Name: BERHANU First Name: Michaël

Birth date: 3 November 1980

Nationality: French

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#### Position:

From October 2010: Permanent researcher (CR1) CNRS in the laboratory

"Matière et Systèmes Complexes" MSC ("Matter and Complex systems")

of the Université de Paris (formerly Université Paris Diderot).

#### Current research interests:

• Hydrodynamics of erosion by dissolution and application to geomorphology

• Surface Waves and Wave Turbulence. Gravity-capillary wave turbulence. Surface waves generation by an underwater moving bottom

- Turbulence and free surface flows. Interaction between surface waves and flows.
- Granular gas of magnetized particles
- Capillarity and aggregation of floating particles.

# Previous research appointments and education:

2008-2010: Post-doctoral research at Clark University (Massachusetts/USA) in the group of

**Arshad Kudrolli**. Experimental research about granular physics, capillarity, geomorphology.

2005-2008: PhD Student at the laboratory of statistical physics (LPS) in the « Ecole Normale Supérieure » (ENS). PhD thesis under the guidance of Stéphan Fauve and Nicolas Mordant and defended September 15th 2008: « Turbulent magnetohydrodynamics in liquid metals flows ».

2004-2005: Master 2 of Physics at the ENS Lyon, option statistical physics and out of equilibrium phenomena.

2003-2004: Agregation de Sciences Physiques (2004) (National Competitive Exam for teaching in High school) 2001-2005 : Student at the Ecole Normale Supérieure de Lyon (ENS-Lyon) Master of physics (2001-2005), **ENS-Lyon** 

1998-2001: Undergraduate studies, Lycée Chaptal, Paris

#### Summary:

- 39 articles in international peer-reviewed journals
- 21 invited communications
- 5 invited talks in international conferences
- 11 Proceedings

Membership: European Mechanics Society(Euromech), Société Française de Physique (SFP) and American Physical Society (APS).

Referee for Physical Review Letters, Physical Review E, Journal of Fluid Mechanics, Physics of fluids, EPL, Langmuir, International Journal of Heat and Fluid Flow, Journal of Geophysical Research Earth Surface ...

### **Service:**

- Co-organization of workshop: « Mini-Colloque des rencontres du Non-Linéaire 2017: Interactions non linéaires entre ondes » Paris March 2017
- Co-organization of workshop: « Non-linear Hydrodynamic Waves: Wave interactions and Wave turbulence » Paris September 2013
- Co-organization of general seminars of the laboratory MSC since September 2011. (about 150 seminars organized)

### **Funding:**

- ANR Défis de tous les savoirs (JCJC) Erodiss (2017-2020) 250 000 €, PI
- BQR Université Paris Diderot Gaz granulaire magnétique (2012) 13 500 €, PI
- ANR Blanche Turbulon (2012-2016) PI: Éric Falcon

### **Teaching experience:**

- 2011-2020 : Oral examinations and written corrections at undergraduate Level for students applying for joining the Ecoles Normales Supérieures.
- 2014- 2017: Experimental physics projects, Physics Department, University Paris Diderot (96h by year)
- June-July 2011: Oral examinations at undergraduate Level for aspiring engineer students.
- 2005-2008 : Teaching assistant at the Ecole Normale Supérieure de Paris (ENS) in physics: Experimental physics and Hydrodynamics

### **Outreach:**

- September 2020: Online presentation to the French "Pint of Science Festival online". "Waves in weightlessness".
- Team leader with Adrian Daerr of the team of the Université de Paris at the "French Physicists' Tournament", 2020 edition
- May 2016, 2017, 2018 et 2019. Organisation of a formation « Complex materials and carbon nanomaterials » for high school teachers. Lecture about surface waves.
- Since 2010. Regular participation to the « Fête de la Science ».
- 2013-2014 Setup of interactive experiments about foam physics.

#### **Advising:**

- Adrien Guérin (September 2017/September 2020). Postdoctoral researcher (co-supervised with Sylvain Courrech du Pont) ANR ERODISS (24 months) Hydrodynamics of erosion by dissolution.
- Clément Lutringer (March 2020/July 2020) Internship Master 2, (co-supervised with Julien Derr). Subject : Etude numérique du rôle de la topographie dans convection induite par la dissolution.
- Cyril Ozouf (March 2017/July 2017) Internship Master 2, (co- supervised with Sylvain Courrech du Pont) Subject. Solutal convection experiments.
- Julien Philippi (June 2016/December 2016). Postdoctoral researcher (co-supervised with Julien Derr and Sylvain Courrech du Pont). CNRS (6 months). Hydrodynamics of erosion by dissolution.
- Annette Cazaubiel (January 2016/June 2016) Internship Master 2, (co-supervised with Eric Falcon) Submerged fountain and surface waves.
- Caroline Cohen (November 2014/Mai 2016) Postdoctoral researcher (co-supervised with Sylvain Courrech du Pont) ANR Exodunes (18 months). Hydrodynamics of erosion by dissolution.
- Florence Haudin (February 2015/January 2016). Postdoctoral researcher (co-supervised with Eric Falcon) ANR Turbulon (12 months). Resonant interactions between waves. Bathymetry effect on soliton propagation.
- Simon Merminod (October 2013/October 2016) PhD Student (co-supervised with Eric Falcon) Université Paris Diderot., (Internship M2 entre january et july 2013). Subject: 2D Magnetic Granular Gas
- Leonardo Gordillo (November 2012/November 2014) Postdoctoral researcher (co-supervised with Eric Falcon). Bourse Axa Research Fund Fellowship (2 years), project "Generation of tsunami waves".
- Timothée Jamin (October 2012/January 2016) PhD Student (co-supervised with avec Eric Falcon). Funding: DGA CNRS: Subject: Surface waves and flows interactions: tsunamis, breaking, turbulence.

# **Publications:**

- 1. A. Guérin, J. Derr, S. Courrech du Pont and M. Berhanu « Streamwise dissolution patterns created by a flowing water film » Physical Review Letters 125 (19), 194502 (2020) "Editors' Suggestion" "Featured in Physics"
- 2. E. Opsomer, J. Schockmel, N. Vandewalle, S. Merminod, M. Berhanu and E. Falcon « Patterns in magnetic granular media at the crossover from two to three dimensions» Physical Review E 102 (4), 042907 (2020)
- 3. E. Falcon, G. Michel, G. Prabhudesai, A. Cazaubiel, M. Berhanu, N. Mordant, S. Aumaître and F. Bonnefoy

Physical Review Letters 125 (13), 134501 (2020)

4. • C. Cohen, M. Berhanu, J. Derr and S. Courrech du Pont « Buoyancy-driven dissolution of inclined blocks: Erosion rate and pattern formation » Physical Review Fluids 5 (5), 053802 (2020)

- 5. G. Castillo, S. Merminod, E. Falcon and M. Berhanu,
  - « Tuning the distance to equipartition by controlling the collision rate in a driven granular gas experiment » Physical Review E 101 (3), 032903 (2020)
- 6. M. Berhanu, E. Falcon, G. Michel, C. Gissinger and S. Fauve
  - « Capillary wave turbulence experiments in microgravity »

**Europhysics Letters EPL 128, 34001 (2019)** 

- 7. J. Philippi, M. Berhanu, J. Derr and S. Courrech du Pont
  - « Solutal convection induced by dissolution»

Physical Review Fluids 4 (10), 103801 (2019)

- A. Cazaubiel, F. Haudin, E. Falcon and M. Berhanu
  - « Forced three-wave interactions of capillary-gravity surface waves »

Physical Review Fluids 4 (7), 074803 (2019) ("Editors' Suggestion")

- 9. M. Berhanu, A. Guérin, S. Courrech du Pont, F. Raoult, R. Perrier and C. Michaut
  - « Uplift of an elastic membrane by a viscous flow »

Physical Review E 99, 043102 (2019) ("Editors' Suggestion")

10. • A. Cazaubiel, G. Michel, S. Lepot, B. Semin, S. Aumaître, M. Berhanu, F. Bonnefoy and E.Falcon « Coexistence of solitons and extreme events in deep water surface waves »

Physical Review Fluids 3 (11), 114802, (2018)

- 11. M. Berhanu, E. Falcon and L. Deike
  - « Turbulence of capillary waves forced by steep gravity waves »

**Journal of Fluid Mechanics 850, 803-843 (2018)** 

- 12. G. Michel, B. Semin, A. Cazaubiel, F. Haudin, T. Humbert, S. Lepot, F. Bonnefoy, **M.Berhanu** and E. Falcon
  - « Experimental gravity wave turbulence spectra resulting from the modulation of bound waves »

Physical Review Fluids 3 (5), 054801, (2018)

13. • F. Bonnefoy, F. Haudin, G. Michel, B. Semin, T. Humbert, S. Aumaître, M. Berhanu and E.Falcon « Experimental observation of four-wave resonant interactions in a wave basin »

La Houille Blanche - Revue internationale de l'eau 5, (2017)

- 14. L. Deike, M. Berhanu and E. Falcon.
  - « Observation of hydroelastic three-wave interactions»

**Physical Review Fluids, 2, 064803 (2017)** 

- 15. C. Cohen, M. Berhanu, J. Derr and S. Courrech du Pont
  - « Erosion patterns on dissolving and melting bodies »

(2015 Gallery of Fluid motion) Physical Review Fluids, 1, 050508 (2016)

16. • F. Bonnefoy, F. Haudin, G. Michel, B. Semin, T. Humbert, S. Aumaître, M. Berhanu and E. Falcon « Observation of resonant interactions among surface gravity waves »

Journal of Fluid Mechanics (Rapids) 805, R3 (2016)

- 17. F. Haudin, A. Cazaubiel, L. Deike, T. Jamin, E. Falcon and M. Berhanu,
  - «Experimental study of three-wave interactions among capillary-gravity surface waves»

Physical Review E 93, 043110 (2016)

- 18. S. Merminod, T. Jamin, E. Falcon and M. Berhanu
  - «Transition to a labyrinthine phase in a driven granular medium»

Physical Review E 92, (2015)

19. • L. Deike, B. Miquel, P. Gutiérrez, T. Jamin, B. Semin, M. Berhanu, E. Falcon, F. Bonnefoy «Role of the basin boundary conditions in gravity wave turbulence » **Journal of Fluid Mechanics 781 (2015)** 

20. • T.Jamin, L. Gordillo, G. Ruiz-Chavarría, M. Berhanu and E. Falcon «Experiments on generation of surface waves by an underwater moving bottom» Proceedings of the Royal Society A 471, (2015)

21. • L. Deike, D. Fuster, M. Berhanu and E. Falcon.

«Direct numerical simulation of capillary wave turbulence»

Physical Review Letters 112 (2014)

22. • S. Merminod, M. Berhanu and E. Falcon

«Transition from a dissipative to a quasi-elastic system of particles with tunable repulsive interactions» Europhysics Letters 106, (2014) (Editor's choice).

23. • L. Deike, M. Berhanu and E. Falcon

«Energy flux measurement from the dissipated energy in capillary wave turbulence»,

Physical Review E 89 (2014)

24. • M. Berhanu and E. Falcon

«Space-time resolved capillary wave turbulence »

Physical Review E 87 (2013)

25. • M. Dasgupta, B. Liu, H.C. Fu, M. Berhanu, K.S. Breuer, T.R. Powers and A. Kudrolli « Speed of a Swimming Sheet in Newtonian and Viscoelastic Fluids»

Physical Review E 87 (2013)

- 26. M. Berhanu, A. Petroff, O. Devauchelle, A. Kudrolli and D.H. Rothman
  - « Shape and dynamics of seepage erosion in a horizontal granular bed»

Physical Review E 86 (2012)

27. • L. Deike, M. Berhanu and E. Falcon

«Decay of capillary wave turbulence »

Physical Review E 85 (2012)

28. • M.-J. Dalbe, D. Cosic, M. Berhanu, A. Kudrolli

«Aggregation of frictional particles due to capillary attraction»

Physical Review E 83, (2011)

29. • M. Berhanu, G. Verhille, J. Boisson, B. Gallet, C. Gissinger, S. Fauve, N. Mordant, F. Pétrélis, M. Bourgoin, Ph. Odier, J.-F. Pinton, N. Plihon, S. Aumaître, A. Chiffaudel, F. Daviaud, B. Dubrulle, C. Pirat, «Dynamo regimes and transitions in the VKS2 experiment»

European Physical Journal B 77 (2010)

30. • M. Berhanu, A. Kudrolli

« Heterogeneous structure of granular aggregates with capillary interactions »

Physical Review Letters 105 (2010)

31. • M. Berhanu, B. Gallet, R. Monchaux, M. Bourgoin, Ph. Odier, J.-F. Pinton, N. Plihon, R. Volk, S. Fauve, N. Mordant, F. Pétrélis, S. Aumaître, A. Chiffaudel, F. Daviaud, B. Dubrulle, F. Ravelet, «Bistability between a stationary and an oscillatory dynamo in a turbulent flow of liquid sodium» Journal of Fluids mechanics 641 (2009)

- 32. B. Gallet, M. Berhanu, N. Mordant
  - « <u>Influence of an external magnetic field on forced turbulence in a swirling flow of liquid metal</u> » **Physics of Fluids 21 (2009)**
- 33. R. Monchaux, M. Berhanu, S. Aumaître, A. Chiffaudel, F. Daviaud, B. Dubrulle, S. Fauve, F. Ravelet, N. Mordant, F. Pétrélis, M. Bourgoin, Ph. Odier, J.-F. Pinton, N. Plihon, R. Volk « The VKS experiment: a turbulent dynamo » Physics of Fluids 21 (2009)
- M. Berhanu, B. Gallet, N. Mordant, S. Fauve
   « Reduction of velocity fluctuations in a turbulent flow of gallium by an external magnetic field »
   Physical Review E 78,1, (2008)
- 35. S. Aumaître, M. Berhanu, M. Bourgoin, A. Chiffaudel, F. Daviaud, B. Dubrulle, S. Fauve, L. Marié, R. Monchaux, N. Mordant, P. Odier, F. Pétrélis, J.-F. Pinton, N. Plihon, F. Ravelet, R. Volk « The VKS experiment: turbulent dynamical dynamos » Comptes Rendus Physique 9,7 (2008)
- 36. F. Ravelet, M. Berhanu, R. Monchaux, S. Aumaître, A. Chiffaudel, F. Daviaud, B. Dubrulle, M. Bourgoin, P. Odier, J.-F. Pinton, R. Volk, S. Fauve, N. Mordant and F. Pétrélis « Chaotic dynamos generated by a turbulent flow of liquid sodium» Physical Review Letters 101, (7) (2008)
- 37. R. Monchaux, M. Berhanu, M. Bourgoin, Ph. Odier, M. Moulin, J.-F. Pinton, R. Volk, S. Fauve, N. Mordant, F. Pétrélis, A. Chiffaudel, F. Daviaud, B. Dubrulle, C. Gasquet, L. Marié, and F. Ravelet « Generation of magnetic field by a turbulent flow of liquid sodium», Physical Review Letters 98, (2007)
- 38. M. Berhanu, R. Monchaux, S. Fauve, N. Mordant, F. Pétrélis, A. Chiffaudel, F. Daviaud, B. Dubrulle, C. Gasquet, L. Marié, and F. Ravelet, M. Bourgoin, Ph. Odier, M. Moulin, J.-F. Pinton, R. Volk « Magnetic field reversals in an experimental turbulent dynamo » Europhysics Letters 77, (2007)
- 39. R. Volk, F. Ravelet, R. Monchaux, **M. Berhanu**, A. Chiffaudel, F. Daviaud, P. Odier, J.-F. Pinton, S. Fauve, N. Mordant and F. Pétrélis
  - « <u>Transport of magnetic field by a turbulent flow of liquid sodium</u> »

Physical Review Letters 97, (2006)

# **Proceedings:**

1. • M. Berhanu, E. Falcon and S. Fauve,

"Wave turbulence in microgravity.",

Report to COSPAR (World Committee for Space Research), 42th Scientific Assembly, 14-22 July 2018, Pasadena, USA, CNES Ed., p. 66 - 67 (2018).

2. • M. Berhanu, Simon Merminod, Eric Falcon and Gustavo Castillo,

"Random waves in a vibrated 2D granular."

Compte Rendu des Rencontres du Non-Linéaire 2018.

3. • J. Mignot, R. Pierre, M. Berhanu, B. Busset, R. Roumiguié, H. Bavestrello, S. Bonfanti, T. Miquel, L. O. Marot, and A. Llodra-Perez.

"Fluid dynamic in space experiment."

In 68th International Astronautical Congress (IAC), Adelaide, Australia (IAC-17-A2. 62). 2017. 25-29 September 2017.

4. • A. Cazaubiel, E. Falcon et M. Berhanu,

"Ondes de surface engendrées par un jet turbulent immergé "

Compte Rendu des Rencontres du Non-Linéaire 2017.

5. • M. Berhanu, A. Cazaubiel, L. Deike, T. Jamin et E. Falcon

" Etude expérimentale des interactions à trois ondes des vagues capillaires "

Compte Rendu des Rencontres du Non-Linéaire 2015.

6. • S. Merminod, M. Berhanu et E. Falcon

"Transitions structurales dans un gaz granulaire magnétique"

Compte Rendu des Rencontres du Non-Linéaire 2014.

7. • M. Berhanu et Eric Falcon

"Propriétés spatio-temporelles de la Turbulence d'ondes capillaires"

Compte Rendu des Rencontres du Non-Linéaire 2012.

8. • G Ruiz-Chavarria, M. Berhanu et Eric Falcon

"Génération d'ondes à la surface d'un fluide par un fond mobile"

Compte Rendu des Rencontres du Non-Linéaire 2012.

9. M. Berhanu, B. Gallet, N. Mordant et S. Fauve

"Réduction des fluctuations de vitesse d'un écoulement turbulent de Gallium sous champ magnétique." Compte Rendu des Rencontres du Non-Linéaire 2008.

10. • M. Berhanu, N. Mordant et S. Fauve

"Écoulement turbulent dans un cylindre : haut nombre de Reynolds et fluctuations à basse fréquence." Compte Rendu des Rencontres du Non-Linéaire 2007.

11. • M. Berhanu, A. Chiffaudel, F. Daviaud, S. Fauve, R. Monchaux, N. Mordant, Ph. Odier, F. Ravelet, F. Pétrélis, J.-F. Pinton and R. Volk

"Observation de transport de champ magnétique dans un écoulement turbulent de sodium liquide." Compte Rendu des Rencontres du Non-Linéaire 2006.

#### **Invited communications:**

- 1. Non-linear interactions and turbulence of capillary surface waves Séminaire laboratoire PMMH, ESPCI. April 2019
- Hydrodynamics in erosion by dissolution: the case of solutal convection. Departamento de Física, Facultad de Ciencia, Universidad de Santiago de Chile, November 2018
- 3. Hydrodynamics in erosion by dissolution: the example of solutal convection induced by dissolution Séminaire Matière Molle de l'institut de Physique de Rennes. March 2018
- 4. Wave Turbulence of Gravity-capillary surface waves. Congreso de la division de dinamica de Fluidos, Puebla, Mexique, November 2015
- 5. Wave Turbulence of Gravity-capillary surface wavess. Cargèse summer school "Wave propagation in complex media", August 2015
- Magnetic Granular Gas Seminario Extraordinario DFI, Universidad del Chile, Santiago Chili, November 2014
- 7. Experimental investigation of three-wave interactions of capillary surface-waves. Dynamics days South America, Valparaiso Chili November 2014
- 8. Gaz granulaire magnétique. Séminaire du Laboratoire de Physique Statistique ENS (Paris) April 2014
- Wave Turbulence of Gravity-capillary surface waves New Challenges in Turbulence Research III, Les Houches, France, Mars 2014
- 10. Agrégats granulaires formés par attraction capillaire . Séminaire Képler, laboratoire NAVIER, ENPC (France) January 2014
- 11. Magnetic Granular Gas. Physics Colloquium, Clark University (USA) November 2013
- 12. Turbulence d'ondes capillaires. Séminaire fluides de l'institut Jean Le Rond d'Alembert (Paris) April 2013
- 13. Aggregates shaped by capillarity. Séminaire du SPEC CEA Saclay (France) September 2012
- 14. Spatial statistics of capillary wave turbulence. Physics Colloquium, Clark University (USA) November 2011
- 15. *Granular aggregates with capillary interactions* Séminaire du GRASP Université de Liège (Belgium) March 2011
- 16. *Granular aggregates with capillary interactions.* Soft matter Seminar, Georgetown University (USA) August 2010
- 17. *Granular aggregates with capillary interactions.* Seminar of the center for Fluid mechanics, Brown University (USA) May 2010

- 18. MHD measurements with liquid Gallium, to understand turbulent dynamos. Séminaire LGIT Université Joseph Fourier (Grenoble) March 2010
- 19. Structure of a capillary granular aggregate. Role of rain in seepage erosion of granular material Séminaire du laboratoire Matière et systèmes complexes (MSC):

  Université Paris Denis Diderot December 2009
- 20. New results on the VKS experimental turbulent dynamo

  European geophysical union meeting, Vienne (Austria) April 2008
- 21. VKS: a turbulent homogeneous dynamo with liquid sodium Physics Colloquium, Clark University (USA) March 2008

### Presentations in international conferences (since 2010):

- Morphology of scallop patterns in erosion by dissolution. EGU (European Geophysical Union) General Assembly 2020, Vienne, Austria May 2020. Online session.
- Turbulence of capillary waves forced by steep gravity waves. 17th European Turbulence Conference, Turin, Italy September 2019
- Erosion patterns created by a water film flowing over an inclined soluble rock.
   EGU (European Geophysical Union) General Assembly 2019, Vienne, Austria April 2019
- Random wave dynamics in a vibrated 2D granular medium with magnetic dipolar interactions.
   Southern Workshop on Granular Materials 2018, Puerto Varas, Chile, December 2018.
- Erosion patterns created by a water film flowing over an inclined soluble rock.
   DFD (Division of Fluids dynamics) Meeting, APS (American Physics Society), Atlanta (USA) November 2018
- Solutal convection induced by dissolution. Influence on erosion dynamics and interface shaping
   DFD (Division of Fluids dynamics) Meeting, APS (American Physics Society), Denver (USA) November 2017
- Solutal convection induced by dissolution. Influence on erosion dynamics and interface shaping. EGU (European Geophysical Union) General Assembly 2017, Vienna Austria Avril 2017
- Dispersion relations of random waves in a vibrated 2D granular medium with magnetic dipolar interactions. **Réunion du LIA MSD (France Chili)**, Matière Structure et dynamique, Lyon, July 2017.
- Deformation of an air-water interface by hydrodynamic turbulence **Meeting of GDR Turbulence** at l'IMFT, Toulouse, June 2017.
- Liquid-solid-like phase transition in a 2D granular gas with magnetic dipolar interactions.
   International conference on Statistical Physics, Statphys 26, Lyon, July 2016.
- Role of the basin boundary conditions in gravity wave turbulence
   DFD (Division of Fluids dynamics) Meeting, APS (American Physics Society),
   Boston (USA) November 2015

- Experimental investigation of three-wave interactions of capillary surface-waves **DFD** (Division of Fluids dynamics) Meeting, APS (American Physics Society), San Francisco (USA) November 2014
- Interactions between capillary wave turbulence and hydrodynamics turbulence **DFD** (**Division of Fluids dynamics**) **Meeting**, APS (American Physics Society), Pittsburgh (USA) November 2013
- Spatio temporal investigation of capillary wave turbulence: hypothesis of weak non linearity under scrutiny. European Turbulence Conference 14, Lyon, September 2013
- Spatio-temporal characterization of Capillary Wave Turbulence. **DFD** (Division of Fluids dynamics) Meeting, APS (American Physics Society), San Diego (USA) November 2012
- Spatial statistics of capillary wave turbulence. Wave turbulence Workshop Ecole de physique des Houches, France, Mars 2012
- Spatial statistics of capillary wave turbulence. **DFD** (Division of Fluids dynamics) Meeting, APS (American Physics Society), Baltimore (USA) November 2011
- Damping of a turbulent gallium flow by an external magnetic field. Dynamo international GDR, Cargèse, Corse, France, September 2011