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Curriculum vitae

1. Curriculum vitae

2026 - Presently Professor at Université Paris-Saclay.
2023 - Senior member of Institut Universitaire de France.
2018 -2023 Senior member of Institut Universitaire de France
2004 -09 Junior member Institut universitaire de France.
2003 Visiting professor MSRI, Berkeley California
2002 Visiting Miller professor, University of California, Berkeley
1998 - Professor in université Paris-Sud IX (which became Université Paris-Saclay in 2020).
1991-98 - Chargé de Recherche in CNRS (Centre de Mathématiques de l'Ecole Polytechnique).

2. Education

1992 - PhD from Université Paris-Sud on « Contrôle de l'équation des plaques en présence d'obstacles strictement convexes ». PhD advisor : G. Lebeau.
1989 - Master in Mathematics from Université Paris 7. Master advisor M. Vergne
1986-90 - Student in l'Ecole Normale Supérieure.

3. Distinctions :

- Laureate of ERC advanced grant (projet GEOEDP) 2023-2028
- Senior member Institut Universitaire de France (sept 2018-23 and again from 2023).
- Invited speaker International Congress of Mathematicians ICM 2010 Hyderabad, (section : équations aux dérivées partielles).
- Grand prize 2007 of the french academy of science (Prix fondé par l'état).
- Junior member Institut Universitaire de France (sept 2004–aout 2009).
- Prix 2004 de l'Institut Henri Poincaré (avec P. Gérard et N. Tzvetkov), for our article « On nonlinear Schrödinger equations in exterior domains »*(Annales de l'I.H.P. Vol. 21, n.3, 2004, pp. 295-318).*
- Miller Professor, University of California, Berkeley, sept-déc. 2002.
- Invited speaker European Congress of Mathematicians ECM3 Barcelona 2000.

4. Publication list 2020-26

[1] Nicolas Burq. Decays for Kelvin-Voigt damped wave equations I: the black box perturbative method. *SIAM J. Control Optim.*, 58(4):1893–1905, 2020.

[2] N. Burq and C. Sun. Decays for Kelvin-Voigt damped wave equations II: the geometric control condition. *arXiv:2010.05614 to appear Proceeding of the AMS*, 2021.

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[4] N. Burq and L. Thomann. Almost sure scattering for the one dimensional nonlinear schrödinger equation. *Preprint, arXiv:2012.13571 to appear Memoirs of the AMS*, 2022.

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[6] N. Burq and I. Moyano. Propagation of smallness and control for heat equations. *arXiv:1912.07402 to appear Journal of the EMS*, 2021.

[7] V. Banica and N. Burq. Microlocal analysis of singular measures. *arXiv:2104.09931 submitted*, 2021.

[8] J.M. Bouclet and N. Burq. Sharp resolvent and time decay estimates for dispersive equations on asymptotically euclidean backgrounds. *Duke Math. J.*, 170(11):2575–2629, 2021.

[9] Nicolas Burq and Joachim Krieger. Randomization improved Strichartz estimates and global well-posedness for supercritical data. *Ann. Inst. Fourier (Grenoble)*, 71(5):1929–1961, 2021.

[10] Nicolas Burq and Chenmin Sun. Decay rates for Kelvin-Voigt damped wave equations II: the geometric control condition. *Proc. Amer. Math. Soc.*, 150(3):1021–1039, 2022.

[11] Nicolas Burq and Chenmin Sun. Decay for the Kelvin-Voigt damped wave equation: piecewise smooth damping. *J. Lond. Math. Soc. (2)*, 106(1):446–483, 2022.

[12] Nicolas Burq and Laurent Thomann. Almost sure scattering for the one dimensional nonlinear schrödinger equation. *Mem. Amer. Math. Soc.*, 296(1480):vii+87, 2024.

[13] Nicolas Burq and Chenmin Sun. Time optimal observability for grushin schrödinger equation. *Analysis & PDE*, 15(6):1487–1530, 2022.

[14] N. Burq, V. Georgiev, N. Tzvetkov, and N. Visciglia. H^1 scattering for mass-subcritical NLS with short-range nonlinearity and initial data in Σ. *Ann. Henri Poincaré*, 24(4):1355–1376, 2023.

[15] Nicolas Burq and Iván Moyano. Propagation of smallness and control for heat equations. *J. Eur. Math. Soc. (JEMS)*, 25(4):1349–1377, 2023.

[16] Nicolas Burq and Claude Zuily. A remark on quantitative unique continuation from subsets of the boundary of positive measure. *Proc. Amer. Math. Soc.*, 151(9):3903–3912, 2023.

[17] Nicolas Burq and Iván Moyano. A remark on the logarithmic decay of the damped wave and Schrödinger equations on a compact Riemannian manifold. *Port. Math.*, 80(3-4):369–390, 2023.

[18] Nicolas Burq, Belhassen Dehman, and Jerôme Le Rousseau. Measure propagation along C^0 vector field and wave controllability on a rough compact manifold. *Analysis and PDE*, 17(8):2683–2717, 2024.

[19] Nicolas Burq, Belhassen Dehman, and Jerôme Le Rousseau. Semi-classical observation suffices for observability: wave and schrödinger equations. *COCV*, 30(10), 2024. preprint: arXiv:2306.00536.

[20] Nicolas Burq and Laurent Thomann. Evolution of gaussian measures and application to the one dimensional nonlinear schrödinger equation. *RIMS Workshop: Nonlinear and Random Waves, RIMS, Oct 2022, Kyoto (Japan), arXiv:2303.06964*, 2023. To appear.

[21] Nicolas Burq, Aurelien Poiret, and Laurent Thomann. Bilinear strichartz estimates and almost sure global solutions for the nonlinear schrödinger equation. *preprint: arXiv:2304.10979*, 2023. To appear Mémoires de la Société mathématique de France,.

[22] Nicolas Burq and Robert Schippa. Strichartz estimates for maxwell equations on domains with perfectly conducting boundary conditions. *preprint: arXiv:2304.13368*, 2023. Submitted.

[23] Nicolas Burq, Nicolas Camps, Mickaël Latocca, Chenmin Sun, and Nikolay Tzvetkov. The second picard iteration of nls on the 2d sphere does not regularize gaussian random initial data. *EMS Surveys in Mathematical Sciences*, 2025. To appear, arXiv:2404.18241.

[24] Nicolas Burq and Ivan Moyano. Propagation of smallness and spectral estimates. *J. Anal. Math.*, 156(1):35–46, 2025.

[25] Nicolas Burq and Claude Zuily. Domains of dependence for subelliptic wave equations and unique continuation for fractional powers of Hörmander's operators. *ESAIM Control Optim. Calc. Var.*, 31:Paper No. 88, 21, 2025.

[26] Nicolas Burq and Cyril Letrouit. Delocalized eigenvectors of transitive graphs and beyond. *J. Spectr. Theory*, 16(1):145–181, 2026.

[27] Valeria Banica and Nicolas Burq. Remarks on hypoelliptic equations. *Ann. H. Lebesgue*, 9:85–96, 2026.

[28] Nicolas Burq, Pierre Germain, Massimo Sorella, and Hui Zhu. Trace and observability inequalities for Laplace eigenfunctions on the torus. *Forum Math. Sigma*, 14:Paper No. e47, 26, 2026.

[29] Nicolas Burq and Mickaël Latocca. Strichartz estimates for Baouendi–Grushin operators. *Rev. Mat. Iberoam.*, 42(3):903–920, 2026.

[30] Thomas Alazard, Nicolas Burq, Mikhaela Ifrim, Daniel Tataru, and Claude Zuily. Nonlinear interpolation and the flow map of quasilinear equations. *Journal of the European Mathematical Society*, 2026. To appear.

5. Statement of purpose

The last decade has witnessed a very fast and deep development in the field of evolution partial differential equations (and particularly the dispersive equations). These major advances allow some perspectives which appeared to be completely out of reach a few years ago and open the very exciting perspective of studying deep dynamical properties of solutions of Partial differential equations. On the other hand, specialists of dynamical systems successfully extended methods and ideas, developed for the study of finite dimensional models, to infinite dimensional ones. This led to spectacular results concerning long time behavior of solutions of some non-linear partial differential equations, especially in one space dimension or for critical models. The tools developed in the PDE context to handle non-linear PDEs could also lead to major breakthroughs, when combined with some dynamical properties of the equations. Finally, the study of partial differential equations in the presence of randomness, a topic originating in ideas from statistical mechanics, has also recently seen spectacular results. The goal of my research project is to blend together ideas from these three points of view, to gain some new insights on the behaviour of solutions of partial differential equations in some asymptotic regimes :

- Long time behavior,
- Existence, scattering,
- Stabilities, instabilities,
- Rough geometries and control.

5.1. Context, position and objectives of my activities. — During the last decade, the interface between some very active fields of research in mathematics, linear or non-linear partial differential equations, infinite dimensional dynamical systems and probabilities has been growing rapidly. Indeed, the numerous advances in non linear partial differential equations allow some

perspectives which appeared to be completely out of reach a few years ago and open very exciting perspectives. My research project is at the core of these questions. I plan to study some questions in control theory and large time PDE?s description via the use of randomness to reveal new phenomena. The guidelines of my project are the study of partial differential equations in some asymptotic regimes in connection with geometry. The aims are to obtain on various topics descriptions of the dynamical behavior of solutions. The originality of the project is that I intend to do so by blending together ideas coming from different fields such as micro-local analysis, dynamical systems and probabilities, by studying some statistical quantities rather than using the more precise (but less amenable) deterministic approach.

5.2. State of the art. — During the last fifteen years, a number of results have been obtained at the confluent of control theory, infinite dimensional dynamical systems and non-linear partial differential equations. I will describe here the state of the art in several sub-domains of these matters which are at the heart of my project.

5.2.1. *Random non-linear partial differential equations.* — In most cases, when dealing with random perturbations of non linear partial differential equations, randomness is seen as a problem to tackle. Indeed, for example, many advances have been performed to handle the typical poor regularity of random forces in stochastic PDE?s. Here the point of view we adopt is the opposite : instead of being a problem to tackle, randomness could in some cases help. Following the pioneering works by Bourgain on Gibbs measures for the non linear Schrödinger equation, major progress have been done in recent years using stochastic methods to construct local or global solutions of some Hamiltonian equations. The main point is that in many cases, the behaviour of solutions to nonlinear PDE?s is better than expected (when one has in mind the deterministic theory), when initial data are chosen randomly. More specifically, Burq and Tzvetkov [13, 14, 15] started the study of the behaviour of solutions to wave or Schrödinger equations with random initial data. The idea is to understand in which sense this behaviour is better than in the deterministic case. For the local Cauchy theory, this is true in a very general setting for wave as well as for Schrödinger equations (Burq-Tzvetkov-Thomann [45]). Indeed, it is possible to show that these equations are well posed almost surely (for natural probability measures on the space of initial data), for regularity thresholds which are noticeably smaller than the ones which (after the works by Lebeau [28, 27] and Christ-Colliander-Tao [18]) are known to be optimal from the deterministic point of view. Some global in time results were also obtained, in some particular geometries (torus, harmonic oscillator). Colliander and Oh also obtained recently very interesting results on the non linear Schrödinger equation on the one dimensional torus with random initial data below L2 (see also the work by Nahmod-Pavlovic-Staffilani [41]).

5.2.2. *Blow-up, Instabilities and large time behavior for non-linear PDEs.* — Many Hamiltonian non-linear PDEs exhibit finite time blow-up, starting from non singular initial data. This is the case for the nonlinear Schrödinger equation (NLS), the Korteweg-de Vries equation (KdV) and its modified and generalized forms, as well as the nonlinear wave equation (NLW). In the last decade, several breakthroughs were achieved in the understanding of the blow-up behavior, in particular by Raphaël and Merle for NLS [34, 33], Martel and Merle for KdV [31, 30] (see also [44, 35, 32]). Blow-up dynamics for NLW in one space dimension have been fully elucidated by Merle and Zaag [40, 39, 37, 36] and Côte and Zaag [20]. Among the many difficulties one has to face to prove such results, a major one is the non self-adjoint character of linearized operators around limiting profiles. Those difficulties were overcome thanks to the use of dynamical systems? formulations,

together with non-linear PDEs techniques. The use of rigidity theorems (or Liouville-type theorems) was essential in those results. Let me also mention the very nice works by Kenig-Merle and Duyckaerts-Kenig-Merle on the description of large time behavior of solutions to energy critical wave equations (soliton resolution conjecture). Another approach for detecting instabilities for solutions to non linear PDE?s is to construct approximate solutions which exhibit this instability phenomenon, and of course to prove that these approximate solutions are close to an exact solution. The difficulty in this approach is precisely that the more drastic the instability, the more difficult it is to prove this latter approximation property (in other words, the more unstable the equation, the more difficult it is to prove that it is indeed unstable !). This approach was successfully applied by Christ Colliander, Tao [18], Lebeau [28, 27] and Burq, Gérard, Tzvetkov [10, 9].

In some systems where global well posedness is achieved, one observes an arbitrary wide growth of norms (for high Sobolev regularity) during the evolution of the solution to the Cauchy problem with appropriate initial data, despite of the conservation of energy (usually in H1). That is the case, for instance, in the weak turbulence result of Colliander, Keel, Staffilani, Takaoka and Tao [19], who have shown a transfer of energy to high frequencies in the cubic defocusing nonlinear Schrödinger equation. This beautiful result transposes nonlinear dynamical effects in finite dimension to the infinite dimensional setting, showing genuine nonlinear phenomena. This result was recently nicely extended on $\mathbb{R} \times \mathbb{T}^2$ by Hani-Pausader-Tzvetkov-Visciglia [24].

5.2.3. *Control theory, dispersion and geometry.* — For the control of wave equations and (sufficiently) smooth geometries, the situation is, since the work by Bardos-Lebeau and Rauch quite well understood : the geometric control condition (all geodesics have to encounter the control region in finite time) is essentially necessary and sufficient [10,13]. It is also known [31] that it is sufficient for Schrödinger equations. However, in some particular geometries (tori [24,7], some hyperbolic surfaces [49]) this condition is not necessary. While one might think that the field is by now quite well understood, many fascinating questions remain open : what happens or very rough coefficients/geometries ? Can we obtain non trivial results on some other particular geometries, etc...

5.3. Goals of the project. —

5.3.1. *Random non-linear partial differential equations.* — Until recently, the main ideas in the proofs of the stochastic results described in the preceding section came from the works of Lebowitz-Rose-Speer [29], Bourgain [6, 7] and Zhidkov [50]. The strategy is the following : First construct a formally invariant measure (this uses the Hamiltonian structure of the equation). Then, develop an almost sure well posedness theory. Finally, get the global existence of the flow, using a Galerkin approximation and the invariance of the measure. This scheme was already fruitful for Bourgain [6, 7] and Zhidkov [50] for NLS on the torus, Tzvetkov [46, 47] for NLS on the disc, Burq-Tzvetkov [15] for the wave equation, Oh [42, 43] for Schrödinger-Benjamin-Ono and KdV systems, and Burq-Thomann-Tzvetkov [12] for the one-dimensional Schrödinger equation. However, this strategy has a major drawback : the use of Gibbs measures induces an important algebraic rigidity. Two main objectives will be pursued : first break the rigidity of the tools (namely Gibbs measures) used to prove global existence. Indeed, they limit a lot the scope of applicability of such an approach, as they restrict both the type of (Hamiltonian) PDEs and the level of regularity required. Some steps were already performed in this direction by Colliander and Oh and by Burq-Thomann-Tzvetkovin [16, 11] and Nahmod,

Pavlovic and Staffilani [41]. Here I plan to deepen this approach and try to construct only almost invariant measures (measures such that their push-forward by the evolution flow is only absolutely continuous with respect to the initial measure) and deduce some dynamical properties of the flow. The second goal, more ambitious but very natural, once a global flow is shown to exist on a full measure statistical set, is precisely to study the dynamical properties of this flow, and take benefit of the statistical approach to exhibit non trivial properties, presently out of reach of deterministic methods (transfer of energy in frequencies, bounds from below or above on the growth of Sobolev norms even for example at levels of regularity where deterministic solutions exist, quasi-invariant measures, scattering properties of solutions). Once again, a focus will be put on large time studies. Finally, I intend to develop this point of view to the study of Euler or Navier-Stokes equations. Indeed some very interesting results on the topic have already been obtained by Nahmod, Pavlovic and Staffilani [41]. In fluids mechanics, problems may very often be very difficult, with few advances made on some particular topics since the seminal works of Leray (weak solutions) and Kato (strong solutions). An idea to bypass these strong difficulties could be to adopt a statistical point of view. For example, if one considers the two-dimensional Euler equation, it is known that there exists global solutions in $C^0(\mathbb{R}_y\ ; H^s)$ as soon as s ¿ 2. However, the bounds on the "complexity" of the flow are double exponential in time :

A natural question in this context is whether one can avoid this double exponential and get (for example) a single exponential. I plan to investigate this type of questions from a statistical point of view (i.e. asking whether one can construct probability measures on the set of initial data for which one could prove that the probability measure of the set of solutions for which it is indeed possible is 1, or at least positive).

5.3.2. *Blow-up, Instabilities and large time behavior for non-linear PDEs.* — With Raugel and Schlag we are presently investigating the large time behavior of solutions of energy subcritical focusing damped wave equations. In particular, our purpose is to blend into this topic new ideas coming from dynamical system theory. This leads in this context to the analog of the soliton resolution conjecture for radial data. Namely we proved that all global in time solutions are bounded and converge to an equilibrium (notice that since very few is known about the equilibria, even when boundedness is assumed, the convergence to equilibria is non trivial). We managed recently to extend the result to a class of damping vanishing asymptotically for large time. We plan to develop further this line of research and study non radial solutions, non global dampings. The strategy we intend to follow is to mix these new ideas from dynamical systems with the machinery developped by Kenig-Merle (and many other authors). Another quite exciting question would be to adopt a dynamical point of view in order to investigate the question of exact controllability of the defocusing wave equations with a geometric time (that is, a time independent of the size of the initial data). Recall that presently all controllability results for semi-linear equations rely on the following strategy : first prove stabilisation results, then prove local controllability near the 0 solution, finally combine these results to get global controllability results. As a consequence, for large data, exact controllability requires large times (the time necessary to implement the stabilisation scheme). The techniques developed above are not specific to the Klein-Gordon equation and some of them should be applicable as well to the Schrödinger equation with weak dissipation and to other dispersive systems with weak dissipation.

5.3.3. *Control theory, dispersion and geometry.* — The first question I plan to study is the question of controlability of semi-linear wave equations mentionned above. I also plan to continue

a project iniciated with P. Gérard where we investigate the stabilization of wave equations on tori where the damping function is only L^∞. In this framework, the geometric control condition does not make sense any more. However there is a natural substitute. In the particular case where the damping function is a sum of caracteristic functions of polygons, we can prove via a second microlocalization approach, that this condition is necessary and sufficient for stabilization. I am presently completing an extension of the result to general manifolds. In this new work, I understand better the control questions (in particular the time necessary to achieve exact control) The underlying question is to understand stabilisation and control problems with very rough regions (measurable sets?). These questions are linked to the understanding of dispersion properties for solutions to PDE?s in some particular geometries. Another open question that I have in mind is the obtention of non trivial dispersion results on hyperbolic manifolds leading to improvements for dispersion/Strichartz estimates for the solutions, and eventually to improvements for the Cauchy theory (recall that even on hyperbolic surfaces, the best known result for dispersive estimates for solutions to Schrödinger equations is the semi-classical estimate [16], which is true for any geometry ! In some sense, the recent results by Dyatlov and Lin [57] (after Dyatlov-Bourgain)are a first step in this direction.

5.4. Project bibliography. —

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Sincerely yours,

