Curriculum Vitae

Miguel Ibáñez Berganza

Dipartimento di Fisica, Università di Roma "La Sapienza", Ple. A. Moro, 5, 00185, Roma, Italy

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EDUCATION

Universidad Autónoma de Madrid October 2007-November 2011
Ph. D. Degree (*Doctor en Física, mención cum laude*) Thesis: *Exactly solvable models in low-dimensional many-body physics*, supervised by Prof. G. Sierra.[1]

CECAM / École Normale Supérieure de Lyon September 2004-September 2005
Masters degree in Condensed Matter Physics *(Modelling Atoms and Molecules in Condensed Matter Physics)*. Thesis performed at the Physics Department of "La Sapienza".[2]

Universidad de Granada September 1998-September 2004
Graduation degree in Physics (*Licenciatura en Física*).[3]

SCIENTIFIC WORK EXPERIENCE

Physics Department, Università di Roma, "La Sapienza" October 2016 –
Post-doctoral researcher (Physics Department contract) *Roma*

· *Machine learning; quantitative analysis of aesthetic perception as a cognitive process.*

(1) I have devised and carried on the QUESTHETICS project, an experimental, quantitative characterization of facial attractiveness under a complex-system perspective, analyzed throught information-theoretical and machine-learning tools.

(2) I have taught a 28-hour regular course in the Masters degree of Mathematics (*laurea magistrale*) of the Mathematics Department, Università "La Sapienza"; I am an official support teacher for a course in the Physics Department; I am supervising three thesis (*tesina*) for a course in the *laurea magistrale*, that I have contributed to teach. I am the official co-supervisor of a *Laurea* thesis in the Physics Department.

INFN (Italian Institute for Nuclear Physics) November 2014 – September 2016
Post-doctoral researcher (INFN studentship) *Parma*

· *Synchronization in neural networks; statistical physics of complex graphs.*

(1) I have contributed to the theoretical characterization of the emergence of a novel dynamical phase in event-driven models for neural dynamics with synaptic plasticity. I have officially co-supervised a Ph. D. student (F. Pittorino, University of Parma (UPr)) on this topic.

[1] [*Doctor en Programa Oficial de Postgrado de Física de la Materia Condensada y Nanotecnología.* A provisional title has been released the 14th April 2016, by the "Administrador Gerente de la Facultad de Ciencias, Universidad Autónoma de Madrid" Miguel Ángel Martínez Navarro.]

[2] [*Diplôme de Master, Sciences, Technologies, Santé, Mention Sciences de la Matière*, ENSL 5894058]

[3] [*Licenciado en Física*, Granada 16 de septiembre de 2004, registro nacional de títulos 2005/043875]

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(2) I have been investigating the exotic magnetic transitions of the XY model in complex topologies. I have officially co-supervised the Graduation (*Laurea*) thesis of F. Cescatti, UPr on this topic (March 2017).

(3) I have taught an official inter-faculty Ph. D. course (see pr.infn.it/home/miguel.berganza).

IPCF-CNR (Italian Research Council) November 2011 - November 2014
Post-doctoral researcher (CNR post-doctoral research fellowship) *Roma*

· *Statistical mechanical theory of non-linear electromagentic waves.*

(1) I have mainly contributed to the statistical-mechanical description of nonlinear electromagnetic wave interaction in lasers and random lasers ([4], [7], [5], [6]), and undertaken an analysis of the nature of the phase transitions in XY ferromagnets [11] and spin glasses in complex topologies.

(2) I have co-administrated the GPU cluster computing resource.

(3) I have undertaken a fundamental research on the properties of the metastable phases of several models presenting a first-order transition ([10], [9]), and officially co-supervised a Ph. D. Thesis on this topic (P. Coletti, Università "Roma Tre").

IFT-UAM/CSIC (Spanish Research Council) September 2009 - November 2011
Ph. D. researcher (Spanish "Ministerio de Educación y Ciencia" fellowship) *Madrid*

· *Theory of quantum information in extended low-dimensional quantum systems.*
During my Ph. D. internship, I have mainly contributed to:

(1) the characterization of low-dimensional quantum systems by means of quantum information ([2], [14], [13], [8])

(2) the study of electron pairing models with exact solutions ([16], [15]).

Physics Department, Università "La Sapienza" February 2005 - December 2006
Pre-doctoral researcher (Physics Department contract) *Roma*

· Statistical physics of first-order phase transitions (in the framework of my Masters degree thesis at CECAM/ENSL). Our research led to the publications: [18, 19, 17, 9].

PARTICIPATION IN RESEARCH PROJECTS

§ "Biological applications of theoretical physics methods" (TO16 INFN research project). Local Main researcher: R. Burioni. Since 2014.

§ "Statistical mechanics of disordered granular laser systems: theory and experiments" (FIRB RBFR08M3P4 001 SMDGL). Main researcher: L. Leuzzi. Since 2011.

§ "Theoretical condensed matter and quantum information (FIS2009-11654, Spanish Ministry for Science). Main researcher: G. Sierra. Since 2009.

§ "Analytical and exact numerical methods in condensed matter (FIS2006- 04885, Spanish Ministry for Science). Main researcher: G. Sierra. From 2006 to 2009.

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RESEARCH EXPERTISE

§ **Theory of first-order transitions.** Metastability, nucleation and droplet (Fisher) theories [10, 3]. § **Critical phenomena.** Finite size scaling, computation of critical exponents [11]. Systems with long-range interaction [11]. § **Graph theory and processes in complex networks.** Graph generation and analysis. Algorithms for cycle detection, graph coloring and searching. Computation of spectral properties and spectral dimension of graphs. Random walks in graphs. [11] § **Information theory and inference.** Maximum entropy models [5]. § **Statistical theory of optical processes** [7, 6, 4]. Spin systems with four-body interactions [6]. § **Spin glass theory.**

§ **Exact solutions in the quantum many-body problem.** The Bethe Ansatz [16]. Exactly solvable quantum spin chains: Bogoliubov transformations, correlations in quantum spin models [2, 15]. § **Quantum information.** Universality of entanglement entropies in 1+1 dimensions [14, 13]. Entanglement among non-spatial partitions [2, 8]. § **Models for pairing electrons and superconductivity.** BCS theory, canonical-ensemble BCS and Projected-BCS [16].

§ **Machine learning algorithms and data analysis.** Clustering, principal component analysis, Restricted Boltzmann Machines, genetic algorithms, statistical tests.

COMPUTATIONAL AND ANALYTICAL SKILLS

- § **Advanced Monte-Carlo methods in computational physics.** Cluster algorithms (the Fourtuin-Kasteleyin-Wolff representation) [3]. Numerical simulation of spin glasses: Parallel Tempering and Overrelaxation algorithms. Finite-size analysis [11]. Error estimation (*Jack-knife, boostrap* methods). Dynamical Monte Carlo methods. Tethered Monte-Carlo and microcanonical simulations [3]. § **Parallel computing in Graphics Processing Units.** Parallel Monte Carlo integration of spin and spin glass models in graphs [11, 10, 7]. The Synchronous Parallel algorithm for dense spins systems [7]. § **Linear algebra.** Exact diagonalization: the Power and Lanczos methods [14, 13]. § **Event-driven maps in neural dynamics.** § **Matrix Product States based algorithms.** The DMRG [8]. § **Genetic algorithms.**
- § **Field theory and the renormalization group.** Theory of critical phenomena. Elements of conformal field theory in quantum systems [14, 13]. Functional Renormalization Group in statistical physics. § **Replica theory and population dynamics methods.**

COMPUTER SKILLS

Programming Languages C++, C , Python (see my teaching experience in the next section). Perl, CUDA, Mathematica, octave, bash scripts.

LINUX (I have administrated the GPU clusters during my internship at the IPCF).

Tools Gimp. `gnuplot`. LaTeX. Vim. `html` (see my website).

LANGUAGE KNOWLEDGE

Spanish (native), Italian (bilingual), English and French (fluent).

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TEACHING EXPERIENCE

Università di Roma, "La Sapienza" (Italy). Since October 2016

- I have been the official teacher of a 30-hour regular course of the Masters degree in Mathematics (*Laurea Triennale*), of the Department of Mathematics of "La Sapienza". The course (entitled *Sistemi Operativi*) is mainly an introduction to high-level programming and to machine learning in Python (see further information in my website).

Università di Roma, "La Sapienza" (Italy). Since July 2017

- I am co-supervising the *Laurea magistrale* thesis of Ambra Amico (machine learning analysis of the aesthetic perception as a cognitive process).

Università di Roma, "La Sapienza" (Italy). Since October 2016

- I have participated in the teaching of the course *Sistemi Complessi*, taught by Prof. Vittorio Loreto. In particular, I have taught four lessons about neural networks, with emphasis on the information theoretical background of some learning algorithms (see further information in my website). I have also supervised the thesis (final exam of the course) of three students.

Università di Roma, "La Sapienza" (Italy). Since February 2016

- I am the official *support teacher* of the course *Physics* of the Masters Degree (*Laurea*) in Biology.

University of Parma (Italy). May – July 2016

- I have taught a 30-hour official inter-Faculty Ph. D. course entitled *Introduction to Monte Carlo methods in Statistical Physics* (see more information in my website).

University of Parma 2015–2017

- I have co-supervised the Ph. D. Thesis of Fabrizio Pittorino (2017), and the Graduation (*Laurea*) Thesis of Fabiana Cescatti (2017).

University "Roma Tre" (Italy) 2012-2014

- I have co-supervised the Ph. D. Thesis of Pietro Coletti.

San Pablo-CEU University (Spain). February-March 2011

- I have co-taught a set of seminars on the epistemology of physics (the concept of model, the structure of theories, chaos and classical uncertainty, quantum uncertainty and the EPR paradox), together with Prof. Ignacio Verdú.

PUBLICATIONS

I have published a total of twenty publications in peer-reviewed international journals, with a total of $n = 196$ number of citations han an h-index of $h = 5$ according to researcherID ($n = 308$ and $h = 8$ according to scholar.google.it). See my R-ID profile in researcherid.com/rid/H-9965-2015, where you can find the number of citations to each article (sometimes underestimated).

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References

[1] Fabrizio Pittorino, Miguel Ibáñez Berganza, Matteo di Volo, Alessandro Vezzani, and Raffaella Burioni. Chaos and correlated avalanches in excitatory neural networks with synaptic plasticity. *Phys. Rev. Lett.*, 118:098102, Mar 2017.

[2] M. Ibáñez-Berganza, J. Rodríguez-Laguna, and G Sierra. Fourier-space entanglement of spin chains. *Journal of Statistical Mechanics: Theory and Experiment*, 2016(5):053112, 2016.

[3] M. Ibáñez-Berganza. Phenomenological theory of the potts model evaporation-condensation transition. *EPL (Europhysics Letters)*, 113(2):26002, 2016.

[4] F. Antenucci, A. Crisanti, M. Ibez-Berganza, A. Marruzzo, and L. Leuzzi. Statistical mechanics models for multimode lasers and random lasers. *Philosophical Magazine*, 96(7-9):704–731, 2016.

[5] P. Tyagi, A. Pagnani, F. Antenucci, M. Ibáñez Berganza, and L. Leuzzi. Inference for interacting linear waves in ordered and random media. *Journal of Statistical Mechanics: Theory and Experiment*, 2015(5):P05031, 2015.

[6] F. Antenucci, M. Ibáñez Berganza, and L. Leuzzi. Statistical physics of nonlinear wave interaction. *Phys. Rev. B*, 92:014204, Jul 2015.

[7] F. Antenucci, M. Ibáñez Berganza, and L. Leuzzi. Statistical physical theory of mode-locking laser generation with a frequency comb. *Phys. Rev. A*, 91:043811, Apr 2015.

[8] J. Rodríguez-Laguna, M. Ibáñez Berganza, and G. Sierra. Energy space entanglement spectrum of pairing models with s-wave and p-wave symmetry. *Phys. Rev. B*, 90:041103, Jul 2014.

[9] M. Ibáñez Berganza, A. Petri, and P. Coletti. Dynamic metastability in the two-dimensional potts ferromagnet. *Phys. Rev. E*, 89:052115, May 2014.

[10] M. Ibáñez Berganza, P. Coletti, and A. Petri. Anomalous metastability in a temperature-driven transition. *EPL (Europhysics Letters)*, 106(5):56001, 2014.

[11] M. Ibáñez Berganza and L. Leuzzi. Critical behavior of the xy model in complex topologies. *Phys. Rev. B*, 88:144104, Oct 2013.

[12] J. Rodríguez-Laguna, P. Migdal, M. Ibáñez Berganza, M. Lewenstein, and G. Sierra. Qubism: self-similar visualization of many-body wavefunctions. *New Journal of Physics*, 14(5):053028, 2012.

[13] M. Ibáñez Berganza, F. C. Alcaraz, and G. Sierra. Entanglement of excited states in critical spin chains. *Journal of Statistical Mechanics: Theory and Experiment*, 2012(01):P01016, 2012.

[14] F. C. Alcaraz, M. Ibáñez Berganza, and G. Sierra. Entanglement of low-energy excitations in conformal field theory. *Phys. Rev. Lett.*, 106:201601, May 2011.

[15] C. Dunning, M. Ibáñez, J. Links, G. Sierra, and S.-Y. Zhao. Exact solution of the p + ip pairing hamiltonian and a hierarchy of integrable models. *Journal of Statistical Mechanics: Theory and Experiment*, 2010(08):P08025, 2010.

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[16] M. Ibáñez, J. Links, G. Sierra, and S.-Y. Zhao. Exactly solvable pairing model for superconductors with $p_x + ip_y$-wave symmetry. *Phys. Rev. B*, 79:180501, May 2009.

[17] A. Petri, M. Ibáñez de Berganza, and V. Loreto. Ordering dynamics in the presence of multiple phases. *Philosophical Magazine*, 88(33-35):3931–3938, 2008.

[18] M. Ibáñez de Berganza, V. Loreto, and A. Petri. Phase ordering and symmetries of the potts model. *Philosophical Magazine*, 87(3-5):779–786, 2007.

[19] M. Ibáñez Berganza, E. E. Ferrero, S. A. Cannas, V. Loreto, and A. Petri. Phase separation of the potts model in the square lattice. *Eur. Phys. J. Special Topics*, 143:273–275, 2007.

CONFERENCES AND SCHOOLS

I have followed three international Schools on specialized topics. I have presented contributions in eight international conferences and I have been invited to an international conference.

OTHER APPOINTMENTS

I have been a reviewer for the American Physical Society, the Nature and the IOP Publishing Groups. I have refereed a research project submitted to the US Department of Energy in 2013.

REFERENCES

- **Dr. Luca Leuzzi**, NANOTEC-CNR, Institute of Nanotechnology, National Research Council of Italy, Soft and Living Matter Laboratory, Rome, Piazzale Aldo Moro 2, 00185, Rome, Italy. `luca.leuzzi@cnr.it`
- **Prof. Jon R. Links**, School of Mathematics and Physics, The University of Queensland, Brisbane QLD 4072, Australia. `jrl@maths.uq.edu.au`
- **Prof. Vittorio Loreto**, Dipartimento di Fisica, Universit'a degli studi di Roma "La Sapienza", Ple. Aldo Moro, 2, 00185 Roma, Italy. `loreto@roma1.infn.it`
- **Dr. Alberto Petri**, ISC, Istituto dei Sistemi Complessi, sede di Roma 2-Tor Vergata. Via del Fosso del Cavaliere, 100, 00133 Roma, Italy. `alberto.petri@isc.cnr.it`
- **Prof. Germán Sierra**, IFT (CSIC). Facultad de Ciencias, C-XVI. Universidad Autónoma de Madrid, Cantoblanco, Madrid 28049, Spain. `german.sierra@uam.es`

Roma, 1st August 2017

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