

# Workshop II: Dynamics of Density Operators

**APRIL 28 - May 2, 2025**

## Scientific Overview

The quest to devise a non-commutative counterpart of the Monge-Kantorovich optimal transport theory began about thirty years ago with early proposals by Connes and Voiculescu. These early attempts focused mostly on the static Monge and Kantorovich formulations using duality theory. At about the same time, a dynamical reformulation of optimal transport was taking place in the works of Benamou and Brenier, McCann, and Otto. The ensued recasting of the Fokker-Planck equation as the gradient flow of the free energy in the Wasserstein metric by Jordan, Kinderlehrer and Otto proved pivotal, with applications from geometry to fluid mechanics and thermodynamics.

As a result of these developments, a new angle for casting dynamics in a non-commutative environment emerged. The first proposal was put forth by Carlen and Maas to devise a gradient flow theory in the quantum setting. In parallel to this entropy-centric dynamical template, a rich mosaic of alternatives drew upon the early Connes' proposal and on the Riemannian structure of statistical manifolds, to devise natural metrics and geodesic flows in the space of positive Hermitian and density operators.

This developing landscape has left us with several natural questions. What are underlying unifying principles? Which of these structures provide implications in quantum physics? Can these structures predict new physical properties, such as natural time constants of quantum processes? Can functional inequalities and rates provide answers to these questions? Is there a natural notion of curvature that dictates non-commutative flows and brings further insights into quantum evolutions? Is there a stochastic model for non-commutative transport?

With many questions and few answers, it is our hope and expectation that the workshop will provide creative feedback and help spur further progress on this fast-developing subject. Complementary views will help focus, specifically, on problems of potentially great physical significance.

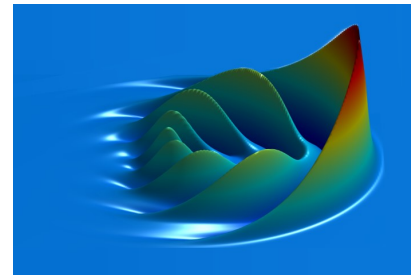
## Long Program Schedule

This workshop is part of the long program Non-commutative Optimal Transport.

- Opening Day: March 10, 2025
- Non-commutative Optimal Transport Tutorials: March 11-14, 2025
- Workshop I: Optimal Transport for Density Operators: Theory and Numerics: March 31 - April 4, 2025
- **Workshop II: Dynamics of Density Operators: April 28 - May 2, 2025**
- Workshop III: Statistical and Numerical Methods for Non-commutative Optimal Transport: May 19-23, 2025
- Non-commutative Optimal Transport Culminating Workshop at Lake Arrowhead : June 9-13, 2025

## Participation

Additional information about this workshop including links to register and to apply for funding, can be found on the webpage listed below. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission, and we welcome their applications.



## Organizers

**Tryphon Georgiou** (University of California, Irvine (UCI))

**Leonard Monsaingeon** (Group of Mathematical Physics of the University of Lisbon (GFMUL))

**Oliver Tse** (Eindhoven University of Technology)

## Invited Speakers

Ángela Capel (University of Cambridge)

Eric Carlen (Rutgers University)

Katy Craig (University of California, Santa Barbara (UCSB))

Nilanjana Datta (University of Cambridge)

Rocco Duvenhage (University of Pretoria)

Di Fang (University of California, Berkeley (UC Berkeley))

Shmuel Friedland (University of Illinois at Chicago)

Wilfrid Gangbo (University of California, Los Angeles)

(UCLA)

Tryphon Georgiou (University of California, Irvine

(UCI)) Francois Golse (École Polytechnique)

David Andrew Jekel (University of Copenhagen)

Andrew Jordan (Chapman University)

Marius Junge (University of Illinois at Urbana-Champaign)

Leonard Monsaingeon (Group of Mathematical

Physics of the University of Lisbon (GFMUL))

Aaron Palmer (University of California, Los Angeles (UCLA))

Dimitri Shlyakhtenko (University of California, Los Angeles (UCLA))

Anna Vershynina (University of Houston)

Daniel Virostek (Alfréd Rényi Institute)

Dmitry Vorotnikov (University of Coimbra)

Melchior Wirth (Institute of Science and Technology Austria (IST Austria))

Jean-Claude Zambrini (University of Lisbon)

Haonan Zhang (University of South Carolina)

Karol Zyczkowski (Jagiellonian University)



For more information, visit the program web page:

[www.ipam.ucla.edu/NOTWS2](http://www.ipam.ucla.edu/NOTWS2)