Dynamical Systems*, 45(11):4139–4159, 2025.

[2] N. Doumèche et al. Physics-informed kernel learning. *JMLR*, 26(124):1–39, 2025.

[3] C. Cardoen et al. A moment approach for entropy solutions of parameter-dependent hypoerbolic conservation laws. *Numerische Mathematik*, 156:1289–1324, 2024.

Key Missions

1. **Theoretical Development**:
    - Adapt moment-SoS hierarchies and RKHS methods for **hyperbolic/parabolic PDE** and **stochastic extensions**, as well as **control and inverse problems**.

- Investigate measure-valued solutions, duality properties, and regularization strategies.

2. **Collaboration**:
   - Work with **Christophe Prieur** and external partners (e.g. Francis Bach, RTE).
   - Co-supervise PhD students on related tasks.
3. **Dissemination**:
   - Publish in **top-tier venues** (e.g. *IEEE TAC*, *SICON*, *CDC*, *ECC*, *PSCC*...).
   - Contribute to **open-source repositories** and F.A.I.R. science.

Profile

Required Skills

- **Technical Expertise**:
  - Infinite-dimensional optimization (e.g. optimal transport, PDE constraints).
  - Polynomial methods (e.g. sum-of-squares) or Hilbert space techniques.
  - Numerical implementation (Python/Matlab) for control/optimization algorithms.
- **Scientific Rigor**:
  - Peer-reviewed publications in optimization, control theory, or applied mathematics.
  - Ability to bridge theory and applications (e.g., from PDEs to computational tools).

Nice-to-Haves

- Knowledge of stochastic PDEs, inverse problems or shape optimization.
- Experience in collaborative research with industrial partners.

Soft Skills

- Fluent English (working language).
- Strong communication and teamwork skills.
- Commitment to open science (software, preprints, workshops).

Practical Information

- **Duration**: 18 months (full-time), flexible start (**Q4 2026 – Q1 2027**).
- **Location**: **GIPSA-lab, Grenoble, France** (CNRS-affiliated).
- **Protection of scientific & technical potential**: Since GIPSA-lab is classified as a restricted area, hiring is conditioned by authorization of the security & defence high officer.
- **Salary**: approximately €3,000 gross/month (CNRS scale).
- **Funding**: Fully covered by ANR PIVOINE (no teaching duties).
- **Application**: Submit **CV**, **cover letter**, & **publication list** on the CNRS PLATFORM.