

FRANCESCO PIAZZA

Ecole Polytechnique Fédérale de Lausanne (EPFL),
Institute of Theoretical Physics - LBS,
BSP-720, CH 1015 Lausanne
Switzerland
Tel/Fax: +412169305-13/23
Email: Francesco.Piazza@epfl.ch
<http://marie.epfl.ch/fpiazza/>

Born 3/11/1970,
married with two daughters

Av. Cour 12, 1007 Lausanne.
Tel. +41216165043, GSM +41795262528

Professional record

2003 - present	Research associate. Ecole Polytechnique Fédérale de Lausanne (EPFL), SB-ITP-LBS, Group of Statistical Biophysics.
1/9-1/12/2006	CNRS visiting scientist (chercheur associé), Ecole Normale Supérieure de Lyon.
February/March 2006	Swiss National Foundation visiting scientist, JNU, New Delhi, India.
2001-2003	INFN fellow. Dipartimento di Fisica, Università di Firenze, Italy. FORUM project "Study of statistical and dynamical models of biomolecules" (STADYBIS).
Fall term, 2001-2002	Assistant professor at the University of Florence, Faculty of Engineering

Education:

- *November 2002.* Ph.D. in Physics. Heriot-Watt University, Edinburgh, UK.
- *July 1996.* Degree in Physics, Università di Firenze, Italy. Final mark: 106/110.
- *July 1989.* Diploma. Classical Lyceum "Dante Alighieri", Florence. Mark: 60/60.

Teaching experience

- September 2007. Teaching assistant for the course of Advanced Statistical Physics III, Phase transitions, EPFL, Switzerland
- Since 2005. Supervision of master and Practical work (TP) students.
- *September 2003–February 2004:* Teaching assistant for the course of Advanced Statistical Physics, EPFL, Switzerland.



- *Fall semester 2001/2002*: Assistant Professor (professore a contratto) for the course of General Physics I (Mechanics and Thermodynamics), University of Florence, Italy
- *October 1997–October 1999*: Tutor for the courses of Experimental Physics I and II, General Physics I. Heriot-Watt University, Edinburgh, UK.

Funding

- *1997–2001*: Heriot-Watt Ph.D. Scholarship, HW University, UK. Project title "Nonlinear dynamics of high- T_c superconductors". Size: 6000 pounds/year (maintenance) + tuition fees.
- *2001-2003*: INFM grant within the project "Statistical and dynamical properties of bio-molecular structures (STADYBIS)": Size: 15 kEUR/year, co-investigator.
- *September 2005*: Swiss National Science Foundation (SNF) short visiting grant. Project "Experimental and theoretical study of energy relaxation in nano-scale materials", to be carried out at JNU, New Delhi, India. Size: 5.2 kCHF, Principal investigator.
- *September-December/2006*. CNRS chercheur associé (invited professor), Laboratoire Joliot-Curie, Ecole Normale Supérieure de Lyon. Size: 6,0 kEUR. Principal investigator.

Language proficiency

- Excellent knowledge of written and spoken English.
- Excellent knowledge of written and spoken French.

International Conferences, seminars and schools

- *25 March 2008*, "Discrete breathers in nonlinear network models of proteins", Laboratoire J. Kuntzmann, ENSIMAG, Grenoble (invited seminar).
- *21 March 2008*, "Discrete breathers in nonlinear network models of proteins", Laboratoire J. Dieudonné, Université de Nice (invited seminar).
- *6 March 2008*, "Discrete breathers in nonlinear network models of proteins", ICTP, Trieste, Italy (invited seminar).
- *16 January 2007*, "Discrete breathers in nonlinear network models of proteins", Centre de Physique Théorique, Université de la Méditerranée Aix-Marseille, France (invited seminar).
- *19 December 2007*, "Discrete breathers in protein structures", Ecole Normale Supérieure de Lyon (invited seminar).
- *12 November 2007*. "Discrete breathers in nonlinear network models of proteins", Bayreuth University, Germany (invited seminar).
- *11 June 2007*. "Freezing proteins to see them move", Department of Physics, Edinburgh University, UK (invited seminar).
- *23 November 2006*. "Binding dynamics of PDZ domains. A comprehensive view through coarse-grained models". Laboratory of Theoretical Biochemistry, UPR 9080 CNRS / PARIS 7 UNIVERSITY (invited seminar).
- *2nd October 2006*. "Surface effects in non-linear distributed systems: slow relaxation and spontaneous emergence of localized coherent modes". Ecole Normale Supérieure de Lyon, (invited seminar).
- *5-9 June 2006*. XX SITGES CONFERENCE on STATISTICAL MECHANICS, Physical Biology: from Molecular Interactions

to Cellular Behavior. Sitges, Barcelona, SPAIN, "Functional dynamics of proteins and normal modes at working temperatures" (poster).

- *13 March 2006*. School of Physical Sciences, JNU, New Delhi. "A critical view on slow energy relaxation in complex systems" (invited seminar).
- *1-3 March 2006*. International Workshop on Nano-Biosciences, Kolkata University, India. "Vibrational properties and relaxation mechanisms in proteins and nanoparticles: theoretical aspects and applications" (invited lecture).
- *14-16 November 2005*: International Conference "Nanoscience & Nanotechnology 2005", Monteporzio Catone, (Roma), Italy. "Slow energy relaxation and energy transfer in bio-molecules and nano-clusters" (poster).
- *29 June 2005*: Laboratoire Joliot-Curie, Ecole Normale Supérieure de Lyon (ENS-Lyon). "Freezing proteins to see them move" (invited seminar).
- *15-19 May 2005*: Workshop Flexibility in Bio-molecules, Tempe (AZ), USA. "Slow energy relaxation of Macromolecules and Nanoclusters in Solution" (poster).
- *3-4 March 2005*: Nonlinear double day (NLDD005), Sevilla (Spain). "Slow Energy Relaxation in Linear and Nonlinear Systems" (invited talk).
- *11-13 February 2004*: BIFI 2004 - Biology after the genome: a physical view, I International Conference, Zaragoza (Spain). "Freezing Immunoglobulins to see them move" (contributed talk).
- *3-5 February 2003*, II mini-school of biology, Center for the study of complex systems of the University of Florence, Italy. "Random walks in biology" (invited lecture).
- *July 2002*: Invited lecture "Statistical analysis of DNA sequences: a review", International IP-Socrates summer school 2002, Villa Agape, Florence, Italy.
- *17-21 June 2002*: San Lorenzo de El Escorial, Spain, International Workshop Localization and Energy transfer in Nonlinear Systems. "Cooling non-linear lattices till energy localization" (contributed talk).
- *23-27 March 2002*: Arcachon (FR), International workshop DNA in chromatin, at the frontiers of physics and biology. "Study of low-complexity DNA sequences in Eukaryotes and Prokaryotes" (poster).
- *13-17 June 2001*: Eu-US International Workshop on Discrete Breathers/Intrinsic Localized Vibrations, FORTH, Heraklion, Crete. "Slow energy relaxation and Localization in 1D and 2D lattices" (contributed talk).
- *29 August-10 September 1999*: EPSRC-Theory of Condensed Matter Summer School, Coleg Harlech, Wales. Org. Prof. JMF Gunn, University of Birmingham.
- *1 April 1998*: IOP Superconductivity meeting, Birmingham, UK. "Microscopic coupling between holes in high-Tc cuprates through vibrational anharmonicities" (poster).

Scientific collaborations

- Dr Yves-Henri Sanejouand, Laboratoire de Physique, Ecole Normale Supérieure de Lyon, France.
- Prof. Roberto Livi, Dipartimento di Fisica, Università di Firenze, Italy.

- Dr Michael Kastner, Bayreuth Universitat.
- Prof. Ulf Skoglund, Cell and Molecular Biology Department, Karolinska Institute, Stockholm, Sweden.
- Dr Pietro Lio, Computer Laboratory, University of Cambridge, UK.

Supervision activity

- Ph.D.
Cecile Caretta-Cartozo (with Prof. De Los Rios), EPFL
- Master theses
Marc Weber, EPFL
"Thermal energy relaxation in non-linear chains".
Samuel Urfer, EPFL
"Discrete breathers in nonlinear network models of proteins"
- Research practicals
Sebastian Weber. "Energy relaxation in a 1D FPU chain in contact with a thermal bath", EPFL.
Samuel Urfer, "Discrete breathers in proteins".

Selected recent publications

- **Discrete breathers in protein structures**
F. Piazza and Y.H. Sanejouand
to be published in Physical Biology. Pre-print:
<http://arxiv.org/abs/0802.3593v2>
- **Discrete Breathers in Nonlinear Network models of proteins**
B. Juanico, Y.-H. Sanejouand, F. Piazza and P. De Los Rios,
Physical Review Letters, **99** 238104 (2007)
- **Glass-like structure of proteins and the Boson peak**
S. Ciliberti, P- De Los Rios and F. Piazza,
Physical Review Letters, **96**, 198103 (2006)
- **Slow Energy Relaxation of Macromolecules and Nano-clusters in Solution**
F. Piazza, P. De Los Rios and Y.-H. Sanejouand
Physical Review Letters, **94**, 145502 (2005)
- **Stretched-exponential relaxation in arrays of coupled rotators**
M. Eleftheriou, S. Lepri, R. Livi and F. Piazza
Physica D, **204**, 230-239 (2005)
- **Freezing immunoglobulins to see them move**
L. Bongini, D. Fanelli, F. Piazza, P. De Los Rios, S. Sandin and U. Skoglund
PNAS, **101**, 6466-6471 (2004).

Research interests and recent activity

Broadly speaking, my research interests are in the field of applied mathematics, most recently with particular emphasis on problems concerning biological systems. I have contributed to biological physics and mathematics in different contexts, from the study of protein dynamics from single-molecule experimental reconstructions to the development of a dual-series approach for the solution of mixed-boundary problems modeling encounter reactions between complex macromolecules in solution.

A background in theoretical physics, I have acquired along the years a special expertise in the field of nonlinear discrete dynamical systems, where I contributed in particular to the understanding of the peculiar properties of a class of space-localized periodic orbits known as discrete breathers (DB) in a variety of spatially extended systems. Recently, inspired by the vast and crucial open problem of storage and directed transfer of energy in proteins, I have introduced a simple model with the idea of probing the role of nonlinear effects in such phenomena. The first results of this activity confirm that discrete breathers are easily excitable even in media as heterogeneous as protein structures. In particular, distinct features of DBs (such as their excitation energy threshold) show to be tightly connected with the peculiar topological properties of the protein folds (i.e. as specified by the connectivity graph describing their equilibrium structures), so that the intriguing possibility that space-modulated, non-linear dynamical effects might regulate specific biological functions emerges naturally. For example, we find that, at variance with translationally invariant extended systems, DBs in a disordered medium exhibit a whole hierarchy of excitation thresholds. While in a Hamiltonian system whose equilibrium structure is a regular lattice the lowest energies of DB orbits are dictated by the space dimension and the type of nonlinearity *only*, in a disordered system all properties of DB families become *site-dependent*. In other words, also the *geography* of the connectivity rules determines, among other properties, the energy gaps of DB dispersion relations. Remarkably, in proteins corresponding to connectivity graphs of thousands of vertexes, a handful of special sites typically host DB families that have vanishing energy thresholds and that are, as a consequence, most easily excitable.

The rich future follow ups of the above research line hold promise of shedding utterly new light into basic problems in molecular biology, such as ATP-fuelled enzyme catalysis and the functioning of molecular motors. Moreover, from a theoretical point of view, our model ventures into the rather unexplored field of discrete dynamical systems with spatial disorder. More generally, indeed, we study networks of nonlinear oscillators with given connectivity rules or, in other words, *complex networks* of nonlinear oscillators. In the case of proteins, the connectivity rules are provided by the contact graphs specified by the equilibrium structures (e.g. as solved through X-ray crystallography). However, our theoretical framework can be readily extended to arbitrary connectivity rules. Therefore, from a fundamental point of view, we shall explore basic properties of localized periodic orbits (such as existence and linear stability) in complex networks as functions of the topological characteristics of the underlying graph - more precisely, in a context where localization is to be measured in the graph-theoretical sense of distances, i.e. the minimum number of edges between two selected vertexes. The application to protein dynamics can then be recovered as a special case where the graph is embedded in three-dimensional Euclidean space.

Full publication list

1. **Superconducting cuprates: a simple model of coupling between electronic holes through apical ions**
L. Cianchi, P. Moretti and F. Piazza
Phys. Lett. A. **246**, 451 (1998)
2. **Slow energy relaxation and localization in 1D lattices**
F. Piazza, S. Lepri and S. Livi
J. Phys. A. **34**, 9803 (2001)
3. **Study of atomic motions in $\text{EuBa}_2\text{Cu}_3\text{O}_{7-8}$ by Moessbauer and EXAFS spectroscopies**
F. Piazza et al.
J. Superc., **14**, 675 (2001)
4. **Nonlinear Lattice Dynamics of High-Tc Superconductors**
F. Piazza
Ph.D. thesis, Heriot-Watt University, Edinburgh (2001)
5. **A quantum perturbative pair distribution for determining interatomic potentials from EXAFS**
F. Piazza
J. Phys. C, **14** (45), 11623 (2002)
6. **Thermal activation of breathers in 2D nonlinear lattices**
F. Piazza, S. Lepri and R. Livi
proceedings of the International Workshop Localisation and Energy transfer in Nonlinear Systems, San Lorenzo de El Escorial, Spain (2002), World Scientific
7. **Cooling nonlinear lattices toward localization**
F. Piazza, S. Lepri and R. Livi
invited paper, *Chaos - Focus Issue "Nonlinear localised modes, Fundamental Concepts and Applications"*, **13** (2), 637-645 (2003)
8. **Freezing immunoglobulins to see them move**
L. Bongini, D. Fanelli, F. Piazza, P. De Los Rios, S. Sandin and U. Skoglund
PNAS, **101**, 6466-6471 (2004)
9. **Statistical analysis of low-complexity sequences in the human genome**
F. Piazza and P. Lio
Physica A, **347**, pp 472-488 (2005)
10. **The anti-FPU problem**
T. Dauxois, R. Khomeriki, F. Piazza and S. Ruffo
invited paper, *Chaos*, **15**, 015110 (2005)
11. **Dynamics of antibodies from cryo-electron tomography**
L. Bongini, D. Fanelli, F. Piazza, P. De Los Rios, S. Sandin and U. Skoglund,
Biophysical Chemistry, **15**, 235-240 (2005)
12. **Anticooperativity in diffusion-controlled reactions with pairs of anisotropic domains: a model for the antigen-antibody encounter**

- F. Piazza, P. De Los Rios, D. Fanelli, L. Bongini and U. Skoglund
European Biophysics Journal, **34**, 899-911 (2005)
13. **Functional dynamics of the PDZ binding domain: a Normal Mode Analysis**
F. Cecconi, G. Dietler, P. De Los Rios, A. Grignoli-Pretre, B. Juanico, O. Michielin and F. Piazza
Biophysical Journal, **89** (1), 14-21 (2005)
 14. **Slow Energy Relaxation of Macromolecules and Nano-clusters in Solution**
F. Piazza, P. De Los Rios and Y.-H. Sanejouand
Physical Review Letters, **94**, 145502 (2005)
 15. **Stretched-exponential relaxation in arrays of coupled rotators**
M. Eleftheriou, S. Lepri, R. Livi and F. Piazza
Physica D, **204**, 230-239 (2005)
 16. **The Glass-like structure of Globular Proteins and the Boson Peak**
F. Piazza S. Ciliberti and P. De Los Rios
Physical Review Letters, **96**, 198103 (2006)
 17. **On the origin of the Boson Peak in globular proteins**
S. Ciliberti, P. De Los Rios and F. Piazza
Philosophical Magazine, **87** (3-5), 631-641 (2007)
 18. **Bottleneck Genes and Community Structure in the Cell Cycle Network of *S. pombe***
C. Caretta-Cartozo, P. De Los Rios, F. Piazza and P. Lio'
Plos Computational Biology, **3**(6), 968-976 (2007)
 19. **Diffusion-limited unbinding of small peptides from PDZ domains**
F. Cecconi, P. De Los Rios and F. Piazza
Journal of Physical Chemistry B, **111**(37), 11057 -11063 (2007)
 20. **Resolving the geometry of bio-molecules imaged by cryo-electron tomography**
L. Bongini, D. Fanelli, S. Svensson, M. Gedda, F. Piazza and U. Skoglund
Journal of Microscopy, **228**(2), 174-184 (2007)
 21. **A dynamical study of antibody-antigen encounter reactions**
L. Bongini, D. Fanelli, F. Piazza, P. De Los Rios, M. Sanner, U. Skoglund
Physical Biology, **4**(3), 172-180 (2007)
 22. **Discrete breathers in nonlinear network models of proteins**
B. Juanico, Y.H. Sanejouand, F. Piazza and P. De Los Rios
Physical Review Letters, **99**, 238104 (2007)
 23. **Surface effects in nonlinear extended systems: slow relaxation and spontaneous emergence of localized coherent modes**
F. Piazza
invited book chapter for "New Nonlinear Phenomena Research", edited by T. B. Perlidze, Nova Science Publishers, NY (2008)
 24. **Discrete breathers in protein structures**
F. Piazza and Y.H. Sanejouand
to be published in *Physical Biology*. Pre-print: <http://arxiv.org/abs/0802.3593v2>

Names of reference

1. **Roberto Livi**
Università di Firenze, Dipartimento di Fisica,
Via G. Sansone 1, 50019, Sesto F.no (FI), Italy
Tel. +39 055 4572332
Email: Livi@fi.infn.it
2. **Stefano Ruffo**
Università di Firenze, Dipartimento di Energetica,
Via di Santa Marta, 3
I-50139, Florence, Italy
Tel. +39 055 4796344
Email: Stefano.Ruffo@unifi.it
3. **Paolo De Los Rios**
Ecole Polytechnique Fédérale de Lausanne,
Laboratoire de Biophysique Statistique (LBS/ITP/SB)
BSP-720, CH-1015, Lausanne, Switzerland
Tel. +41 21 6930510
Email: Paolo.Delosrios@epfl.ch
4. **Juan Archilla**
Departamento de Física Aplicada I, University of Sevilla,
Avda Reina Mercedes s/n, SEVILLA 41012, Spain
Tel. +34 954552782
Email: archilla@us.es