

# Control of Degenerate and Singular Parabolic Equations

## Teacher

Genni Fragnelli

## Course description

Controllability issues for parabolic problems have been a mainstream topic in recent years, and several developments have been pursued: starting from the heat equation in bounded and unbounded domain, related contributions have been found for more general situations. In details: given an initial condition, the associated equation is said to be null controllable at time  $T > 0$  if there exists a control such that the solution  $u$  of the associated problem satisfies  $u(T) \equiv 0$  in the space domain. Due to degeneracy or singularity, classical null controllability results do not hold in general. Thus, a good notion is the so called 'regional null controllability': we can drive the solution to rest at time  $T$  on a subset of the space domain, contained in the set where the equation is nondegenerate. However, the notion of global null controllability is stronger than the regional one and in general it is the useful one. A common strategy in showing this type of controllability is to prove that certain global Carleman estimates hold true for the operator, which is the adjoint of the given one, and, from them, to find related observability inequalities for the solution of the initial problem. In this course we follow this approach, focusing on some classes of degenerate and/or singular parabolic operators. The interest in this kind of equations is due to the fact that many problems coming from Physics, Biology, and Mathematical Finance are described by parabolic equations which admit these types of degeneracy and/or singularities.

## Course period

June-July 2026

## SSD

MAT/05

## Course References

- [1] G. Fragnelli, D. Mugnai, Control of degenerate and singular parabolic equation, BCAM Springer Brief, ISBN 978-3-030-69348-0, 2021.
- [2] G. Fragnelli, D. Mugnai, Carleman estimates and observability inequalities for parabolic equations with interior degeneracy, Adv. Nonlinear Anal. 2 (2013), 339-378.
- [3] P. Cannarsa, G. Fragnelli, D. Rocchetti, Controllability results for a class of one-dimensional degenerate parabolic problems in nondivergence form, J. Evol. Equ. 8 (2008), 583-616.
- [4] F. Alabau-Boussouira, P. Cannarsa, G. Fragnelli, Carleman estimates for degenerate parabolic operators with applications to null controllability, J. Evol. Equ. 6 (2006), 161-204.

## Credits and Hours

2 lectures credits (8 hours per credit), for a total of 16 hours.

**Exam Modality**

The student will present a paper between two papers suggested by the teacher. No groups are allowed.

**Teacher CV**

CV attached.

**Teacher Main Publications**

See the attached list.

# Curriculum di Genni Fragnelli

## PERSONAL INFORMATION

Family name, First name: Fragnelli, Genni  
Researcher unique identifier(s): ORCID:0000-0002-5436-7006,  
Author ID (Scopus) 13806838100,  
ResearcherID (WOS) Q-3282-2016,  
MR Author ID (MathSciNet) 707132  
Date of birth: 11/08/1975  
Sex: Female  
Children: 3

## CAREER BREAKS

•Maternity leaves: 2/9/08-1/6/09, 3/6/08-2/7/09, 19/8/11-19/1/12, 1/9/15-12/5/16, 13/5/16-19/6/16

## EDUCATION

•1999 Graduated in Mathematics, Mathematics Dep., Univ. of Lecce (Italy), 110/110 *cum Laude*  
•11/02/2002 PhD, Math. Department, Univ. of Tübingen (Germany), *Magna cum Laude* under the supervision of Prof. Rainer Nagel

## CURRENT AND PREVIOUS POSITIONS

•6/12/2010-2/7/2017 Researcher, Mathematics Department, University of Bari  
•3/7/2017-19/12/2021 Associate Professor, Mathematics Department, University of Bari  
•Since 20/12/2021 Associate Professor, Ecological and Biological Sciences Department, Tuscia University

## PAPERS

Author of 11 and co-author of 66 papers published on international journals with referee and 8 papers submitted for publication; author of a book review; co-author of the monograph: G. Fragnelli, D. Mugnai, Control of degenerate and singular parabolic equations. Carleman Estimates and Observability. BCAM SpringerBriefs, ISBN 978-3-030-69348-0, 2021

## AWARDS

•Since 27/07/18: Qualification as Full Professor in Mathematical Analysis after National Evaluation  
•Since 09/11/20: Qualification as Associate Professor in Mathematical Physics after National Evaluation  
•Winner, as Associate Professor, to the 2017 FFABR funding with score 59/60  
•Since 2011 in the list of *1000 Excellent Curricula* of Fondazione Bellisario  
•2011: Acknowledgment “for the excellent and brilliant professionalism and expertise in the field of research, innovation and development”, given on 17/07/ 2011 from Fondazione Bellisario during the XXIII edition of Marisa Bellisario Prize *Donne Innovazione e Capitale Umano*

## FELLOWSHIPS

•1/10/99-28/02/02: Winner of a scholarship from *Istituto Nazionale di Alta Matematica*, INdAM  
•4/03/02-3/03/03: Winner of a post-doc position at the Univ. of Roma Tor Vergata (Italy)  
•1/04/03-31/10/05: Winner of a grant from INdAM for post-doc students  
•1/02/03-31/01/05: Winner of a post-doc position at the Math. Department of the Univ. of Bari (not used)  
•1/11/05-13/07/10: First winner of a grant from the Univ. of Siena (Italy) for post-doc students

## SUPERVISION OF GRADUATE STUDENTS, PHD STUDENTS AND POSTDOCTORAL FELLOWS

•2021/2022: 2 degree theses in Mathematics  
•2020/2021: Supervision of Dr. Brahim Allal in the project *Grants for foreign and Italian citizens abroad* funded by the Italian Government for 9 months.  
•Since 2021: 1 PhD Student in Mathematics at the University of Bari  
•Since 2023: 1 PhD Student in Mathematics at the University of Bari

## RESPONSIBLE

•in 2021 for 10 Erasmus agreements in Mathematics  
•in 2015 Referent for the Visiting Professor position of N. S. Papageorgiou, funds from GNAMPA  
•in 2018 Referent for the Visiting Professor position of G. Ruiz Goldstein, funds from University of Bari Aldo Moro  
•in 2020 Referent for the Visiting Professor position of G. Ruiz Goldstein, funds from University of Bari Aldo Moro  
•in 2020 Referent for the Visiting Professor position of J. Salhi, funds from University of Bari Aldo Moro

- in 2024 Referent for the Visiting Professor position of M. Akil, funds from GNAMPA

## TEACHING ACTIVITIES

### Lectures for PhD Schools

- Since 2002: 8 PhD courses (*Univ. of Roma Tor Vergata* (Italy); *Univ. of Ulm* (Germany); *Univ. of Bari* (Italy); *ENS of Fez* (Morocco))

### Lectures for Degrees

- Since 2000: 18 Chair of University courses, 27 parts of courses, 2 training courses (*Univ. of Tübingen* (Germany); *Univ. of Roma Tor Vergata* (Italy); *Univ. of Siena* (Italy); *Univ. of Perugia* (Italy); *Univ. of Bari* (Italy); *Univ. of Tuscia* (Italy))

## ORGANISATION OF SCIENTIFIC MEETINGS

- 2001-2022: Member of the Scientific and Organizing Committees for 17 international Workshops and for 2 summer PhD Schools (June 2022, July 2022).

### • In 2023:

- \* Member of the Scientific and Organizing Committees of the following workshops:

- *At the interface of Mathematics, Artificial Intelligence and Earth Observation applications*, Bari 3- 5/7/23;
- Minisymposium *Control, stability and their applications* in SIAM Conference on Control and Its Applications (CT23), Philadelphia (U.S.) 24-26/07/23;

- Minisymposium *Analysis and Control of Climatological and Biological Models* in SIAM Conference on Control and Its Applications (CT23), Philadelphia (U.S.) 24-26/07/23;

- \* Member of Program Committee for the *SIAM Conference on Control and Its Applications (CT23)*, Philadelphia, Pennsylvania, U.S., 24-26/07/23

### • In 2024:

- \* Member of the Scientific and Organizing Committees of the following workshops:

- Minisymposium *Analysis, control and inverse problems in climate sciences* in the Joint Meeting AMS-UMI 2024, Palermo, 23-26/07/2024;

- \* Member of Program Committee for the 10th edition of the International Conference on Control, Decision, and Information Technologies (CoDIT 2024), Valletta (Malta), 1-4/07/24.

## INSTITUTIONAL RESPONSIBILITIES

- 2005/10: Member of several examination committees in Math. Analysis, Num. Analysis, Mathematical Physics and Physics (*Univ. of Perugia*, *Univ. of Siena*, *Univ. of Bari* and *Univ. of Tuscia* (Italy))

- 2011/12: Member of the examination committee *Progetto ISOMERI* for the *Univ. of Bari* (Italy)

- Since 2013/14: Member of the *Teaching Board for the PhD School* in Mathematics and in Computer Sciences, *Univ. of Bari* (Italy)

## COMMISSIONS OF TRUST

- Member of the Editorial Board of the following peer-reviewed Journals: *Nonlinear Analysis: Real World Applications* (since 2018); *Evolution Equations and Control Theory* (since 2017); *Discrete and Continuous Dynamical Systems - Series S* (since 2017); *Discrete Dynamics in Nature and Society* (2017-2024); *SCIREA Journal of Mathematics* (2019-2024); *Journal of Mathematics* (since 2021); *Axioms* (since 2022)

- Since 2014: Guest Editor of 9 Special Volumes

- Referee of three Ph.D theses (J. Salhi 2018, S. Boujjijane 2022, H. Yazbek 2023)

- Referee of four international projects (South Africa's National Research Foundation (NRF); National Science Centre Poland, 2021 and 2023)

- Since 2002: Review for *Mathematical Reviews*

- Since 2002: Referee for *Mathematical Journals* such as *NoDEA*, *Commun. Pure Appl. Anal.*, *Math. Anal. Appl.*, *Discrete Contin. Dyn. Syst.*, *Mathematical Control and Related Fields*, *Electron. J. Qual. Theory Differ. Equ.*, *Math. Model. Anal.*, *Nonlinear Anal. Real World Appl.*, *Math. Methods Appl. Sci.*, *Commun. Pure Appl. Anal.*, *Proceedings of IFAC*, *Proc. Amer. Math. Soc.* and *Appl. Math. Optim.*

- In 2023: Member of the commission for the *Axioms 2023 Best Paper Award*

- Member of the committee for the following positions:

- RTDA, Math. Department, University of Rome Tor Vergata, 2021

- RTT, Econ. Department, Universitas Mercatorum, 2022

- Associate Professor, Engineering, Information Sciences and Mathematics Department, University of L'Aquila 2024

- Member of the committee for the PhD title of

- Samir Boujjijane, Université Cadi Ayyad, Marrakech (Marocco), 01/04/2022

- Hawraa Yazbek, Université de Bordeaux, Bordeaux (Francia), 11/10/2023
- F. Trad, Lebanese University and Université Polytechnique Hauts-de-France, 2024

#### **MEMBERSHIPS OF SCIENTIFIC SOCIETIES**

- Since 2002: *GNAMPA Gruppo Nazionale per l'Analisi Matematica, la Probabilità e le loro Applicazioni*
- Since 2003: *UMI Unione Matematica Italiana*
- Since 2021: *UMI "Modellistica Socio-Epidemiologica (MSE)"*
- Since 2023: *UMI "CliMath Modellistica Matematica per lo studio del clima, del cambiamento climatico e dei suoi impatti"*
- Since 2023: *European Women in Mathematics*

#### **MAIN INVITED SEMINARS AND TALKS**

- Since 1998: 59 Invited Talks in International Workshop. In particular:

##### In 2024:

- Talk at *Some Mathematical Approaches to Climate Change and its Impacts*, Pisa 22-23/04/2024.
- Invited to give a talk during the the minisymposium *Women in Control* in the *9th European Congress of Mathematics (9ECM)*, Seville (Spagna), 15-19/07/2024.
- Invited to give a talk during the minisymposium *PDEs Applications to Nonlinear Phenomena in the Joint Meeting AMS-UMI 2024*, Palermo, 23-26/07/2024.
- Invited to give a talk during the minisymposium *Analysis and Control of Evolutionary Partial Differential Equations* in the Joint Meeting AMS-UMI 2024, Palermo, 23-26/07/2024.
- Invited to give a talk during the minisymposium *Advanced theoretical aspects in PDEs and their applications* in the *International Conference on Elliptic and Parabolic Problems: GAETA 2024*, Gaeta, 20-24/05/2024.
- Invited to give a talk during the workshop *EDP Seminar and Applied Mathematics*, Rio de Janeiro (Brazil), 7- 11/10/2024.

- Since 1999: 19 Invited Seminars in various universities

#### **FUNDED RESEARCH PROJECTS**

- 2005/24: Member of 6 *MIUR* Projects and of a Research Project *CNR-MTA* (Perugia-Szeged)
- 2010/2023: Member of the project European Research Group (GDRE) on Control of Partial Differential Equations (CONEDP), between French Centre National de la Recherche Scientifique and INdAM
- 2012/18: Member of 5 projects of the Univ. of Bari (Italy) on evolution equations
- 2013/14, 2019/20: **PI** of 2 *GNAMPA* projects
- 2015/2025: Member of 7 *GNAMPA* projects
- 2018: local **PI** for the Univ. of Bari for the *ACRI Young Investigator Training Program* Project
- 2019/24: Member of the project *COST Mathematical models for interacting dynamics on networks (MAT-DYN-NET) CA18232*
- 2021: **PI** of the *Horizon Europe Seeds* Project *STEPS: STEerability and controllability of PDES in Agricultural and Physical models*, Univ. Bari, funded with 50.000Euros
- 2022/25: Member of the project *PNRR Rome-Technopole*, funded by the European Union
- 2022: **PI** of the *Progetto Horizon Europe* *CONtrollability of PDEs in the Applied Sciences*, Univ. Tuscia
- 2023: Member of the project *To the stability of tower buildings*, Federation of Hauts-de-France and CNRS France

#### **OTHER INFORMATIONS**

- Bibliometric indicators at 7/05/2024
- SCOPUS: 1076 citations, h-index 20
- WOS: 965 citations, h-index 18
- For the VQR 2011-2014 I presented a paper for the University of Bari Aldo Moro taking the valuation 1 (excellent)
- For the VQR 2015-2019 I presented four papers for the University of Bari Aldo Moro and one for GNAMPA obtaining one A (excellente and extremely relevant) and three B (excellent).

## 10 main publications in the last 15 years by Genni Fragnelli

10. A. Camasta, G. Fragnelli, A stability result for a degenerate beam equation, *SIAM J. Control Optim.* 62 (2024), 630–649.
9. A. Camasta, G. Fragnelli, New results on controllability and stability for degenerate Euler-Bernoulli type equations, *Discrete Contin. Dyn. Syst.* (2024), doi:10.3934/dcds.2024024, 39 pagine.
8. I. Boutaayamou, G. Fragnelli, D. Mugnai, *Boundary controllability for a degenerate wave equation in non divergence form with drift*, *SIAM J. Control Optim.* 61 (2023), 1934–1954
7. G. Fragnelli, M. Yamamoto, *Carleman estimates and controllability for a degenerate structured population model*, *Appl. Math. Optim.* 84 (2021), 999-1044.
6. G. Fragnelli, *Null controllability for a degenerate population model in divergence form via Carleman estimates*, *Adv. Nonlinear Anal.*, 9 (2020), 1102-1129.
5. I. Boutaayamou, G. Fragnelli, *A degenerate population system: Carleman estimates and controllability*, *Nonlinear Anal.*, 195 (2020), 111742, 1-29.
4. G. Fragnelli, *Carleman estimates and null controllability for a degenerate population model*, *J. Math. Pures Appl.*, 115 (2018), 74-126.
3. G. Fragnelli, D. Mugnai, *Carleman estimates for singular parabolic equations with interior degeneracy and non smooth coefficients*, *Adv. Nonlinear Anal.*, 6 (2017), 61-84.
2. G. Fragnelli, D. Mugnai, *Carleman estimates, observability inequalities and null controllability for interior degenerate non smooth parabolic equations*, *Mem. Amer. Math. Soc.*, 242 (2016), no. 1146, v+84 pp.
1. G. Fragnelli, *Interior degenerate/singular parabolic equations in nondivergence form: well-posedness and Carleman estimates*, *J. Differential Equations* 260 (2016), 1314-1371.