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 2023

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 leave: 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*
•2002 PhD in Mathematics, Math. Department, Univ. of Tübingen (Germany), *Magna cum Laude*

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 59 papers published on international journals with referee and 4 papers submitted for publication; co-author of a monograph and author of a book review.

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 professionality 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: Dr. Brahim Allal in the project *Grants for foreign and Italian citizens abroad* funded by the Italian Government for 9 months since 01/01/20
•Since 2021: 1 PhD Student in Mathematics at the University of Bari

RESPONSIBLE
•in the 2021 for 10 Erasmus agreements in Mathematics

TEACHING ACTIVITIES
Lectures for PhD Schools
•Since 2002: 6 PhD courses (*Univ. of Roma Tor Vergata* (Italy); *Univ. of Ulm* (Germany); *Univ. of Bari* (Italy))
Lectures for Degrees
• Since 2000: 16 Chiar 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
• Member of the Scientific and Organizing Committees for 17 international Workshops and for 2 summer PhD Schools (June 2022, July 2022).

• In 2023: *At the interface of Mathematics, Artificial Intelligence and Earth Observation applications,* Bari 3-5/7/23; Minisymposium *Control, stability and their applications* and 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** per il *SIAM Conference on Control and Its Applications (CT23)*, Philadelphia, Pennsylvania, U.S., 24-26/07/23

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* (since 2017); *SCIREA Journal of Mathematics* (since 2019); *Journal of Mathematics* (since 2021); *Axioms* (since 2022)
•Since 2014: Guest Editor of 9 Special Volumes
•Referee for two Ph.D theses (J. Salhi 2018, S. Boujijane 2022)
•Referee for two international projects (South Africa's National Research Foundation (NRF) and National Science Centre Poland, 2021)
•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.

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: *European Mathematical Society*

SELECTED MAJOR COLLABORATIONS
Univ. Alberta, Edmonton (Canada): W. Allegretto; *Univ. Memphis* (USA): G. R. Goldstein, J.A. Goldstein; *Université Paul Sabatier* (France): P. Martinez, J. Vancostenoble*; Laboratoire Jacques-Louis Lions Sorbonne Université, Université de Lorraine* (France): F.Alabau-Boussouira; *Univ. Marrakesh*, (Morocco): L. Maniar; *Romanian Academy of Bucharest* (Romania): G. Marinoschi; *Univ. Tuscia* (Italy): *Univ. L'Aquila* (Italy): C. Pignotti; *Univ. Roma Tor Vergata* (Italy): P. Cannarsa, *Univ. Tokio* (Japan): M. Yamamoto

MAIN INVITED SEMINAR AND TALKS
•Since 1998: 55 Invited Talks in International Workshop
•Since 1999: 16 Invited Seminars in various universities

FUNDED RESEARCH PROJECTS
•2005/22: Member of 5 *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), 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
•2015/2023: Member of 5 *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
•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

10 main publications in the last 15 years by Genni Fragnelli

10. I. Boutaayamou, G. Fragnelli, D. Mugnai, *Boundary controllability for a degenerate wave equation in non divergence form with drift*, to appear in SIAM J. Control Optim.

9. G. Fragnelli, M. Yamamoto, *Carleman estimates and controllability for a degenerate structured population model*, Appl. Math. Optim. 84 (2021), 999-1044.

8. G. Fragnelli, *Null controllability for a degenerate population model in divergence form via Carleman estimates*, Adv. Nonlinear Anal., 9 (2020), 1102-1129.

7. I. Boutaayamou, G. Fragnelli, *A degenerate population system: Carleman estimates and controllability*, Nonlinear Anal., 195 (2020), 111742, 1-29.

6. G. Fragnelli, *Carleman estimates and null controllability for a degenerate population model*, J. Math. Pures Appl., 115 (2018), 74-126.

5. G. Fragnelli, D. Mugnai, *Carleman estimates for singular parabolic equations with interior degeneracy and non smooth coefficients*, Adv. Nonlinear Anal., 6 (2017), 61-84.

4. 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.

3. G. Fragnelli, *Interior degenerate/singular parabolic equations in nondivergence form: well-posedness and Carleman estimates*, J. Differential Equations 260 (2016), 1314-1371.

2. 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.

1. G. Fragnelli, D. Mugnai, *Stability of solutions for some classes of nonlinear damped wave equations*, SIAM J. Control Optim. 47 (2008), 2520-2539.