# 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 – 2023 **Advisor** of 19 *Tesi di laurea* (Master) and 10 *Tesi di dottorato di ricerca* (PhD). Supervision of 13 Post docs.

## TEACHING ACTIVITIES

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|---|---|
| 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'energie. Doct. school, ESIEE, Universitè Paris Est (FR). |

**INSTITUTIONAL RESPONSIBILITIES**

1997 – today 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 – 2020 Physic and Geology Department Executive board member, Univ. Perugia (IT)
2010 – 2013 Member of the Academic Senate of the University of Perugia (IT)
2014 – 2020 Member of the Spin-off commission of University of Perugia (IT)
2016 – 2019 President of Fondazione POST (Perugia City Science Museum)
2020 – today Member of the Physics Doctorate teaching board, Univ. Perugia (IT)

**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 – 2020 Editorial Board, ICT-Energy letters, Editor
2013 Reviewer, Swiss Science Foundation (CH)
2000 – today Reviewer European Commission

**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)
2022-2026 Coordinator spoke 9, 10 project VITALITY (IT, PNRR)

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:

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|---|---|
| 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 VIFP) | 290 K€ |
| 2010-2013 EC (NANOPOWER VIIFP) | 2.6 M€ |
| 2010-2013 EC (ZEROPOWER VIIFP) | 600 k€ |
| 2012-2015 EC (LANDAUER VIIFP) | 2.4 M€ |
| 2013-2016 EC (ICT-Energy VIIFP) | 1.5 M€ |
| 2016-2020 EC (OPRECOMP H2020) | 350 K€ |
| 2017-2021 EC (ENABLES H2020) | 300 K€ |
| 2022-2025 PNRR VITALITY | 30 M€ |

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); 2017 Int. Conference Microenergy, Gubbio; International conf. Stochastic Resonance 2021, Perugia (IT); 2023 Conference on Artificial Intelligence, Perugia.

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 Symphosium, 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 Grosmann 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-EPSD 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 smal scales" Zaragoza, 2013; Berkeley Symposium on Energy Efficient Electronic Systems, Berkeley 2013; HiPEAC/EC Workshop 'EnergyEfficient Comp Systems, Brussels 2014; SIGMAPHI Statistical Physics, Rodhes, 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 (2021) -** Citations: **45,407 (**without self citations: **38,412**), most cited paper: **5,199**, second **4,772**; H-index: **86;**
**Google Scholar (2025) -** Citations: **115149**, most cited paper: **24,881**, second **6496**; H-index: **115;**

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

**Books for general public**
- Perché è difficile prevedere il future, L. Gammaitoni, A. Vulpiani, Dedalo ed. 2019
- L'inevitabilità del tempo ed altri accidenti, L. Gammaitoni, Amazon, 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. quatities 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 30 years-long research activity 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 then 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).

• **Stochastic epidemic dynamics** (modeling) where he studied the role of fluctuations on epidemic resurgence, based on the well-known SIR model in the presence of correlated noise (see Scientific Reports 11 (1), 6452, 2021). It is shown that the role of time-correlated fluctuations, far from being negligible, can in fact determine the spreading of an epidemic and, most importantly, the resurgence of the exponential diffusion in the presence of time-limited episodes in promiscuity behaviors.

•**Artificial Intelligence** (theory) where he studied the fundamental limits of AI in modeling physical systems evolutions.

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).
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 cafè, public debates and round tables.

**A list of the 10 most relevant publications**

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: 24041, Impact factor 2023: 45,9

Stochastic resonance
L Gammaitoni, P Hänggi, P Jung, F Marchesoni
Reviews of modern physics 70 (1), 223
Times Cited: 7363, Impact factor 2011: 7,37

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

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