

Pierre RAPHAËL

Herchel Smith Professor of Pure Mathematics
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Research

Non linear evolution equations of mathematical physics (Schrödinger, waves and fluids). Singularity formation and energy concentration mechanisms.

Education

- PhD-Apr 2004 Université de Cergy-Pontoise: “Étude de la dynamique explosive des solutions de l'équation de Schrödinger nonlinéaire L^2 critique”. Advisor: Frank Merle (IHES and CYU)
- MA École des Ponts, Marne-la-Vallée (1998-2001) and Université Paris 6 (1999).
- BA École Polytechnique, Palaiseau, 1995-1998.

Academic Positions

- 2019-present Herchel Smith Professor of Pure Mathematics, Cambridge, UK.
Fall 2015 Chancellor Professorship, UC Berkeley, USA.
Sept 2012 Full professor, Université de Nice Sophia-Antipolis.
Spring 2012 Invited Professor, MIT, Boston, USA.
Fall 2010 Invited Professor, Nachdiplom Lectures, ETH, Zurich, Suisse.
Sep 2007 Associate Professor, University Paul Sabatier, Toulouse, France.
Sep 2007 Adjunct Professor, École Polytechnique, France.
2006-2007 Assistant professor, Princeton University, USA.
2004-2007 Chargé de recherche, CNRS.

Prizes and awards

- 2019-2024 Royal Society Wolfson Fellowship.
Fev 2015 PI of the ERC Consolidator grant SINGWAVE, 2015-2020.
Oct 2014 Grand Prix Alexandre Joannides from the French Academy of Sciences.
Aug 2014 Invited Speaker ICM 2014, joint sessions PDE/Mathematical Physics.
Oct 2011 Junior member of the Institut Universitaire de France.
Sept 2008 PI ERC starting grant, project SWAP funded 300ke by the French ANR.
1998 Prix L.E.Rivot from the French Academy of Sciences.

Grants

- 2015-2020 PI of the ERC consolidator grant SINGWAVE.
2012-2015 Member of the ERC advanced grant BLOWDISOL.
2008-2013 PI of the ERC starting grant SWAP (funded by French ANR).
2006-2009 Member of French ANR Projet Blanc “Ondes non linéaires”.

Selected Conferences

May 2022	Calderon-Zygmund lectures, Chicago.
Oct 2021	Weyl Lectures, IAS, Princeton.
Mai 2020	Princeton Math Colloquium.
June 2019	Conference in honor of Gilles Lebeau, Bergen, Norway.
July 2015	Eq diff conference 2015, Lyon, plenary speaker.
Sept 2014	Conference in honor of C. Kenig 60's birthday, Chicago.
Aug 2014	ICM speaker, joint sessions PDE/Mathematical Physics, Seoul.
Mai 2012	Conference in honor of T. Tao, Northwestern University.
Spring 2011	Nachdiplom lectures, ETH, Zurich.
Jan 2011	Kaleidoscopic view of modern Mathematics, IHES and IHP.
Jui 2008	Clay Summer School on nonlinear dispersive wave equations, ETH.
Avr 2007	Riviere-Fabes lectures, University of Minnesota.

Students

2016-19	E. Pacherie (ENS Ulm), "On Ginzburg Landau vortices"
2014-16	C. Collot (ENS Ulm), "Blow up for energy super critical waves".
2009-12	T. Boulenger (ENS Cachan), "Blow up for NLS on a manifold".
2010-13	R. Schweyer (ISAE), "Blow up for critical parabolic models".

Post docs

2016-17	Y. Naumkin, solitons and weak turbulence for fractional NLS.
2016-17	Y. Bahri, self similar blow up for the mass super critical NLS.
2016-17	J. Zheng, on energy super critical blow up for NLS.

Organization of Programs

June 2019	Coorganizer of the "Nonlinear waves in Nice" conference, Nice, France.
Spring 2016	Coorganizer of the IHES program "Nonlinear PDES" with Y. Martel (Versailles), F. Merle (IHES), F. Planchon (Nice), J. Szeftel (Jussieu).
Fall 2015	Coorganizer of the jumbo MSRI program "New challenges in PDE: Deterministic dynamics and randomness in high and infinite dimensional systems" with K. Kirkpatrick (Illinois), Y. Martel (Versailles), J. Mattingly (Duke), A. Namhmod (UMass), L.Rey-Bellet (Umass), D. Tataru (Berkely), G. Staffiani (MIT).
Jul 2011	Coorganizer with M. Del Pino (Santiago), Y. Martel (Versailles) et F. Merle (IHES) of the Summer school "Qualitative study of PDE's involving solitary waves" in Santiago, Chili.
Spring 2009	Coorganizer of the IHP thematic program "Ondes nonlinéaires et dispersion" with F. Merle (Cergy) and F. Planchon (Paris 13).

Administrative and academic activities

2021	Member of the IUF junior jury.
2010-2011	Coordinator of the international Fermat Prize 2011.
2007- 2011	Member of the scientific council, UFR MIG, Université Paul Sabatier.

Publications

- [1] Faou, E.; Raphaël, P., *On weakly turbulent solutions to the perturbed linear Harmonic oscillator*, to appear in Amer. Math. Journal.
- [2] Merle, F.; Raphaël, P.; Rodnianski, I.; Szeftel, J., *On the implosion of a three dimensional compressible fluid*, to appear in Annals of Maths.
- [3] Merle, F.; Raphaël, P.; Rodnianski, I.; Szeftel, J., *On blow up for the energy super critical defocusing non linear Schrödinger equations*, to appear in Invent. Math.

- [4] Merle, F.; Raphaël, P.; Rodnianski, I.; Szeftel, J., *On smooth self similar solutions to the compressible Euler equations*, to appear in *Annals of Maths*.
- [5] Naumkin, I.; Raphaël, P., *On small travelling to the nonlocal fractional NLS*, *Calc. Var. Partial Differential Equations* 57 (2018), no. 3, Art. 93, 36 p.
- [6] Collot, C.; Merle, F.; Raphaël, P., *On strongly anisotropic type II blow up*, to appear in *Jour. Amer. Math. Soc.*
- [7] Merle, F.; Raphaël, P.; Szeftel, J., *On strongly anisotropic type I blow up*, to appear in *IMRN*.
- [8] Gerard, P.; Lenzman, E.; Pocovnicu, O.; Raphaël, P., *Two soliton dynamics with transient turbulent regime for the cubic half wave on the line*, *Ann. PDE* 4 (2018), no. 1, Art. 7, 166 pp.
- [9] Martel, Y.; Raphaël, P., *Strongly interacting blow up bubbles for the mass critical NLS*, *Ann. Sci. Ec. Norm. Super.* (4) 51 (2018), no. 3, 701–737.
- [10] Collot, C.; Raphaël, P.; Szeftel, J., *On the stability of self similar blow up for the energy super critical heat equation*, *Mem. Amer. Math. Soc.* 260 (2019), no. 1255.
- [11] Martel, Y.; Merle, F.; Nakanishi, K.; Raphaël, P., *Codimension one threshold manifold for the critical gKdV equation*, *Comm. Math. Phys.* 342 (2016), no. 3, 1075–1106.
- [12] Hadzic, M.; Raphaël, P., *Melting and freezing for the Stefan problem*, *J. Eur. Math. Soc.* 21 (2019), no. 11, 3259–3341.
- [13] Collot, C., Merle, F.; Raphaël, P., *Dynamics near the ground state for the energy critical heat equation in large dimensions*, *Comm. Math. Phys.* 352 (2017), no. 1, 215–285.
- [14] Merle, F.; Raphaël, P.; Rodnianski, I., *Type II blow up for the energy supercritical NLS*, *Camb. J. Math.* 3 (2015), no. 4, 439–617.
- [15] Le Coz, S.; Martel, Y.; Raphaël, P. *Minimal mass blow up solutions for a double power nonlinear Schrödinger equation*, *Rev. Mat. Iberoam.* 32 (2016), no. 3, 795–833.
- [16] Raphaël, P.; Schweyer, R., *Quantized slow blow up dynamics for the corotational energy critical harmonic heat flow*, *Analysis and PDE* 7 (2014), no. 8, 1713–1805.
- [17] Raphaël, P.; Schweyer, R., *On the stability of critical chemotactic aggregation*, *Math. Ann.* 359 (2014), no. 1-2, 26–377.
- [18] Martel, Y.; Merle, F.; Raphaël, P.; *Blow up for the critical gKdV equation III: exotic regimes*, *Ann. Sc. Norm. Super. Pisa Cl. Sci.* (5) 14 (2015), no. 2, 575–631.
- [19] Martel, Y.; Merle, F.; Raphaël, P.; *Blow up for the critical gKdV equation II: minimal mass blow up*, *J. Eur. Math. Soc. (JEMS)* 17 (2015), no. 8, 1855–1925.
- [20] Martel, Y.; Merle, F.; Raphaël, P.; *Blow up for the critical gKdV equation I: dynamics near the solitary wave*, *Acta Math.* 212 (2014), no. 1, 59–140.
- [21] Raphaël, P., *Concentration compacité à la Kenig-Merle*, *Séminaire Bourbaki Vol. 2011/2012. Exposé 1043–1058.* *Astrisque* no. 352 (2013), Exp. No. 1046, vii, 121–146.
- [22] Krieger, J.; Lenzmann, E; Raphaël, P., *Nondispersive solutions to the L^2 -critical Half-Wave Equation*, *Arch. Ration. Mech. Anal.* 209 (2013), no. 1, 61129.
- [23] Merle, F.; Raphaël, P.; Szeftel, J., *Collapsing ring blow up solutions to the L^2 super critical NLS*, *Duke Math. J.* 163 (2014), no. 2, 369–431.
- [24] Raphaël, P.; Schweyer, R., *Stable blow up dynamics for the 1-corotational energy critical harmonic heat flow*, *Comm. Pure Appl. Math.* 66 (2013), no. 3, 414480.
- [25] Merle, F.; Raphaël, P.; Rodnianski, I., *Blow up dynamics for smooth equivariant solutions to the energy critical Schrödinger map*, *Invent. Math.* 193 (2013), no. 2, 249365.

- [26] Merle, F.; Raphaël, P.; Szeftel, J., *Instability of Bourgain Wang solutions for the L^2 critical NLS*, Amer. J. Math. 135 (2013), no. 4, 9671017.
- [27] Hillairet, M.; Raphaël, P., *Smooth type II blow up solutions to the energy critical focusing wave equation in dimension four*, Anal. PDE 5 (2012), no. 4, 777829.
- [28] Raphaël, P.; Rodnianski, I., *Stable blow up dynamics for critical corotational wave maps and the equivariant Yang Mills problems*, Publ. Math. Inst. Hautes tudes Sci. 115 (2012), 1122.
- [29] Lemou, M.; Mehats, F.; Raphaël, P., *Orbital stability of spherical gravitational systems*, Invent Math 187 (2012), no. 1, 145194.
- [30] Raphaël, P.; Szeftel, J., *Existence and uniqueness of minimal blow up solutions to an inhomogeneous mass critical NLS equation*, J. Amer. Math. Soc. 24 (2011), no. 2, 471546.
- [31] Lemou, M.; Mehats, F.; Raphaël, P., *A new variational approach to the stability of gravitational systems*, Comm. Math. Phys. 302 (2011), no. 1, 161224.
- [32] Merle, F.; Raphaël, P.; Szeftel, J., *Stable self similar blow up dynamics for slightly L^2 supercritical NLS equations*, Geom. Funct. Anal. 20 (2010), no. 4, 10281071.
- [33] Raphaël, P.; Szeftel, J., *Standing ring blow up solutions to the N -dimensional quintic nonlinear Schrödinger equation*, Comm. Math. Phys. 290 (2009), no. 3, 973–996.
- [34] Krieger, J.; Martel, Y.; Raphaël, P., *Two solitons solution to the gravitational Hartree equation*, Comm. Pure Appl. Math. 62 (2009), no. 11, 1501–1550.
- [35] Krieger, J.; Lenzmann, E.; Raphaël, P., *On Stability of Pseudo-Conformal Blowup for L^2 -critical Hartree NLS*, Ann. Henri Poincaré 10 (2009), no. 6, 1159–1205.
- [36] Colliander, J.; Raphaël, P.; *Rough blow up solutions to the L^2 critical NLS*, Math. Annalen 345 (2009), no. 2, 307–366.
- [37] Lemou, M.; Mehats, F.; Raphaël, P., *Stable self similar blow up solutions to the relativistic gravitational Vlasov-Poisson system*, J. Amer. Math. Soc. 21 (2008), no. 4, 1019–1063.
- [38] Merle, F.; Raphaël, P., *Lower bound on the blow up rate of the critical norm for some radial L^2 super critical NLS equations*, Amer. J. Math. 130 (2008), no. 4, 945–978.
- [39] Lemou, M.; Méhats, F.; Raphaël, P., *Structure of the linearized gravitational Vlasov-Poisson system close to a polytropic ground state*, SIAM J. Math. Anal. 39 (2008), no. 6, 17111739.
- [40] Lemou, M.; Mehats, F.; Raphaël, P., *Uniqueness of the critical mass blow up solution for the four dimensional Vlasov-Poisson system*, Ann. Inst. H. Poincaré Anal. Non Linéaire 24 (2007), no. 5, 825–833.
- [41] Lemou, M.; Mehats, F.; Raphaël, P., *On the orbital stability of the ground states and the singularity formation for the gravitational Vlasov-Poisson system*, Arch. Ration. Mech. Anal. 189 (2008), no. 3, 425–468.
- [42] Planchon, F.; Raphaël, P., *Existence and stability of the log-log blow up dynamics for the L^2 critical nonlinear Schrödinger equation in a domain*, Ann. Henri Poincaré 8 (2007), no. 6, 1177–1219.
- [43] Raphaël, P., *Existence and stability of a solution blowing up on a sphere for a L^2 supercritical nonlinear Schrödinger equation*, Duke Math. J. 134 (2), 199–258 (2006).
- [44] Fibich, G.; Merle, F.; Raphaël, P., *Numerical proof of a spectral property related to the singularity formation for the L^2 critical nonlinear Schrödinger equation*, Phys. D 220 (2006), no. 1, 1–13.
- [45] Merle, F.; Raphaël, P., *On one blow up point solutions to the critical nonlinear Schrödinger equation*, J. Hyperbolic Differ. Equ. 2 (2005), no. 4, 919–962.
- [46] Merle, F.; Raphaël, P., *Profiles and quantization of the blow up mass for critical nonlinear Schrödinger equation*, Comm. Math. Phys. 253 (2005), no. 3, 675–704.

- [47] Merle, F.; Raphaël, P., *Sharp lower bound on the blow up rate for critical nonlinear Schrödinger equation*, J. Amer. Math. Soc. 19 (2006), no. 1, 37–90.
- [48] Raphaël, P., *Stability of the log-log bound for blow up solutions to the critical non linear Schrödinger equation*, Math. Ann. 331 (2005), no. 3, 577–609.
- [49] Merle, F.; Raphaël, P., *On universality of blow up profile for L^2 critical nonlinear Schrödinger equation*, Invent. Math. 156, 565–672 (2004).
- [50] Merle, F.; Raphaël, P., *Sharp upper bound on the blow up rate for critical nonlinear Schrödinger equation*, Geom. Funct. Anal. 13 (2003), 591–642.
- [51] Merle, F.; Raphaël, P., *Blow up dynamic and upper bound on the blow up rate for critical nonlinear Schrödinger equation*, Ann. Math. 161 (2005), no. 1, 157–222.

Miscellaneous

- [52] Martel, Y; Raphaël, P., *Sur la dynamique des solitons: stabilité, collision et explosion*, Gaz. Math. no. 122 (2009), 1530.
- [53] Martel, Y.; Merle, F.; Raphaël, P.; Szeftel, J., *Near soliton dynamics and the formation of singularities in L^2 critical problems*, (Russian) Uspekhi Mat. Nauk 69 (2014), no. 2(416), 77–106.

Teaching support

- [54] Danchin, R.; Raphaël, P., *Analyse nonlinéaire, sur la stabilité des ondes solitaires*, Ecole Polytechnique 2016, 125p.
- [55] Raphaël, P., *On the singularity formation for the nonlinear Schrödinger equation*, Evolution equations, 269–323, Clay Math. Proc., 17, Amer. Math. Soc., Providence, RI, 2013.