



# ERC Advanced Grant

ENRIQUE ZUAZUA

## Dynamic Control



Fundación  
Deusto

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Fundazioa



Universidad Autónoma  
de Madrid

# DyCon, Dynamic Control

## Objectives

- New analytical methods
- New computational paradigms
- New software: DyCon  
Computational Platform



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UAM

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de Madrid



erc

**DyCon**  
DYNAMIC CONTROL

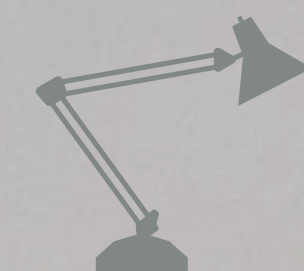
# DyCon, Dynamic Control

People

🧭 IP: Enrique Zuazua



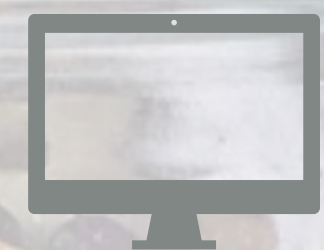
Senior Visitors: 14



Studentship: 13



UAM PhD: 04 (2 Sherpa ai)



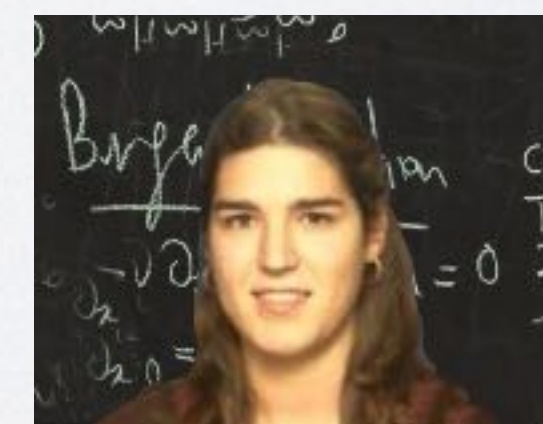
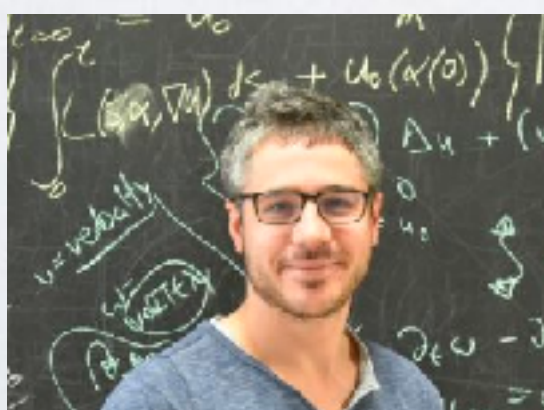
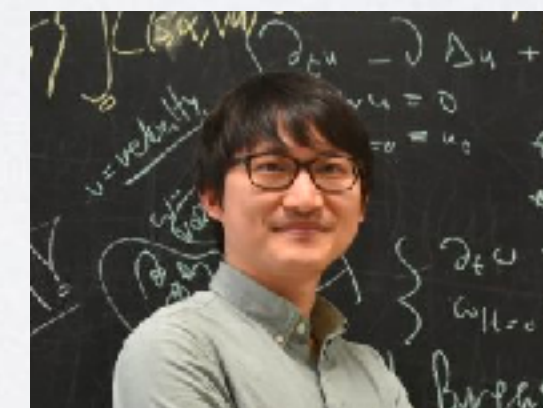
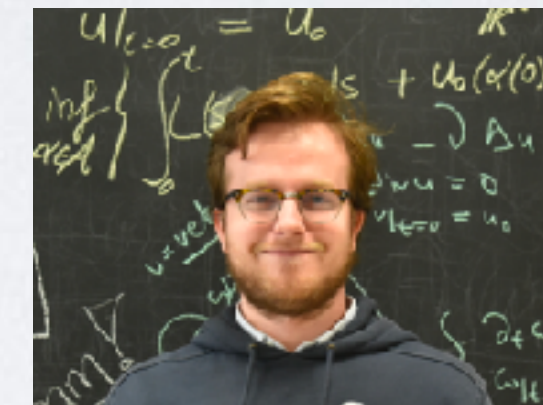
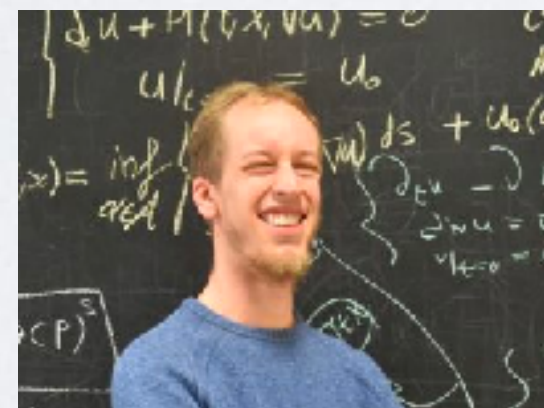
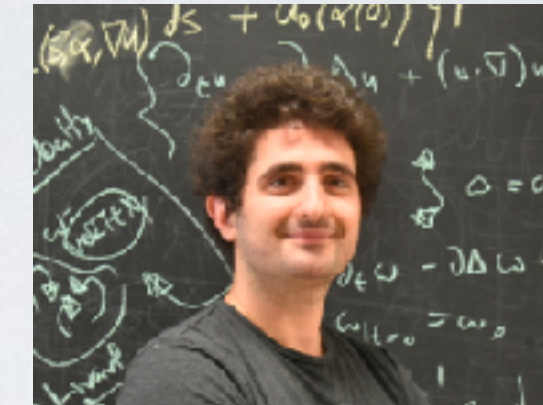
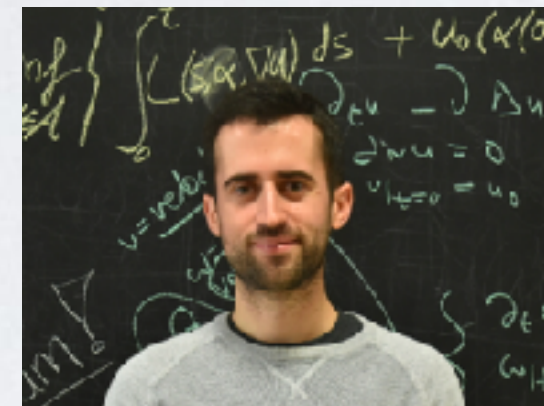
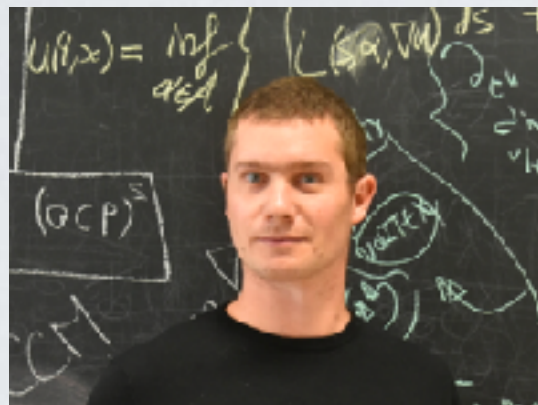
IT Manager: 04



18,9% women

# DyCon, Dynamic Control

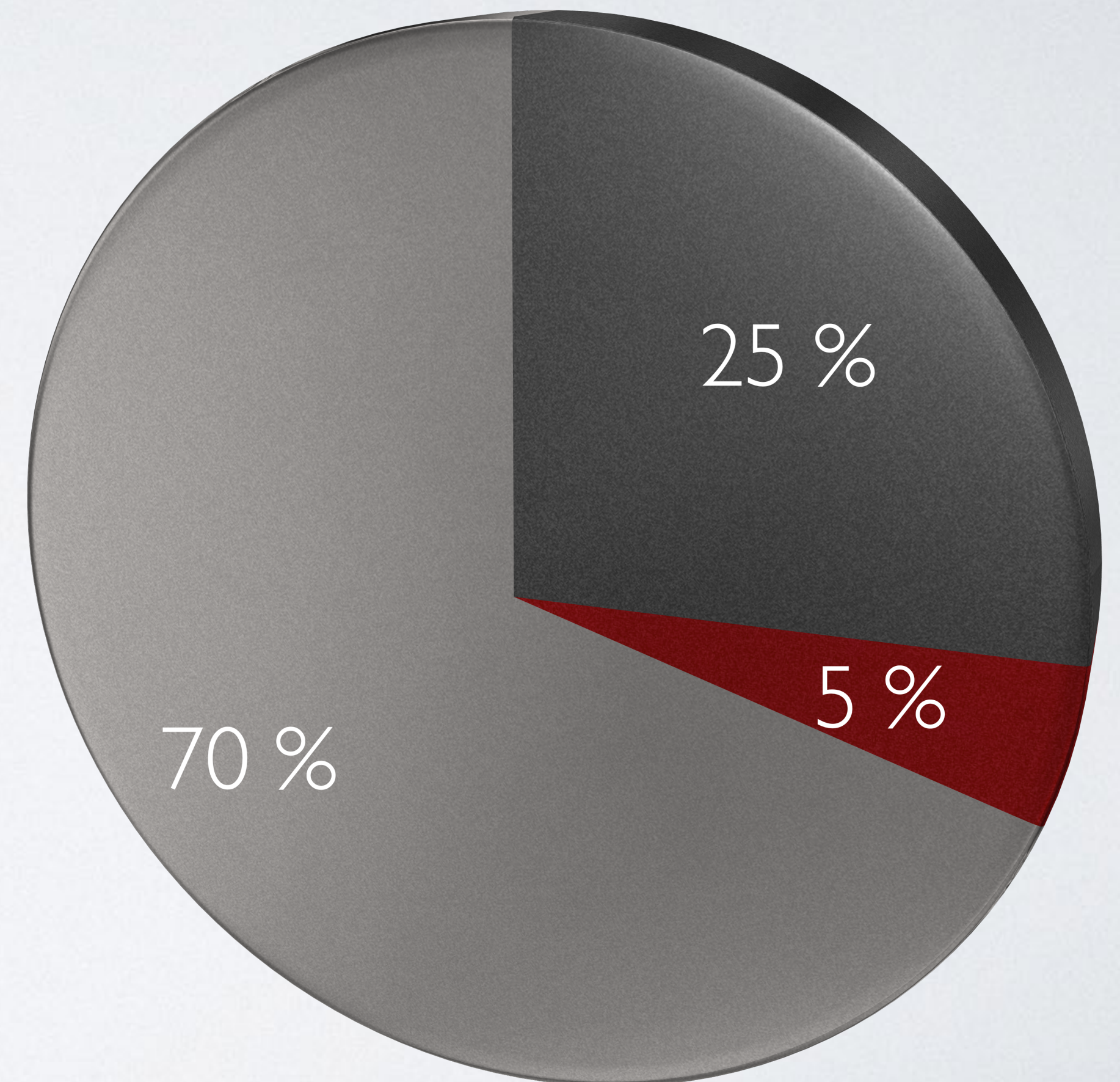
## People



# DyCon, Dynamic Control

Publications (2016 - Today): Current overview

- 72 Publications released
- 05 Accepted
- 26 Submitted



# DyCon, Dynamic Control

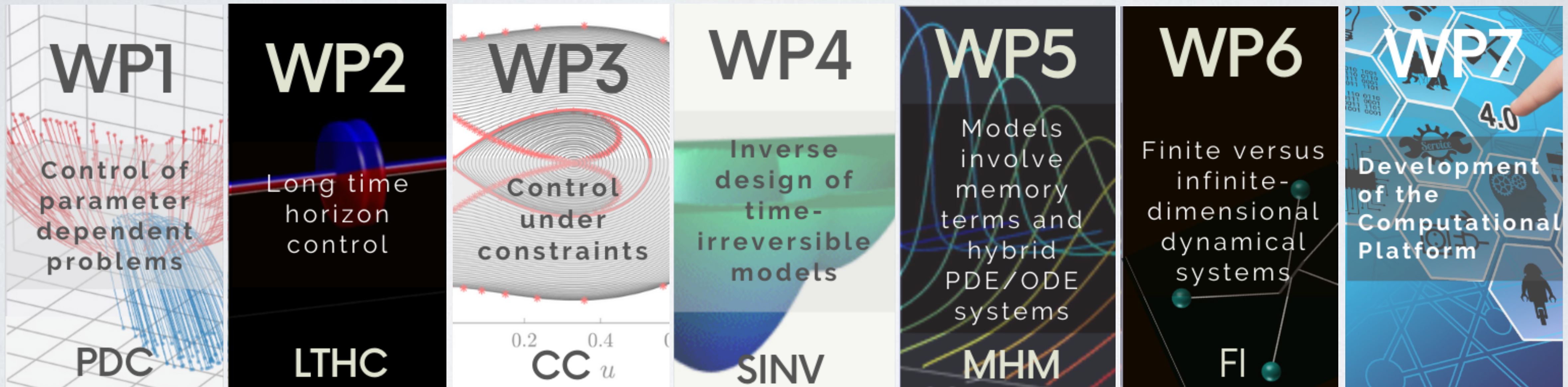
Activities (Oct. 2019 - today)



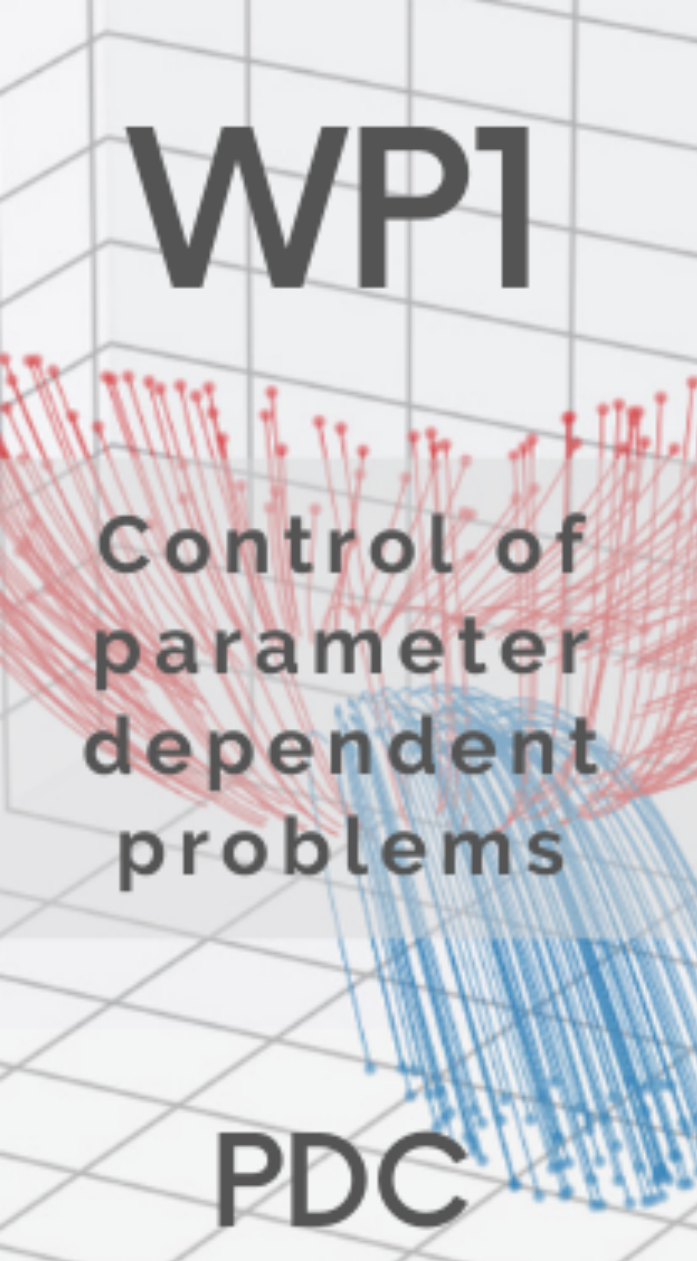
- 118 Seminars
- 09 Courses
- 07 International Internships

# DyCon, Dynamic Control

## Work Packages



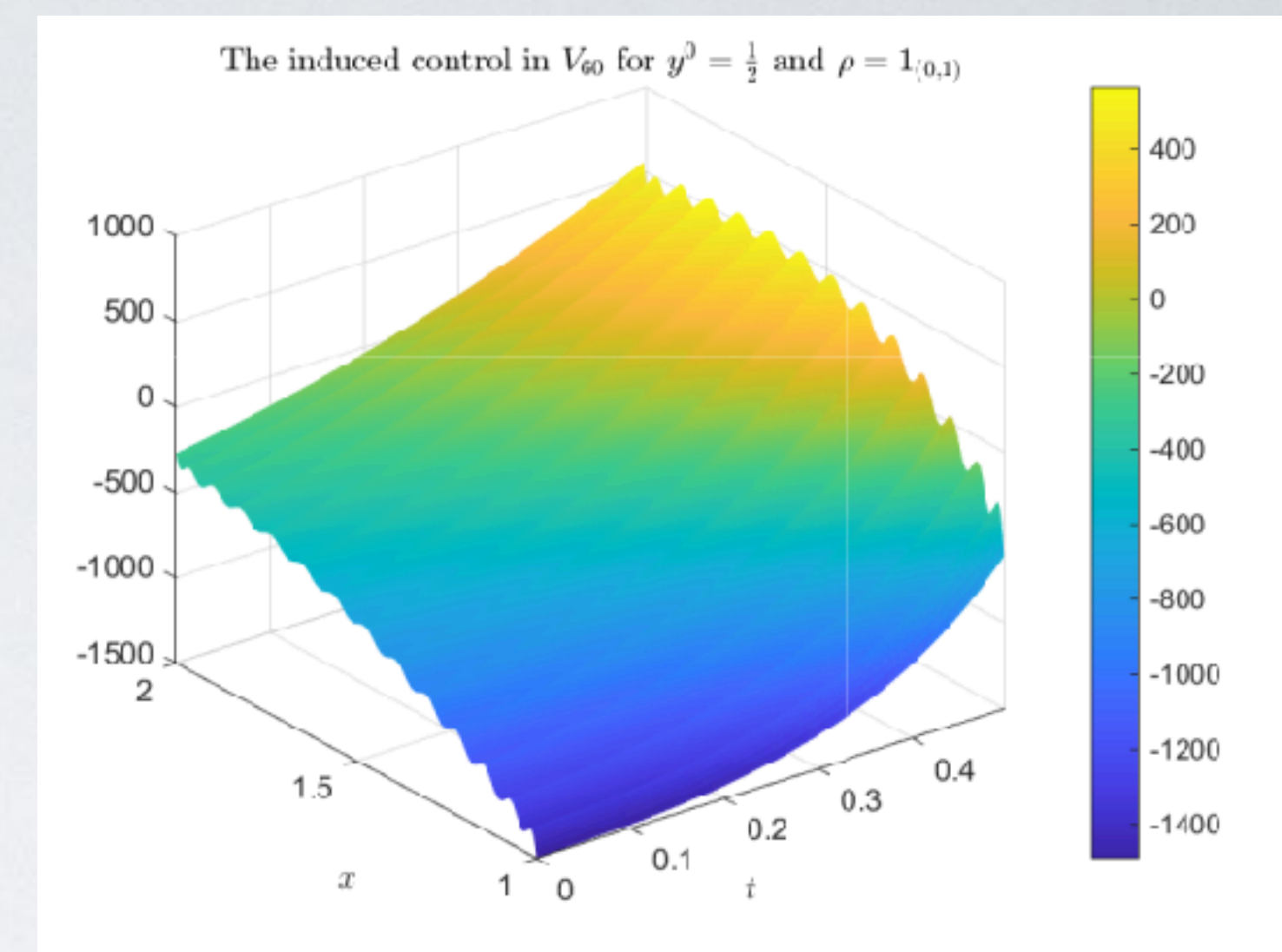
Focus on six key Working Packages



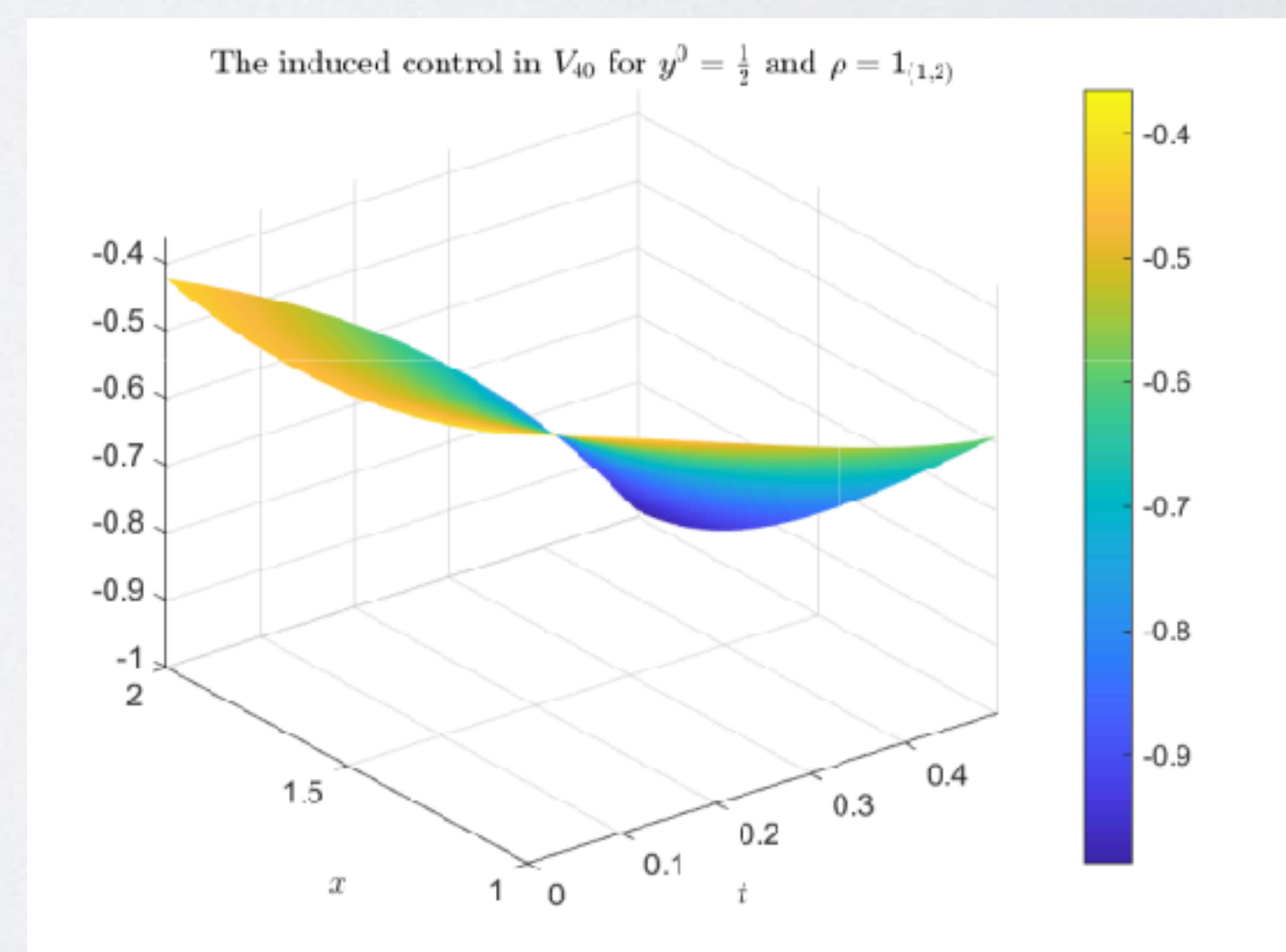
# DyCon, Dynamic Control

Work Packages • WP1

Models describing real-life processes depend on a large number of parameters, often uncertain and undetermined: greedy and averaging methods.



Averaged controls for heat equations with random diffusion.





# WP2

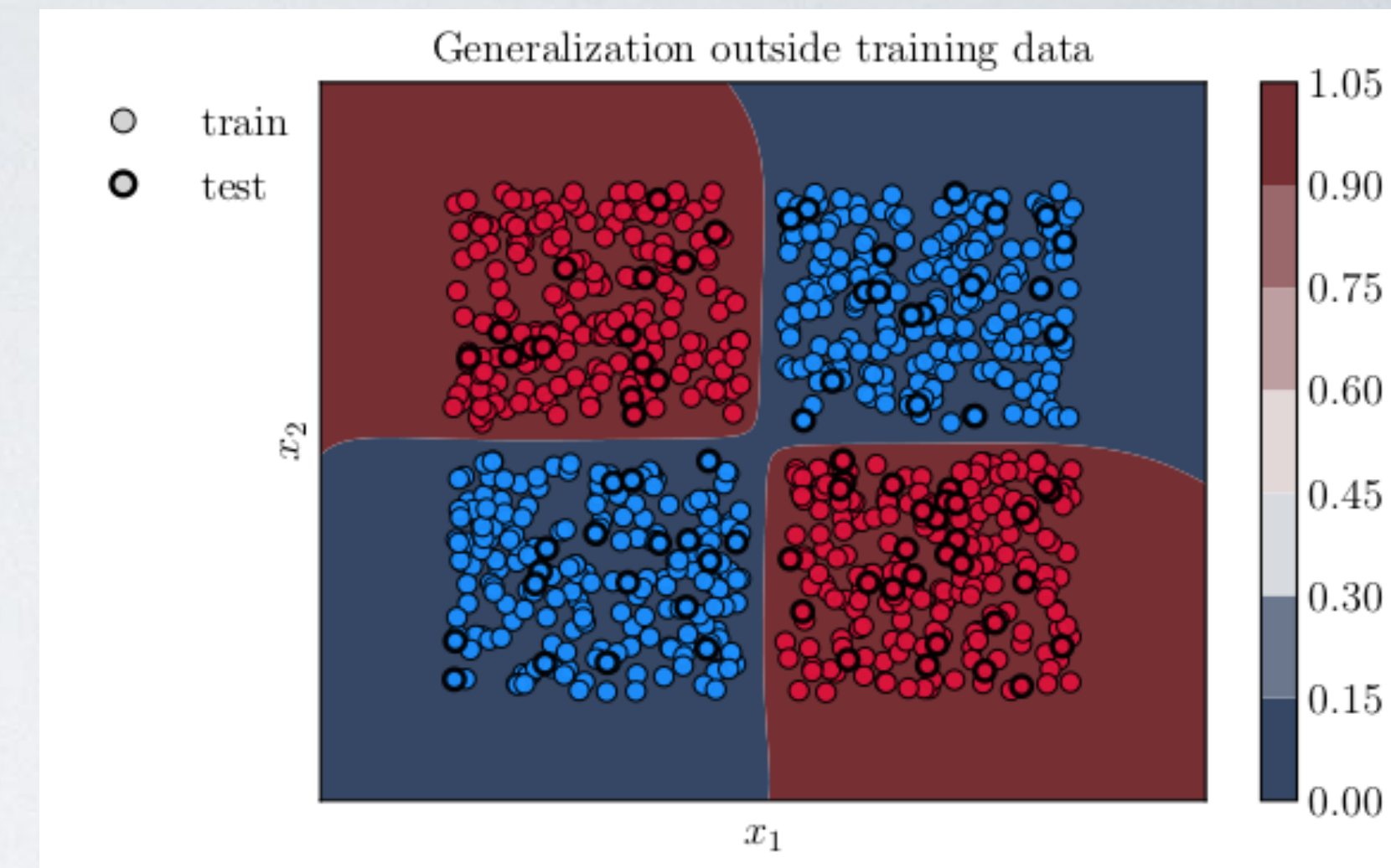
Long time  
horizon  
control

LTHC

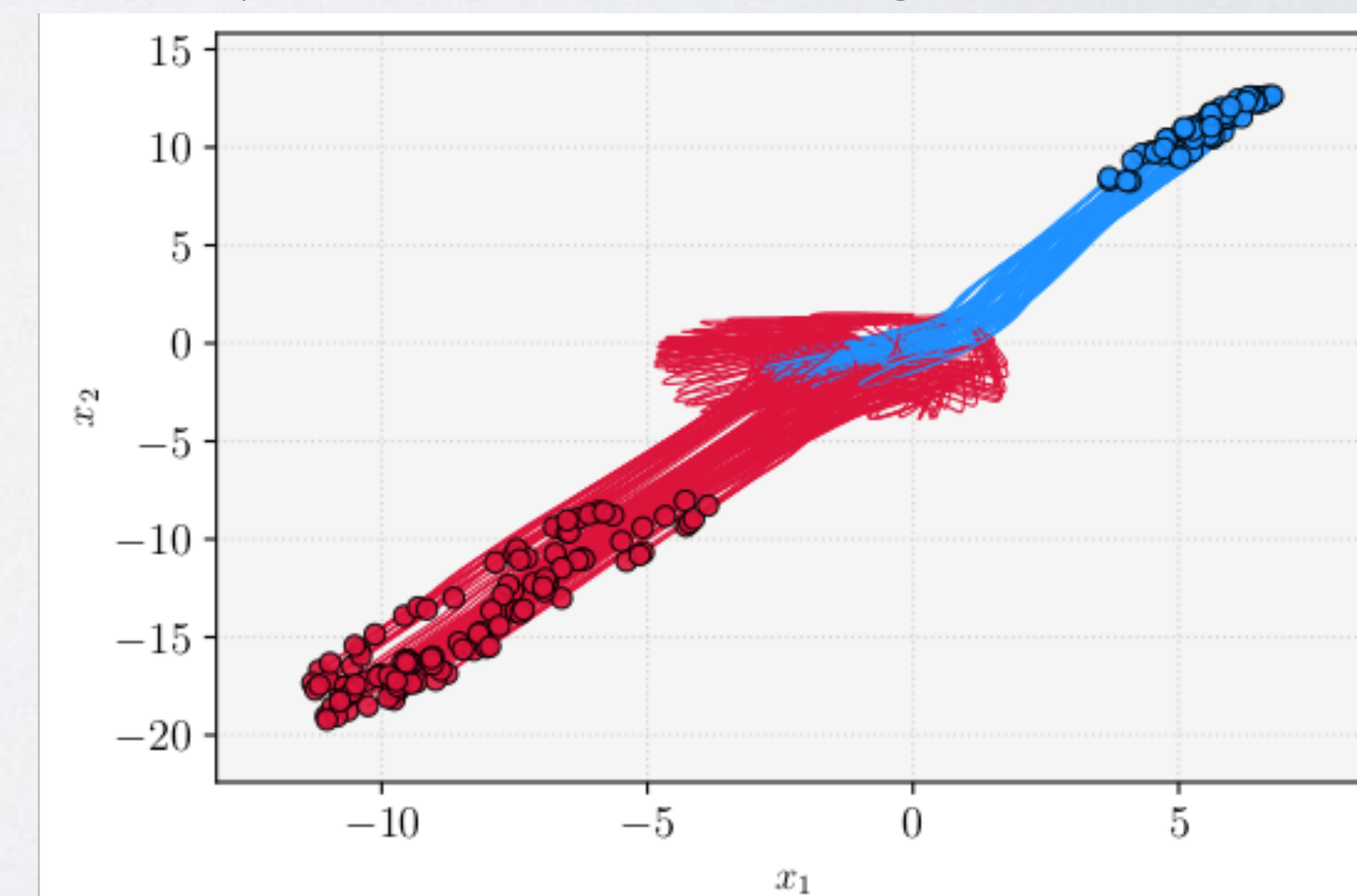
# DyCon, Dynamic Control

Work Packages • WP2

The turnpike principle ensures that optimal controls and trajectories are nearly time-independent in long time horizons.



Turnpike effect in a machine learning classification task.

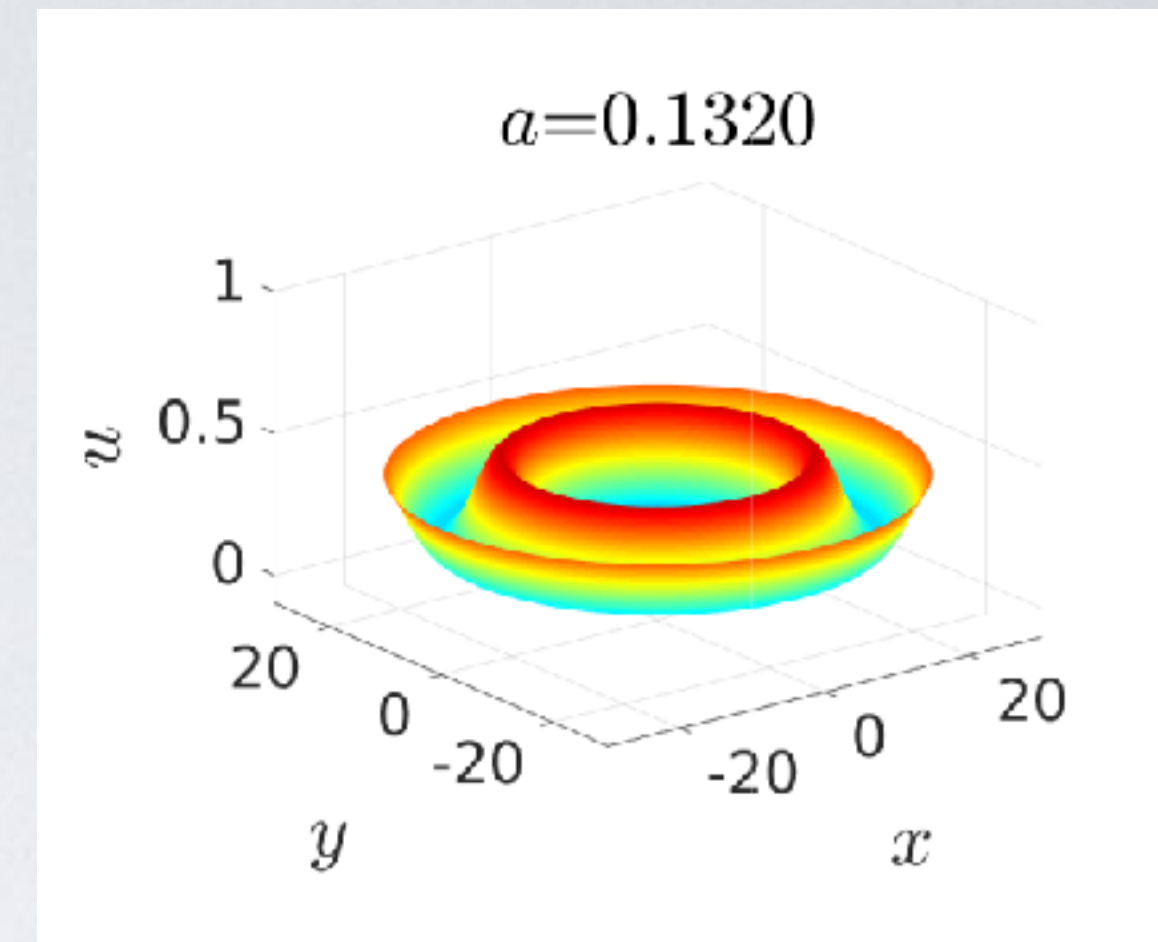




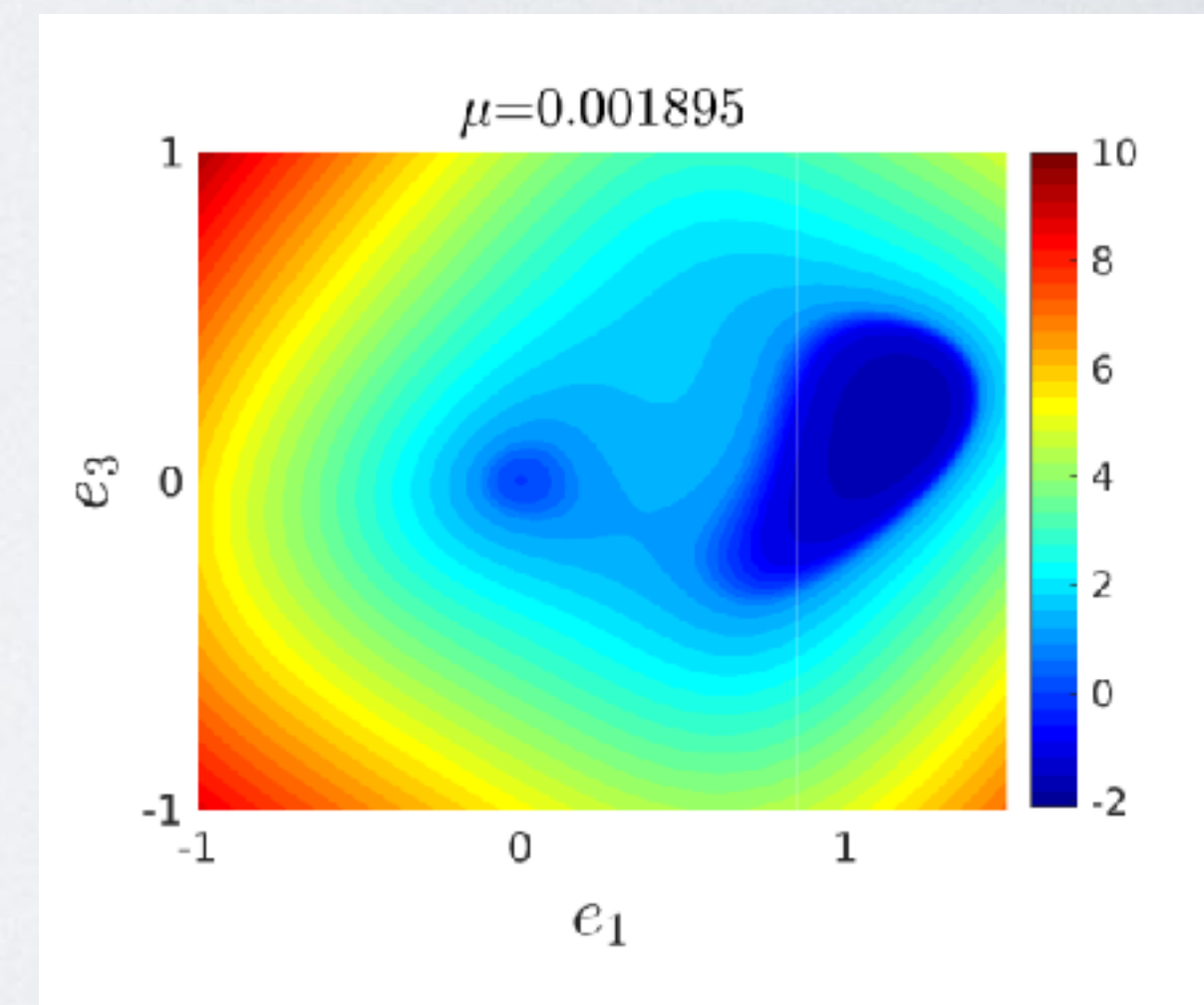
# DyCon, Dynamic Control

Work Packages • WP3

Real-life processes are often submitted to constraints, which may limit or become an impediment for their control due the existence of a minimal controllability time and the emergence of barriers in the phase space.



Path of steady states

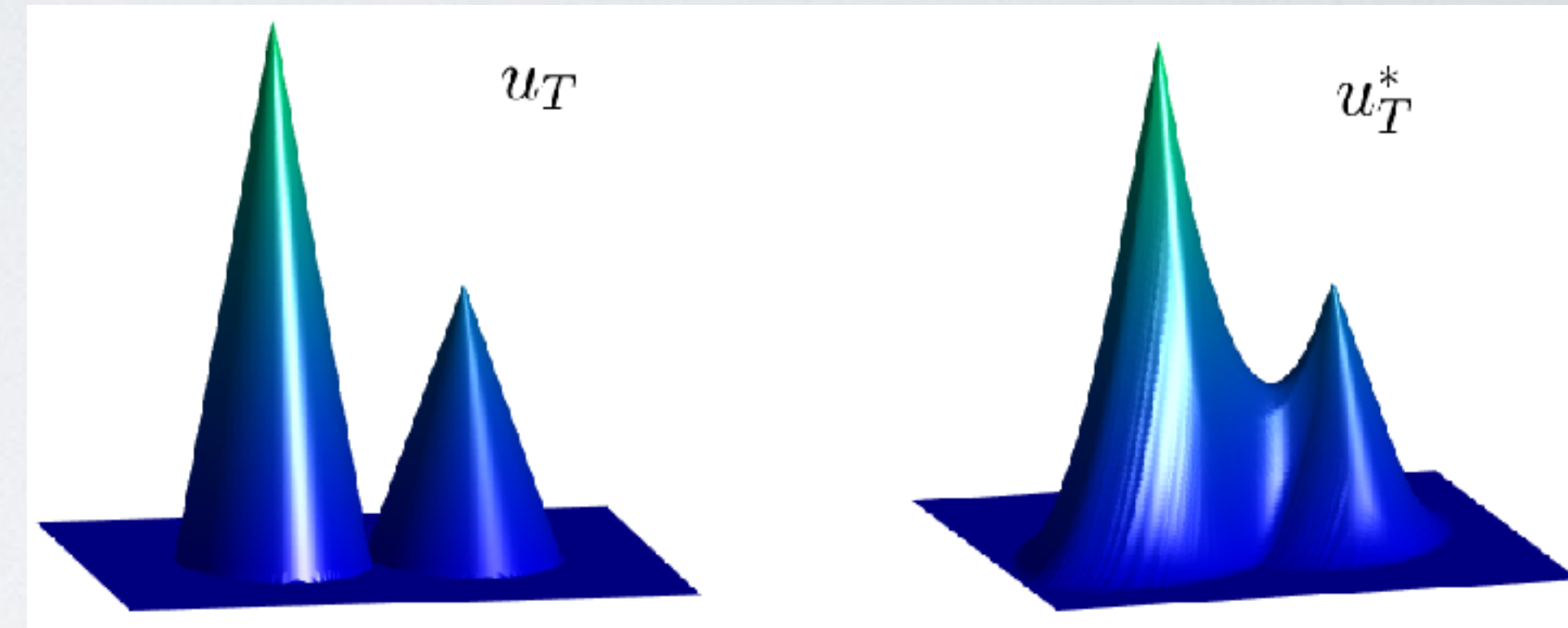


Emergence of an obstruction to controllability when  $\mu$  decreases

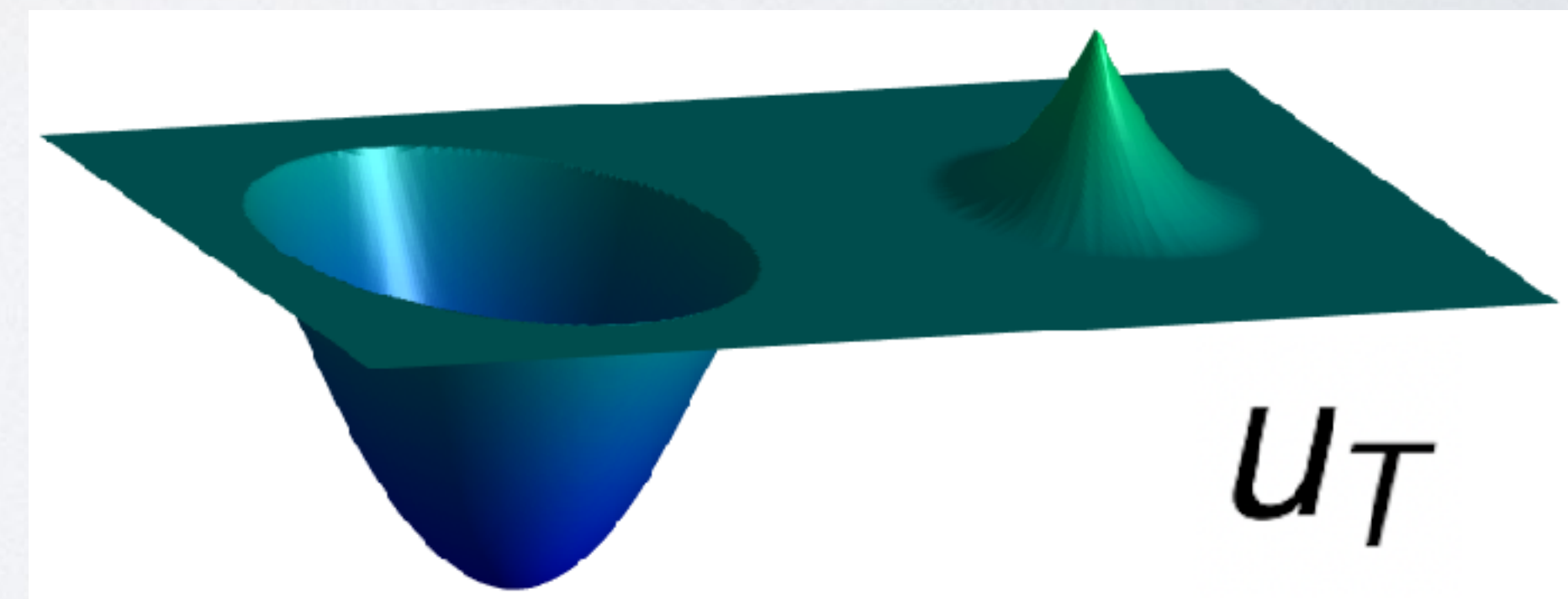
# DyCon, Dynamic Control

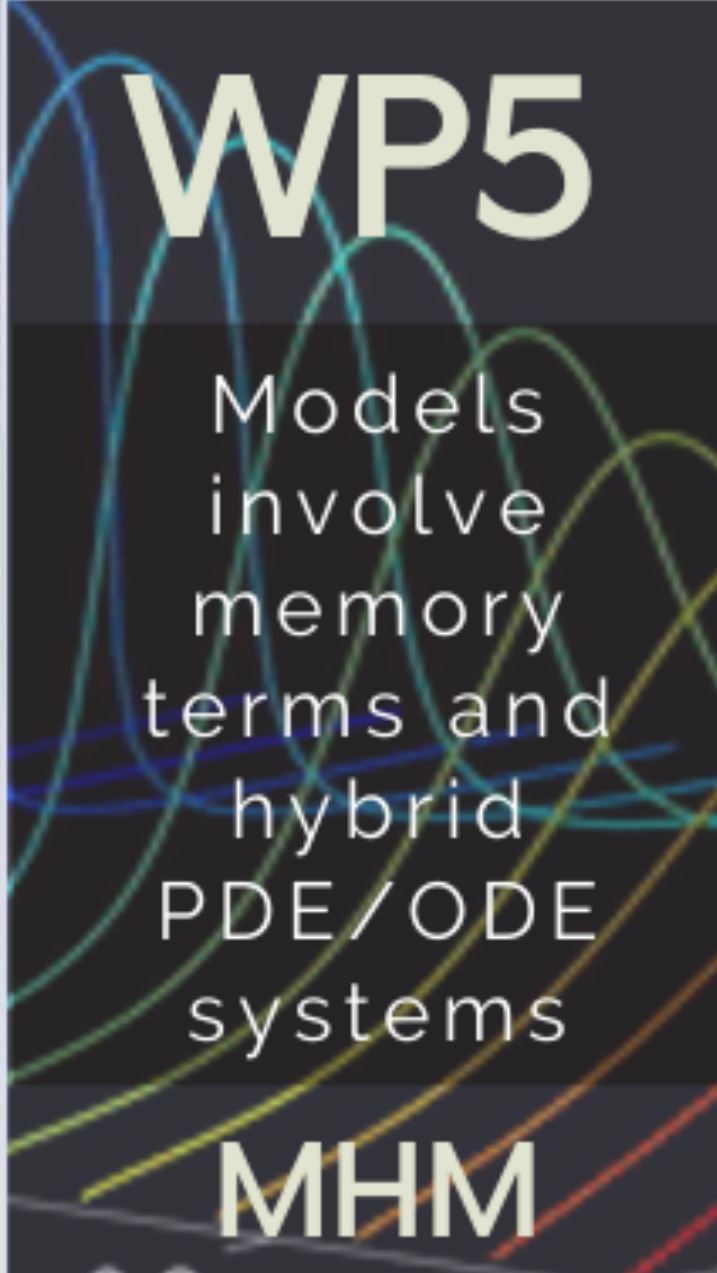
Work Packages • WP4

Dynamical systems often develop singularities: shocks, interfaces, etc. This makes it difficult to implement the classical control strategies, based on linearization arguments. We characterize these singularities in an analytic/geometrics manner, so to develop specific and well-adapted control tools.



Initial datum recognition for the Hamilton-Jacobi equation.

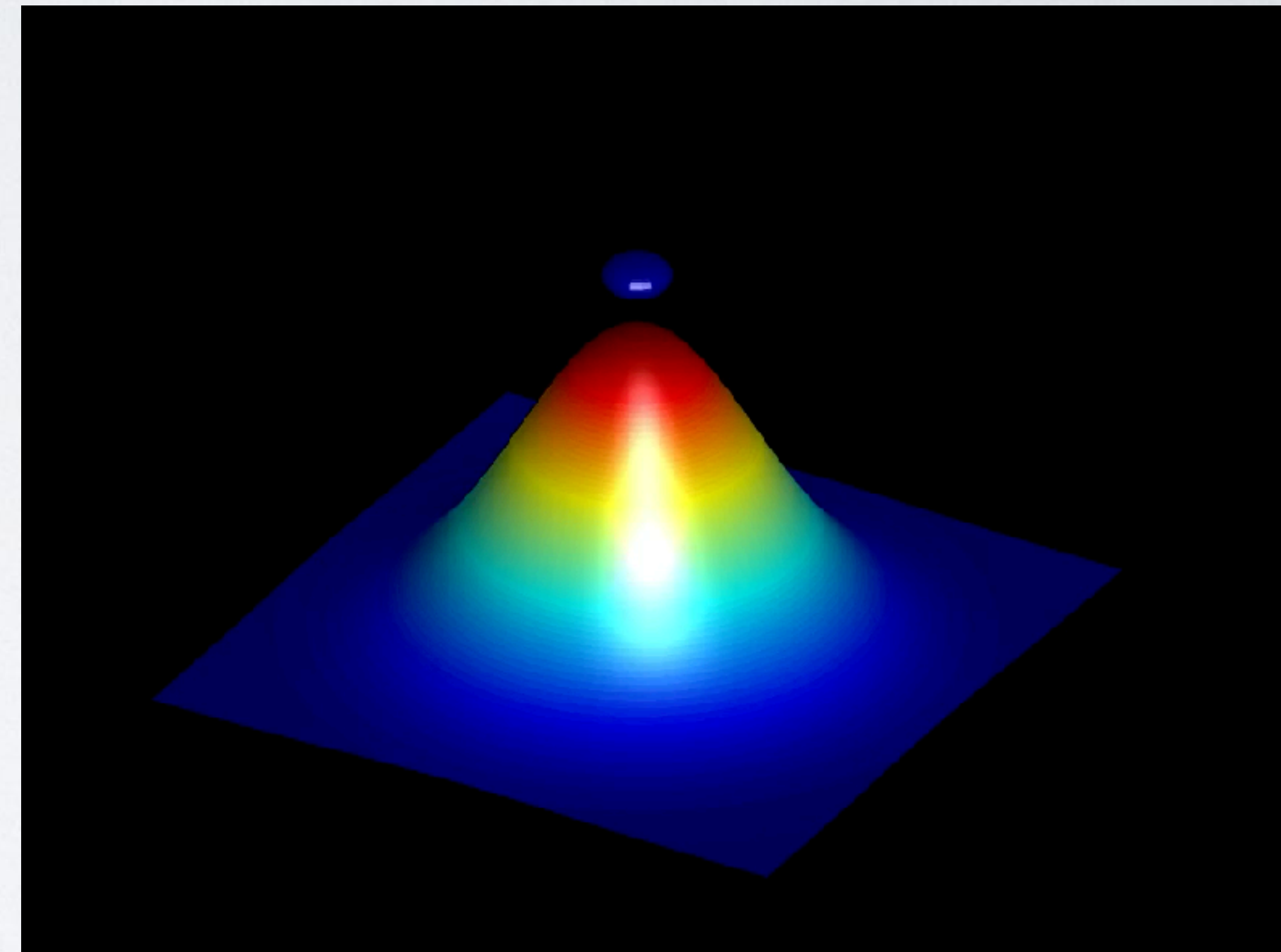




# DyCon, Dynamic Control

Work Packages • WP5

Optimal control strategies are harder to achieve when the dynamics is affected by memory effects. We recast these models as hybrid PDE+ODE systems, allowing for the development of specific control methodologies.



Moving control strategy for the control of hybrid PDE+ODE systems

# WP6

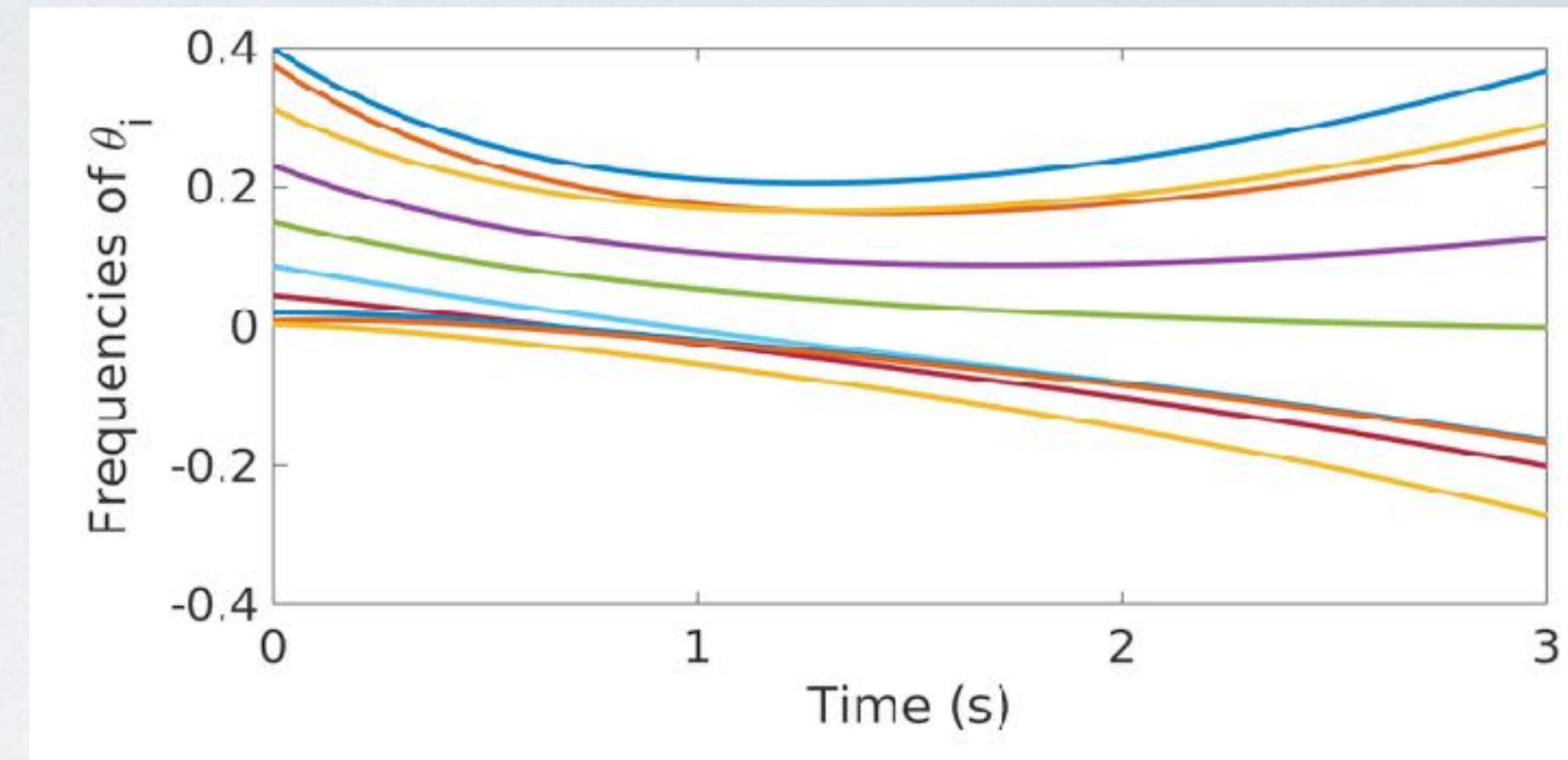
Finite versus  
infinite-  
dimensional  
dynamical  
systems

FI

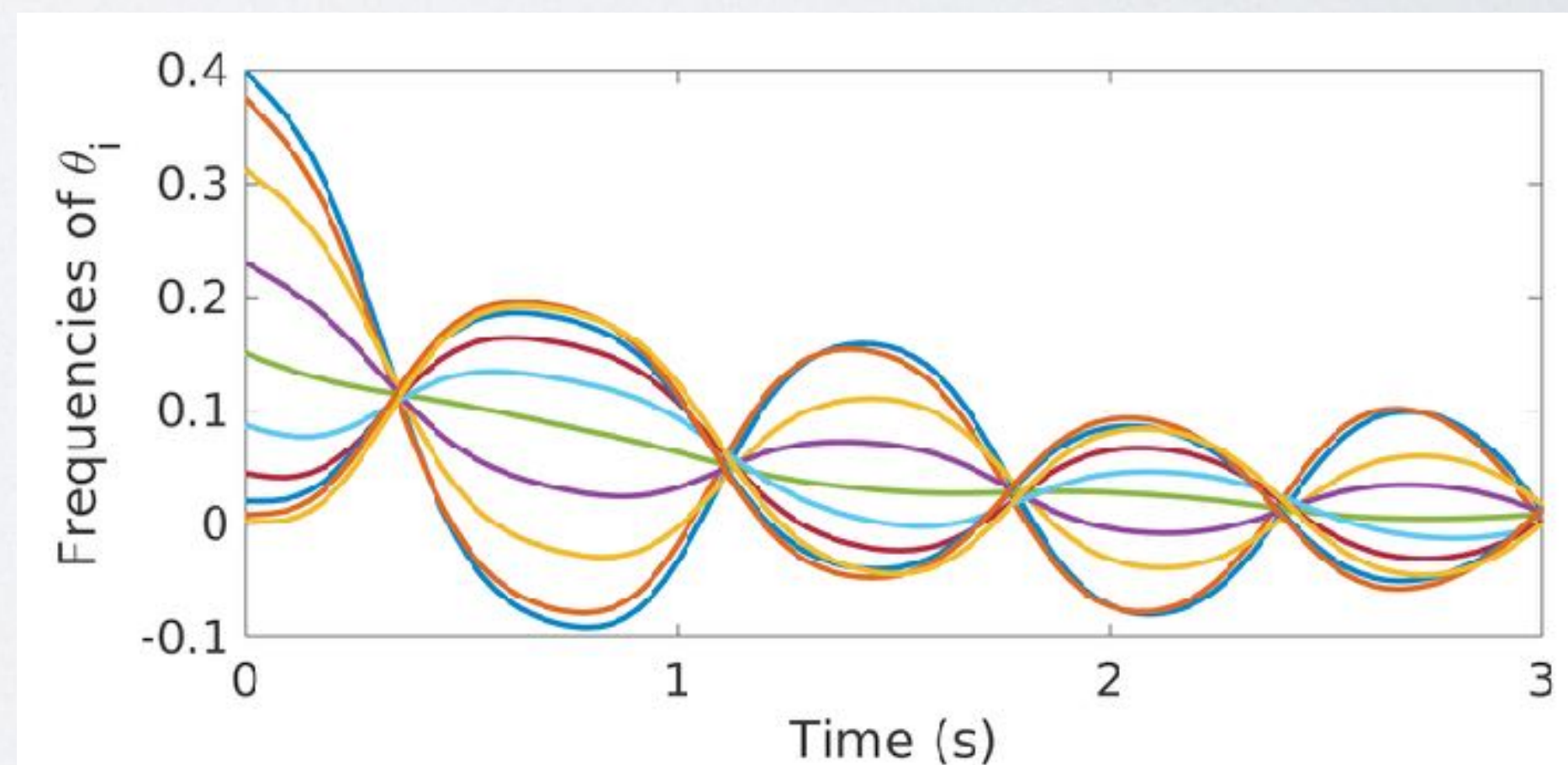
# DyCon, Dynamic Control

Work Packages • WP6

We explore the interplay between finite and infinite-dimensional dynamics in the modeling and control of, for instance, collective behavior models arising in Social Sciences, through mean-field limits.



Free dynamics (top) of the Kuramoto model and controlled one (bottom) via the Random Batch Method.





# DyCon, Dynamic Control

Work Packages • WP7

The DyCon Blog and DyCon Toolbox have been conceived and run in a holistic manner, integrating the research efforts in the mathematical aspects and the software development.

## **DyCon Toolbox**

An open-source MATLAB library built upon the code created by our team. It unifies the DyCon computational developments DyCon Project, building a unique tool for solving problems of Optimal Control through the adjoint methodology.

**DyCon**  
**Toolbox**

**DyConBlog**

**G e n e r a l  
R e g i s t r y o f  
I n t e l l e c t u a l  
P r o p e r t y - R e f  
0 1 / 2 0 2 1 / 7 4 5  
( M a r . 2 0 2 1 )**



Thank you!  
ENRIQUE ZUAZUA



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