Luca Gammaitoni

16-06-1961, Perugia (IT)
(luca.gammaitoni@nipslab.org)

Education: July 1987, Laurea in Fisica, Univ. Di Perugia, 110/110 Summa cum laude
1987-88, Post grad. Corso di specializzazione 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: 1991-1992, Post Doc fellowship, INFM, Perugia
1993-1994 Post Doc fellowship (ex Art. 36) INFN sez. di Perugia
1994-1997 Research position (Ricercatore Univ.) Università degli Studi di Perugia,
1997 Ricercatore Universitario confermato (tenured), Univ. degli Studi di Perugia, 1
2004 Professore Associato, Università Degli Studi di Perugia

Pres. position: - Professore Ordinario (Full Professor) FIS/01, Università degli Studi di Perugia
- Director Noise in Physical Systems Laboratory (www.nipslab.org)
- Founder Wisepower srl (IT), President Wisepower corporation (USA)

Teaching: - 1995 - today: a number of undergraduate and graduate courses, among which:
Physics III, Solid State Physics, The physics of Information theory.
- 2000 - today: physics courses for Doctorate school, among which:
The Physics of Noise, Fundamental limits of computation, Adv. Thermodynamics

Advisor of 13 *Tesi di laurea* and 9 *Tesi di dottorato di ricerca* (PhD Thesis).

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-today Coordinator LANDAUER (EC STREP VII-FP)
2013-today 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

Institutional/Academic roles: 1994 Physics Department membership

1997 Science Faculty
2003 Physics PhD Teaching Board
2004 Faculty Professorship
2006-2013 Physic Department Executive board member
2010-2013 Member of the Academic Senate of the University of Perugia

Private/Enterprise roles:

1996 Umbrars srl - IT (founder)
2000-2006 Sebi Spa - IT (founder and vice President)
2007 Wisepower srl - IT (founder and CEO)
2009 Wisepower corp - US (founder and President)

Main research grants:

1996-today INFN (VIRGO)	2.5 M€
2001-today Private companies	150 K€
2002-2008 INFN (LISA)	350 K€
1999-2015 ONRG (Europe)	350 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€

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 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;

Scientific publications, bibliometrics (as of 1st April. 2015):
Total Articles in ISI Publication List: **226** Articles;

Citation metrics: Sum of the Times Cited (Google Scholar): **14500**, most cited single paper: **4640**; H-index: **54** (ISI H=44)**;** Number of papers on journal with impact factor larger than 6: 14; Number of papers with single author: 6. Number of papers on journal with more than 100 citations each: 26.

Citation indices	All	Since 2010
Citations	14500	7580
h-index	54	36
i10-index	151	109

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).

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

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

International Prizes/Awards/Academy memberships (if applicable)

Awards:
- Prize for excellence in scientific research - GNSM, Pisa - 1990
- First prize for innovation ideas, Spin-off competition, University of Perugia, 2004.
- Start Cup Competition 2004, Torino IT, Qualified.

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 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).

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 cafè, 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: 4640, 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: 274, 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

Spatiotemporal Stochastic Resonance in a φ^{4} Model of Kink-Antikink Nucleation
F Marchesoni, L Gammaitoni, AR Bulsara
Physical review letters 76 (15), 2609-2612, 1996
Times Cited: 147, Impact factor 2011: 7,37

Nonlinear oscillators for vibration energy harvesting
L Gammaitoni, I Neri, H Vocca
Applied Physics Letters 94 (16), 164102, 2009
Times Cited: 200, Impact factor 2012: 3,79

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