

Luca Gammaitoni

PERSONAL INFORMATION

Family name: Gammaitoni, First name: Luca

Researcher unique identifier(s):

Google scholar: user=uZet4d0AAAAJ,

ResearcherID: B-5375-2009

ORCID: 0000-0002-4972-7062

Nationality: Italian

Date of birth: 16 – 06 -1961

URL for web site: www.fisgeo.unipg.it/luca.gammaitoni

Education: July 1987, Laurea in Fisica, Univ. Di Perugia, 110/110 Summa cum laude
1987-88, Post grad. Corso di spec. in Fisica degli Stati aggregati, Perugia
1988-1991 Scuola Dottorato di Ricerca in Fisica, IV ciclo, Pisa (IT)
PhD Diploma 1991 (S. Santucci advisor), University of Pisa.

Prev. position: 1993-1994 Post Doc fellowship (ex Art. 36) INFN sez. di Perugia
1994-1997 Ricercatore Univ. Università degli Studi di Perugia,
1997-2004 Ricercatore Univ. confermato, Univ. degli Studi di Perugia,
2004-2013 Professore Associato, Università Degli Studi di Perugia
2016-2019 President Fondazione POST (IT)

Pres. position: - Professore Ordinario (Full Professor) FIS/01, Università degli Studi di Perugia
- Director Noise in Physical Systems Laboratory (NiPS) (www.nipslab.org)

FELLOWSHIPS AND AWARDS

1988-1991 Borsa di studio Scuola Dottorato di Ricerca in Fisica, IV ciclo, Pisa (IT)
1991-1992 Post Doc fellowship, Istituto Nazionale Fisica Nucleare (INFN) (IT)
1990 Prize for excellence in scientific research - GNSM, Pisa (IT)
2004 First prize for innovation ideas, Spin-off competition, University of Perugia (IT)
2004 Start Cup Competition 2004, qualified, Torino (IT)
2016 **2016 Special Breakthrough Prize in Fundamental Physics** for the observation of gravitational waves, opening new horizons in astronomy and physics.

SUPERVISION OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

1995 – 2022 **Advisor** of 14 *Tesi di laurea* (Master) and 10 *Tesi di dottorato di ricerca* (PhD).
Supervision of 13 Post docs.

TEACHING ACTIVITIES

1995 - today: a number of undergraduate and graduate courses, among which: Physics II and III, Solid State Physics, The physics of Information theory. University of Perugia (IT).
2000 - today: physics courses for Physics Doctorate school, among which: The Physics of Noise, Fundamental limits of computation, Adv. Thermodynamics.
2010 – today: Director of the int. NiPS summer school, annual (11 editions).
2014 Cours de phys. sur l'énergie. Doct. school, ESIEE, Université Paris Est (FR).

ORGANISATION OF SCIENTIFIC MEETINGS

1994 I Thermal Noise Int. Workshop, Pisa (IT), 50 participants, organizer/chair

1995	Virgo general meeting, Perugia (IT), 120 participants, organizer
1997	Applied Non-linear Dynamics near the Millenium, San Diego (US), 90 part., co-organizer
1998	Int. Workshop on Thermal Noise and Low Freq. Noise, Perugia (IT), 70 part., chairman
2005	Crystal: thermal noise studies for Virgo, Perugia (IT), 50 participants, organizer
2008	SR2008– International Conference, Perugia (IT), 120 participants, chairmen
2009	PIERS2009: Electromag Noise Exploitation, Moscow (RU), 35 participants, organizer
2010	Energy Efficient ICT Networking Session, ICT2010, Brussels (BE), 50 part., chairmen
2011	Sustainable ICT: Micro and Nanoscale Energy Mngment, Budapest (HU), 50, chairmen
2013	International conf. NANOENERGY2013, Perugia (IT), 120, organizer/chairmen
2016	International conf. ICT-Energy2016, Aalborg (DK), 50, organizer/chairmen
2017	International conf. Micro Energy 2017, Gubbio (IT), 100, organizer/chairmen
2021	International conf. Stochastic Resonance 2021, Perugia (IT), 100, organizer/chairmen

INSTITUTIONAL RESPONSIBILITIES

1997 – 2014	Faculty member, Science, University of Perugia (IT)
2003 – 2013	Member of the Physics Doctorate teaching board, Univ. Perugia (IT)
2014 – today	Member of the Biotech Doctorate teaching board, Univ. Perugia (IT)
2006 – 2013	Physic Department Executive board member, Univ. Perugia (IT)
2016 – today	Physic and Geology Department Executive board member, Univ. Perugia (IT)
2010 – 2013	Member of the Academic Senate of the University of Perugia (IT)
2014 – today	Member of the Spin-off commission of University of Perugia (IT)
2016 – 2019	President of Fondazione POST (Perugia City Science Museum)

COMMISSIONS OF TRUST

1996 – 2008	Scientific Advisory Board member, Virgo project, INFN-CNRS (IT/FR)
2000 – 2006	Vice President and member Board of trustees, Sebi Spa – (IT)
2003 – today	Evaluator, Marie Curie Fellowship, EC
2009 – 2013	CEO, Wisepower srl (IT)
2009 – 2015	President, Wisepower corp. (US)
2011 – 2013	Editorial Board, Nanoenergy Letters, Editor
2012 – today	Editorial Board, Nano Energy journal, Elsevier
2012	Reviewer, MIUR (IT)
2013 – today	Editorial Board, ICT-Energy letters, Editor
2013	Reviewer, Swiss Science Foundation (CH)

MEMBERSHIPS OF SCIENTIFIC SOCIETIES

1991 – 2015	Research associate Istituto Nazionale Fisica Nucleare (INFN) (IT)
1995 – 2003	Research associate Istituto Nazionale Fisica della Materia (INFM) (IT)
2000 – 2004	Società Italiana di Fisica (SIF) (IT)
2002 – 2007	American Physical Society (APS) (US)
2007 – today	Funding Member, Director, Noise in Physical Systems Laboratory, UNIPG (IT)

Leading scientific initiatives: 1996-2010 Group leader Thermal Noise INFN VIRGO-Perugia
2004-2007 Leader Spin-off project WISEPOWER srl

2006-2009 Group leader Perugia SUBTLE (EC STREP VI-FP)
 2007-today Director Noise in Physical System (NiPS) Laboratory
 2009-2012 Coordinator NANOPOWER (EC STREP VII-FP)
 2010-2013 Coordinator ZEROPOWER (EC CA VII-FP)
 2012-2015 Coordinator LANDAUER (EC STREP VII-FP)
 2013-2016 Coordinator ICT_Energy (EC CA VII-FP)

Research infrastructure realized: 1991 VIRGO1, laboratory, I floor, Physics Dep., Perugia (PG)
 1994 Analog/digital simulation laboratory, IV f., Physics Dep., PG
 1996 VIRGO0, laboratory, 0 f., Physics Dep., PG
 2000 Numerical cluster facility, 0 f., Physics Dep., PG
 2008 MicroICT laboratory, 0 f., Physics Dep., PG
 2011 SEM Laboratory, 0 f., Physics Dep., PG

Private/Enterprise roles: 1996 Umbrars srl - IT (founder)
 2000-2006 Sebi Spa - IT (founder and vice President)
 2007-2010 Wisepower srl - IT (founder and CEO)
 2009-2014 Wisepower corp - US (founder and President)

Innovation/Dissemination roles 2012-2018 Innovation board University of Perugia (member)
 2016-2019 POST Museum Foundation (president)
 2020-today Department delegate for technology transfer

Main research grants: 1996-today INFN (VIRGO) 2.5 M€
 2001-today Private companies 200 K€
 2002-2008 INFN (LISA) 350 K€
 1999-2018 ONRG (Europe) 400 K€
 2003-2009 EGO (IT-FR) 220 K€
 2002-2013 MIUR-PRIN (IT) 300 K€
 2006-2009 EC (SUBTLE STREP VI-FP) 290 K€
 2010-2013 EC (NANOPOWER VII-FP) 2.6 M€
 2010-2013 EC (ZEROPOWER VI-FP) 600 k€
 2012-2015 EC (LANDAUER VI-FP) 2.4 M€
 2013-2016 EC (ICT-Energy VI-FP) 1.5 M€
 2016-2020 EC (OPRECOMP H2020) 350 K€
 2017-2021 EC (ENABLES H2020) 300 K€

International conferences and workshops: Organizer/Chairmen (selection):

I Thermal Noise Int. Workshop, Pisa, 1994; II Thermal Noise Int. Workshop, Orsay, 1995; VIRGO General Meeting, Perugia, 1995; Applied Nonlinear Dynamics near the Millenium, San Diego, 1997; Int. Workshop on Thermal Noise and Low Freq. Noise, Perugia, 1998; Crystal: thermal noise studies for Virgo, Perugia, 2005; SR2008 – International Conference, Perugia, 2008; PIERS2009: Electromag Noise Exploitation, Moscow 2009; International NiPS Summer School, Avigliano Umbro, 2010; Energy Efficient ICT Networking Session, ICT2010 - Brussels, 2010; Scientific Session at fet11 on "Sustainable ICT: Micro and Nanoscale Energy Management", Budapest 2011; International NiPS Summer School, Perugia, 2011; International Summer School, Erice 2012; International NiPS Summer School, Perugia, 2013; International conference NANOENERGY2013, Perugia 2013; V International NiPS Summer School, Perugia, 2014; VI International NiPS Summer School, Fiuggi, 2015; International conference ICT-Energy 2016, Aalborg (DK), 50; 2017 Int. Conference Microenergy, Gubbio.

International conferences and workshops: Invited speaker (selection):

Int. Workshop on Stochastic Resonance, San Diego, 1992; Int. Workshop on Fluctuation Phenomena in Phys. And Bio., Okamville, 1993; Int. Workshop on Thermal Noise in Laser Interferometers, Pasadena, 1994; Int. Workshop on Fluctuation Phenomena in Phys. And Bio., Elba, 1994; Int. meeting on Nonlinear Dyn. And full spectrum proc., Mystic (USA), 1995; Adriatico Research Conf. on Randomness, Stochasticity and Noise, Trieste, 1995; Grav. Wave detection by the year 2000, Tokyo, 1996; Second Int. LISA Symposium, Pasadena, 1998; Around Virgo Int. Conference, Tirrenia, 1998; Euro-Japan Int. Symposium on Gravitational Waves detection, Tokyo, 1998; Third Edoardo Amaldi Conference, Pasadena, 1999; Ninth Marcel Grossmann Meeting, Roma, 2000; Advanced Research Wks on Stoch. Systems, Erice, 2002; Intern. Wks New Horizons in Stochastic Complexity, Seville (SP), 2004; Stochastic Resonance: New Horizons in Phys. and Eng., Dresden (DE), 2004; ICAND-2007: App. in Nonlin. Dyn., Hawaii (USA); Int. Wks: Physics of Fluctuations far from eq., Dresden (DE), 2007; EC Expert consultation on: Molecular scale computing, Brussels, 2008; Masterclass teacher, Energy Harvesting & Storage, Cambridge (UK), 2009; EC Wks on "Towards Zero-Power ICT" (2zeroP), Brussels, 2009; Int. Conference SENSORS2009, Tutorial talk, Christchurch (NZ), 2009; EC Expert consult.: Disruptive Solutions for Energy Efficient ICT, Brussels, 2010; ESF-EPSC Wks on Heat Control and Thermoelectric Efficiency, Erice (IT) 2010; Third NaNoNetworking Summit, Barcelona, 2011; Euromech Colloquium at the University of Bristol (UK) devoted to Structural Control and Energy Harvesting, 2011; Fifth European SINANO Summer School, Bertinoro, 2012; ZEROPWER workshop, Barcelona, 2012; Joint European Thermodynamics Conference, Brescia, 2013; CHIST-ERA 2013, Bruxelles, 2013; Energy Aware COmputing, Bristol, 2013; ESSDERC (Solid-State Device Research Conference) Bucharest, 2013; Heat transfer at small scales" Zaragoza, 2013; Berkeley Symposium on Energy Efficient Electronic Systems, Berkeley 2013; HiPEAC/EC Workshop 'EnergyEfficient Comp Systems, Brussels 2014; SIGMAPHI Statistical Physics, Rhodes, 2014; Keynote at PowerMEMS2014 Awaji Island, Hyogo, Japan, 2014; International Conference on Applications in Nonlinear Dynamics, Denver, Colorado, Aug. 28- Sept. 1, 2016; International Conference on Applications in Nonlinear Dynamics (ICAND), Aug. 5-9, Maui (USA); Dynamic Days Latin America 2018, Dec. 5th 2018.

Scientific publications, bibliometrics (as of Jan 2021):

Total Articles in ISI Publication List: **392** Articles;

Citation metrics:

ISI - Web of Science - Citations: **45,407** (without self citations: **38,412**), most cited paper: **5,199**, second **4,772**; H-index: **78**;

Google Scholar - Citations: **70,104**, most cited paper: **12,881**, second **6496**; H-index: 94;

Number of papers on journal with impact factor larger than 6: 22;

Number of papers with single author: 6.

Number of papers on journal with more than 100 citations each: 62.

Google scholar: <http://scholar.google.it/citations?hl=en&user=uZet4d0AAAAJ>

ResearcherID: <http://www.researcherid.com/rid/B-5375-2009>

Member of editorial comm. for international Journals: ICT-Energy Letters (Editor); Nano Energy (member of the editorial board), Entropy.

Referee for international Journals: Phys. Rev. Lett.; Phys. Rev. E; Phys. Lett. A; Appl. Phys. Lett.; IEEE Trans.; Chem. Phys. D; Europhys. Lett.; Journal of Stat. Mech., Journal of Stat. Physics; Eur. Physical Journal B; Meas. Science and Technology; etc.

Referee for Scientific Institutions: National Science Foundation (US); Swiss Science Foundation (CH); European Commission; MIUR (IT).

Research monographs, chapters in collective volumes.

- *Introduzione alla Scienza dei Computers*, Luca Gammaitoni, McGraw-Hill, Milano, 2003 (book).
- *Noisy Nonlinear Detectors*, A. Dari; L. Gammaitoni, in *Applications of Nonlinear Dynamics: Model and Design of Complex Systems*, 24/09/2007, Volume 2009, p.225-235, APS 2009. (chap. in volume)
- *Nonlinear Dynamics, Materials and Integrated Devices for Energy Harvesting in Wearable Sensors*, Bruno Andò, Salvatore Baglio, Marco Ferrari, Vittorio Ferrari, Luca Gammaitoni and Carlo Trigona in *Wearable and Autonomous Biomedical Devices and Systems for Smart Environment*, Lecture Notes in Electrical Engineering, 2010, Volume 75, 97-113, Springer, 2010. (chap. in volume)
- *ICT-Energy: Nanoscale energy management concepts towards Zero-Power Information and Communication Technology*. L. Gammaitoni, G. Fagas, G. Abadal-Berini, D. Paul editors, InTech Publisher, 2013
- *ICT - Energy Concepts for Energy Efficiency and Sustainability* edited by Giorgos Fagas, Luca Gammaitoni, John P. Gallagher and Douglas J. Paul, ISBN 978-953-51-3012-3, InTech, March 3, 2017
- *The physics of Computing*, Springer, 2022

Granted patents.

10 patents (5 US, 2 Italian, 1 European, 2 PCT)

- US Patent N. 6008642: Stochastic Resonance detector for weak signals, Aug 17, 1997
- US Patent N. 7009392: Method of est. target signals by dyn. fluxgates, Mar. 7, 2006
- US Patent N. 6285249 - Controlled stochastic resonance circuit - 09/04/2001
- US Patent N. 6008642 - Stochastic resonance detector for weak signals - 12/28/1999
- IT RM 2007A00079, Generatore piezoelettrico bistabile - 15/2/2007.
- PCT/IT2008/000081 - WO/2008/099437 - US2010207491 (A1) "Bistable piezoelectric gen." 2008.
- PCT/EP2009/052324 "Sensor for e.m. quantities and method for measuring e.m. quantities" 2009
- IT PG2009A00022, "Generatore elettrico non lineare", 2009

Academic Institution Membership:

- SIF (Società Italiana di Fisica);
- INFN (Istituto Nazionale di Fisica Nucleare, inc. di ricerca);
- CNR (INFM Fisica della Materia);
- EGO (European Gravitation Observatory);
- APS (American Physical Society).

Scientific Leadership Profile

The applicant presents 25 years-long research activities in a wide range of topics in different fields, having as a common denominator the **physics of noise**. Specifically, He has given contributions to:

- **Nonlinear stochastic dynamics** (theory and experiment).

The applicant performed early studies on the phenomenon of **Stochastic Resonance** (SR). He published, together with three international coworkers, a highly cited review article considered the reference paper on this phenomenon (RMP1998, more than 4250 citations). Alone he provided an original description of the Dithering effect as a special case of SR (PRE1995). He introduced a number of **novel** noise-in-nonlinear system phenomena as *Resonant Trapping*, *Resonant Crossing*, *Bonafide SR*, *intra-well/inter-well SR* to mention a few contributing to a **new perception of the role of noise** in physical systems. He set up a laboratory facility for direct measurement of thermal noise in physical systems, with a sensitivity better than $1e-15$ m/sqrt(Hz).

- **The physical limits of energy dissipation in computing** (theory and experiment).

The applicant proposed a novel description of the minimum energy dissipation in logic switches. He funded the novel field of ICT-Energy where the energy transformation processes at micro and nanoscale are studied with reference to the computation tasks in present and future computers.

- **Micro and nanoscale vibration energy harvesting** (theory and experiment).

In this field the applicant has introduced **for the first time the concept of nonlinear energy harvesting** (see e.g. PRL 102, 080601, 2009). He has shown that the new paradigm based on the use of non-linear oscillators instead of the traditional linear ones, has improved the generator efficiency more than 400% opening interesting applications in the ICT domain and fostering an entire new field that was widely recognized and promptly funded by the EC (see e.g. *Toward Zero Power ICT* call ICT-2009 8.6).

- **Energy transport and internal friction in solid-state systems** (theory and experiment).

He provided a characterization of dissipative processes like: Dislocation damping, Thermoelastic relaxation, frequency independent loss angle. He has been **in charge** for 15 years of the design and realization of two generations of low thermal noise – low dissipation suspension systems for the optics of long scale gravitational wave laser interferometers (**VIRGO Project**).

- **Noise driven non-linear micro devices** (theory and experiment), where he introduced the **novel device class** of **Noise Activated Nonlinear Dynamic Sensors** (See e.g. *PRL*, 88, 230601, 2002). Among these the field of **Stochastic computation and noise driven logic gates** where he proposed a new approach to the problem of noise tolerance in the design, e.g. low-voltage CMOS-like logic gates (see e.g. *Noise limited computational speed*, *APL*, 91, 224104, 2007). Moreover he has designed, realized and tested novel noise driven logic gate prototypes (*APL*, 96, 042112, 2010).

The work of the applicant received **wide international recognition and diffusion**, via a vast scientific production of journal articles, conference organization/participation, specialized book chapters, etc. See citation metrics above.

The applicant is a **successful teacher** ranked n.1 among the physicist in 2010, 2012 and 2013 at the Univ. of Perugia. He has inspired more than one generation of students, being the advisor of 14 *Tesi di laurea* (Master Thesis) and 8 (PhD Thesis) and serving as expert for the EC (ICT-FET, expert consultation 2008, 2010).

He has established a world recognized group in Perugia that in 2007 has officially become an institution: the **Noise in Physical Systems Laboratory** (NiPS) presently directed by the applicant. He has also started an **International Summer School** with regular courses each year (2010-2014). Moreover in 2007 he has started an high-tech **spin-off company** (Wisepower srl) that has recently (2010) opened a branch in US (Wisepower corporation).

The applicant has been active in promoting the communication of science in the last 10 years, with 10 magazine articles, 8 national radio and TV interviews, a number of participation as organizer/guest to Science Festival, science café, public debates and round tables.

1. A list of the 10 most relevant publications

Stochastic resonance

L Gammaitoni, P Hänggi, P Jung, F Marchesoni
Reviews of Modern Physics 70 (1), 223, 1998
Times Cited: 4772, Impact factor 2011: 43,93

Tuning in to noise

AR Bulsara, L Gammaitoni
Physics Today 49, 39, 1996
Times Cited: 530, Impact factor 2011: 5,65

Stochastic resonance in bistable systems

L Gammaitoni, F Marchesoni, E Menichella-Saetta, S Santucci
Physical Review Letters 62 (4), 349-352, 1989
Times Cited: 378, Impact factor 2011: 7,37

Nonlinear energy harvesting

F Cottone, H Vocca, L Gammaitoni
Physical Review Letters 102 (8), 080601, 2009
Times Cited: 622, Impact factor 2011: 7,37

Stochastic resonance as a bona fide resonance

L Gammaitoni, F Marchesoni, S Santucci
Physical review letters 74 (7), 1052-1055, 1995
Times Cited: 254, Impact factor 2011: 7,37

An upper limit on the stochastic gravitational-wave background of cosmological origin

BP Abbott, R Abbott, F Acernese, R Adhikari, P Ajith, B Allen, G Allen, ...
Nature 460 (7258), 990-994, 2009
Times Cited: 220, Impact factor 2013: 38,597

Stochastic resonance and the dithering effect in threshold physical systems

L Gammaitoni
Physical Review E 52 (5), 4691, 1995
Times Cited: 200, Impact factor 2011: 2,25

There's plenty of energy at the bottom (micro and nano scale nonlinear noise harvesting)

L Gammaitoni
Contemporary Physics 53 (2), 119-135, 2012
Times Cited: 9, Impact factor 2008: 3,74

Observation of gravitational waves from a binary black hole merger

BP Abbott, R Abbott, TD Abbott, MR Abernathy, F Acernese, K Ackley, ...
Physical review letters 116 (6), 061102, 2016
Times Cited: 10056, Impact factor 2011: 7,37

Sub-k BT micro-electromechanical irreversible logic gate

M Lopez-Suarez, I Neri, L Gammaitoni
Nature communications 7 (1), 1-6, 2016
Times Cited: 46, Impact factor 2019: 12,12