Federico Piazza: Curriculum Vitae

Positions

- *Since November 2010*: Paris Centre for Cosmological Physics (PCCP).
- *2006-2010*: Postdoc at the Perimeter Institute for Theoretical Physics.
- *2005-2006*: Marie Curie Fellowship at the Institute of Cosmology and Gravitation, University of Portsmouth.
- *2003-2004*: Post-doc at the University of Milano Bicocca.
- *20/12/2002*: Università di Milano Bicocca, PhD in Physics: *Gravity and Cosmology of the dilaton at strong coupling.* (Thesis Advisors: Luciano Girardello and Gabriele Veneziano).

Research topics – expertise

General relativity, quantum field theory, cosmology, dark energy, inflation, scalar tensor theories, equivalence principle, dark matter, effective field theory, modifications of gravity, spontaneous breaking of Lorentz symmetries—condensed matter, foundations of physics.

Research Impact and Awards

- More than 30 published articles with about 1300 citations in total. H-index: 14. One *famous* paper (250+ cites) and four very well-known papers (100+ cites) (Spires).
- New Journal of Physics, Best of 2009: "The IR-Completion of Gravity: What happens at Hubble Scales?", F. Piazza, arXiv:0907.0765 [hep-th] PI page
- Honorable Mention at the Gravity Research Foundation essay competition 2009: "Modifying Gravity in the Infra-Red by imposing an 'Ultra-Strong' Equivalence Principle", F. Piazza, arXiv:0904.4299 [hep-th]
- Spring 2004: Marie Curie Intra-European Fellowship
- Press Releases: 1: **"Et si Newton n'avait pas tout prévu?"** ("And if Newton had not foreseen everything?") Cécile Bonneau, Science & Vie, **1038** 54 (March 2004). 2: **"Revising Gravity"** K. Krieger, Physical Review Focus (October 2003)
- Summer 2001: Giulio Racah Scholarship, International School of Nuclear and Subnuclear Physics, Ettore Majorana Centre, Erice, Sicily, Italy.

Supervising Experience and Responsibilities

- *2013*: Co-supervising Heinrich Steigerwald (PhD student of C. Marinoni, CPT Marseille).
- *Oct 2013 –* : "Dark Energy Group Meetings", weekly journal club of *Theory* and *Gravitation and Cosmology* groups of APC, discussion leader and organizer.
- *Sept 2013 –* : Theory group seminars, APC, every tuesday at 14:00, organizer.
- *Feb 7-8 2013*: Workshop "Dark Energy Phenomenology", PCCP, Paris, organizer.
- *April 2012*: "Taming Dark energy with Large Scale Structures" (PCCP fellows meeting- B. Wandelt and P.S. Corasaniti), organizer.

- *March 2* nd *2012*: Workshop "Tests and theories of Lorentz symmetry violations", PCCP, Paris, organizer.
- *Sept-Oct 2011*: Mentor of the undergraduate student Florian Sarron for the program "Initiation à la Recherche".
- *May 23* rd *2011*: Workshop "Gravity in the infrared: issues and opportunities", PCCP, Paris, organizer.
- *March 2011*: "What are Galaxy surveys really measuring?" (PCCP fellows meeting - R. Durrer), organizer.
- *Since Jan 2011*: Head of the local APC-theory group for EUCLID extragalactic survey.
- *May-August 2010*: Supervisor (and referee) of Tomas Galvez Ghersi, summer student at Perimeter Institute.
- *May-August 2009*: Supervisor of Jennifer Lin, summer student at Perimeter Institute.
- *2008-2009*: Supervisor (and referee) of Hongbao Zhang, a visiting PhD student at Perimeter Institute.
- *May-August 2007*: Undergrad. thesis supervisor (and referee) of Fabio Costa, visiting student at Perimeter.
- *2006*: Supervising Elisabetta Majerotto (PhD student) in part of her research work, ICG, Portsmouth.
- Referee for Physical Review Letters, JCAP, JHEP, Physical Review D, Physics Letters B, Foundations of Physics, Journal of Physics A, General Relativity and Gravitation, European Physical Journal C.

Brief description of recent research

Effective field theory of Dark Energy My most recent achievement is the "Effective field theory of Dark Energy" (EFT of DE): a single unifying framework in which the specific features of DE (both at the level of the expansion history and of the growth rate) can be studied and tested against data. With my collaborators I have developed a formalism to parameterize and study the effects of dark energy beyond the background evolution. By extending to late time cosmology the "unitary gauge" formalism developed for inflation by Creminelli et al., we write down the most generic DE action containing only one scalar degree of freedom more than GR. The advantages of the EFT of DE are similar to those that traditional effective field theory has in particle physics. I think this formalism will soon become the *standard* for describing features and properties of DE models, and used to fit data in future galaxy surveys such as EUCLID. In slightly more than one year, my papers (**n. 3, 4, 6, 7** below) have already collected about 60 citations in total, which shows the attention that the community is giving to this approach. I have also been invited to many international conferences and asked to talk about this.

Goldstone theorems, condensed matter from a high-energy perspective etc. Recently, Alberto Nicolis and I have formulated (see **n. 9 and 11** below) a non-relativistic Goldstone theorem of a novel type. In cases of systems at finite charge density, we proved that if such a charge is part of a non-Abelian group of symmetries, the remaining Nambu-Goldstone particles associated with the other broken generators become *massive*, and their masses can be calculated *exactly* in terms of the chemical potential and of the structure constants of the symmetry group. This is one of the very few **exact results in field theory** that involves a finite mass gap (as opposed to be valid in the lowest energy limit, as the usual Goldstone theorem). More recently (see **n. 5** below), in collaboration with Nicolis, Riccardo Penco and Rachel Rosen, I have studied systematically the low energy theory of systems at finite charge density by means of a *coset construction*, which is useful to approach the low-energy behavior of theories in which some of the symmetries are spontaneously broken. Such a construction confirms the existence of the gapped excitations predicted by Nicolis and me, and finds, in some cases, *additional* gapped excitations, whose mass, still of the order of the chemical potential, is not univocally fixed by the symmetry algebra. In an extended collaboration which includes Riccardo Rattazzi, we are now "classifying" condensed matter system on the basis of the possible spontaneous Lorentz-symmetry breaking patterns, in the presence of additional internal symmetries (see **n. 1** below).

Papers

1. **"Zoology of condensed matter: framids, ordinary stuff, and galileids"**
   A. Nicolis, R. Penco, F. Piazza, R. Rattazzi and R. A. Rosen, to appear [hep-th].

2. **"Healthy theories beyond Horndeski"**
   J. Gleyzes, D. Langlois, F. Piazza and F. Vernizzi.
   arXiv:1404.6495 [hep-th] HEP entry

3. **"Phenomenology of dark energy: exploring the space of theories with future redshift surveys"**
   F. Piazza, H. Steigerwald and C. Marinoni. arXiv:1312.6111 [astro-ph.CO] HEP entry
   JCAP, in press.

4. **"Effective Field Theory of Cosmological Perturbations"**
   F. Piazza and F. Vernizzi,
   Class. Quant. Grav. **30**, 214007 (2013) [arXiv:1307.4350 [hep-th]]HEP entry

5. **"More on gapped Goldstones at finite density: More gapped Goldstones"**
   A. Nicolis, R. Penco, F. Piazza and R. A. Rosen,
   JHEP **1311**, 055 (2013) [arXiv:1306.1240 [hep-th]] HEP entry

6. **"Essential Building Blocks of Dark Energy"**
   J. Gleyzes, D. Langlois, F. Piazza and F. Vernizzi,
   JCAP **1308**, 025 (2013) [arXiv:1304.4840 [hep-th]]HEP entry

7. **"The Effective Field Theory of Dark Energy"**
   G. Gubitosi, F. Piazza and F. Vernizzi,
   JCAP **1302**, 032 (2013), [arXiv:1210.0201 [hep-th]] HEP entry

8. **"Infrared-modified Universe"**
   F. Piazza, arXiv:1204.4099 [gr-qc] HEP entry

9. **"Relativistic non-relativistic Goldstone theorem: gapped Goldstones at Finite Charge Density"**
   A. Nicolis and F. Piazza,
   Phys. Rev. Lett. **110**, 011602 (2013) [arXiv:1204.1570 [hep-th]] HEP entry

10. **"Scalar-tensor theories, trace anomalies and the QCD-frame"**
    F. Nitti and F. Piazza,
    Phys. Rev. D **86**, 122002 (2012) [arXiv:1202.2105 [hep-th]], HEP entry

11. **"Spontaneous Symmetry Probing"**
    A. Nicolis and F. Piazza,
    JHEP **1206**, 025 (2012) [arXiv:1112.5174 [hep-th]] HEP entry

12. **"Eternal inflation and a thermodynamic treatment of Einstein's equations"**
    J. T. Galvez Ghersi, G. Geshnizjani, F. Piazza and S. Shandera
    JCAP **1106**, 005 (2011) [arXiv:1103.0783 [gr-qc]] SPIRES entry

13. **"Bimetric structure formation: non-Gaussian predictions"**
    J. Magueijo, J. Noller and F. Piazza
    Phys. Rev. D **82**, 043521 (2010) [arXiv:1006.3216 [astro-ph.CO]] SPIRES entry

14. **"Gauss-Codazzi thermodynamics on the timelike screen"**
    F. Piazza, Phys. Rev. D **82**, 084004 (2010) [arXiv:1005.5151 [gr-qc]] SPIRES entry

15. **"Sub-eV scalar dark matter through the super-renormalizable Higgs portal"**
F. Piazza and M. Pospelov
Phys. Rev. D **82**, 043533 (2010) [arXiv:1003.2313 [hep-ph]] SPIRES entry

16. **"New views on the low-energy side of gravity"**
F. Piazza, arXiv:0910.4677 [gr-qc] SPIRES entry
Talk given at DICE2008, Castiglioncello, Italy, 22-26 Sep 2008 and at Emergent Gravity IV, Vancouver, BC, Canada, 24-28 Aug 2009 and "Emergent Gravity", MIT, Cambridge, Massachusetts, 25-29 Aug 2008

17. **"The universe is accelerating. Do we need a new mass scale?"**
S. Nesseris, F. Piazza and S. Tsujikawa
Phys. Lett. B **689**, 122 (2010) [arXiv:0910.3949 [astro-ph.CO]] SPIRES entry

18. **"The IR-Completion of Gravity: What happens at Hubble Scales?"**
F. Piazza, New J. Phys. **11**, 113050 (2009) [arXiv:0907.0765 [hep-th]]
Selected for the special collection "New Journal of Physics, Best of 2009" SPIRES entry

19. **"Modifying Gravity in the Infra-Red by imposing an 'Ultra-Strong' Equivalence Principle"**
F. Piazza, Int. J. Mod. Phys. D **18**, 2181 (2009) [arXiv:0904.4299 [hep-th]] SPIRES
Honorable mention at the Gravity Research Foundation Essay Competition 2009

20. **"Rapidly-Varying Speed of Sound, Scale Invariance and Non-Gaussian Signatures"**
J. Khoury and F. Piazza
JCAP **0907**, 026 (2009) [arXiv:0811.3633 [hep-th]] SPIRES entry

21. **"Modelling a Particle Detector in Field Theory"**
F. Costa and F. Piazza
New J. Phys. **11**, 113006 (2009) [arXiv:0805.0806 [hep-th]] SPIRES entry

22. **"Renormalized Thermal Entropy in Field Theory"**
S. Cacciatori, F. Costa and F. Piazza
Phys. Rev. D **79**, 025006 (2009) [arXiv:0803.4087 [hep-th]] SPIRES entry

23. **"Volumes of Space as Subsystems"**
F. Piazza and F. Costa, PoS(QG-Ph)032 arXiv:0711.3048 [gr-qc] SPIRES entry
Proceedings of "From Quantum to Emergent Gravity: Theory and Phenomenology".

24. **"Measuring deviations from a cosmological constant: a field-space parameterization"**
R. Crittenden, E. Majerotto and F. Piazza
Phys. Rev. Lett. **98**, 251301 (2007) [arXiv:astro-ph/0702003] SPIRES entry

25. **"SNLS data are consistent with acceleration at z=3"**
L. Amendola, M. Gasperini and F. Piazza
Phys. Rev. D **74**, 127302 (2006) [arXiv:astro-ph/0610574] SPIRES entry

26. **"Quantum degrees of freedom of a region of spacetime"**
F. Piazza, AIP Conf. Proc. **841**, 566 (2006) [arXiv:hep-th/0511285] SPIRES entry
Proceedings of 28th Spanish Relativity Meeting (ERE05): A Century of Relativity Physics, Oviedo, Asturias, Spain, 6-10 Sep 2005

27. **"Enhanced gravitational scattering from large extra dimensions"**
K. Koyama, F. Piazza and D. Wands, arXiv:hep-th/0510210 SPIRES entry

28. **"Glimmers of a pre-geometric perspective"**
F. Piazza, Found. Phys. **40**, 239 (2010) [arXiv:hep-th/0506124] SPIRES entry

29. **"Fitting type Ia supernovae with coupled dark energy"**
L. Amendola, M. Gasperini and F. Piazza
JCAP **0409**, 014 (2004) [arXiv:astro-ph/0407573] SPIRES entry

30. **"Dilatonic ghost condensate as dark energy"**
F. Piazza and S. Tsujikawa
JCAP **0407**, 004 (2004) [arXiv:hep-th/0405054] SPIRES entry

31. **"The Gravitational Suppression Hypothesis: Dynamical Analysis in the Small Velocity Regime"**
C. Marinoni and F. Piazza, arXiv:astro-ph/0312001 SPIRES entry

32. **"The GraS hypothesis: A model for dark matter - baryons gravitational interaction"**
F. Piazza and C. Marinoni arXiv:astro-ph/0309490 SPIRES entry
Proceedings of "Where Cosmology and Fundamental Physics Meet", Marseille, France, 23-26 Jun 2003

33. **"Model for gravitational interaction between dark matter and baryons"**
F. Piazza and C. Marinoni
Phys. Rev. Lett. **91**, 141301 (2003) [arXiv:hep-ph/0304228] SPIRES entry

34. **"Gravity and Cosmology of the Dilaton at strong coupling"**
F. Piazza, PhD Thesis, Milan University (2002).

35. **"Violations of the equivalence principle in a dilaton-runaway scenario"**
T. Damour, F. Piazza and G. Veneziano
Phys. Rev. D **66**, 046007 (2002) [arXiv:hep-th/0205111] SPIRES entry

36. **"Runaway dilaton and equivalence principle violations"**
T. Damour, F. Piazza and G. Veneziano
Phys. Rev. Lett. **89**, 081601 (2002) [arXiv:gr-qc/0204094] SPIRES entry

37. **"Quintessence as a run-away dilaton"**
M. Gasperini, F. Piazza and G. Veneziano
Phys. Rev. D **65**, 023508 (2002) [arXiv:gr-qc/0108016] SPIRES entry

38. **"Quasi-normal modes of charged, dilaton black holes"**
V. Ferrari, M. Pauri and F. Piazza
Phys. Rev. D **63**, 064009 (2001) [arXiv:gr-qc/0005125] SPIRES entry

Teaching

- **APC**
  - Lecturer "Theoretical Physics for non-theoretical physicists", Dec. 2012 - Mar 2013. (16 hours)
- **University of Waterloo**
  - Instructor, "Introduction to Cosmology", senior-undergraduate course (March 2009, 10 hours)
- **Perimeter Institute**
  - Tutor, Summer School: Exploring the Cosmological Frontiers June 24 - July 1 (2009)
  - Mentor, International School for Young Physicists, (Summer 2007 and 2008, 12 hours in total).

- **Institute of Cosmology and Gravitation, Portsmouth University**

  – Instructor, "Quantum Field Theory", PhD Course (Feb. 2006, 8 hours)

  – Instructur, "Mathematical methods in physics", PhD Course (Dec. 2003, Jan. 2005 and Nov. 2005, 48 hours in total)

- **University of Milano Bicocca**

  – Lecturer, "Black hole physics and global issues in General Relativity" (Jan. 2002, 8 hours), "Cosmology and Inflation" (May 2003, 8 hours), General relativity for undergraduates, Prof. Silvia Penati.

Selected Talks

1. **"Massive Goldstones and finite charge density"**,
   – "Low Energy Challenges for High Energy Physicists" Perimeter Institute, May 26-30 2014 (*invited*)
   – "Effective Field Theories for Quantum Many-Body Systems", Madrid, Spain, Jan. 15-17 2014 (*invited*)

2. **"The Effective Field Theory of Dark Energy"**
   – "Cosmological frontiers in Fundamental physics", APC, Paris, 10-13 June 2014 (*invited*)
   – Progress on Old and New themes in Cosmology, Avignon, April 14-18 2014 (*invited*)
   – Rencontre de Moriond, 2014
   – Scuola Normale Superiore, Pisa, Italy, 6/11/2013, – ICTP, Trieste, Italy, 12/11/2013
   – GDR "Terascale", Montpellier 31/1/2013 (*invited*), – LAPTh, Annecy 31/1/2013
   – Tours, 24/1/2013, CPT, Marseille, 18/1/2013, – SNS, Lyon, 17/1/2013
   – APC, 18/12/2012, – CERN 14/11/2012
   – University of Geneva 9/11/2012, – Department of Physics, University of Columbia, NY, 15/10/2012

3. **"Infra-red modified Universe"**, "Physics of de Sitter Spacetime", Hannover, Sept. 11-14 2012 (*invited*)

4. **"Spontaneous Symmetry Probing"**
   – Lausanne, 14/1/2012
   – Università di Padova, Italy, May 27 2012
   – École Polytechnique, Paris, France, Mar 13 2012
   – IAP, Paris, France, Feb. 27 2012
   – DAMPT, Cambridge, UK, Feb. 20 2012

5. **"The Equivalence Principle and the search for new Physics"**
   "Cosmo 2011", Plenary Review Talk, Porto, Portugal, August 2011 (*invited*)

6. **"The IR-completion of gravity: cosmological implications"**
   Cosmology workshop Montpellier, December 2010 (*invited*)

7. **"Modifying gravity in the Infra-Red by imposing an 'ultra-strong' Equivalence Principle"**
   – IPhT, COA-Saclay, Paris, France, June 1 2011
   – University of Michigan, High Energy Theory Seminar, September 17, 2010.
   – IHES, Paris, March 23, 2010, – Imperial College, London, 16/12/2009,
   – Department of Physics, University of Columbia, NY, 07/12/2009, – CITA, Toronto, 30/10/2009
   – Department of Physics, University of Philadelphia, 09/09/2009
   – "Emergent Gravity IV" August 24-28 2009, University of British Columbia, Vancouver (*invited*)
   – Department of Physics, University of Milan Bicocca, July 2009.
   – "New Prospects for Solving the C.C. Problem", Perimeter Institute., May 25-27, 2009 (*invited*)

8. **"Scale invariant spectrum and rapidly varying speed of sound"**
   – PI-CITA day, Toronto, 19/5/2009
   – "New Horizons for Modern Cosmology" Galileo Galilei Institute, Florence (Italy), 2/2/2009
   – ICG, Portsmouth, 15/1/2009

9. **"Which space-time actually emerges? The world as seen from inside a spin system"**
   "Emergent Gravity", MIT, Boston, August 25-29, 2008 (*invited*)

10. **"Particle detector models, thermal entropy and localization"**
    (String Theory-) Seminar, Department of Physics, UCB, Berkeley, September 9, 2008

11. **"Coupling variations and equivalence principle violations in string inspired scenarios"**
    "The Search for Variations of Fundamental Couplings and Mass Scales", Perimeter Instit., July 14-18, 2008 (*invited*)

12. **"Particle Detectors, the Frog Principle and the Unruh Effect"**
    "Hot topics in Modern Cosmology" Cargese (Corse) May 12-17, 2008 (*invited*)
    Perimeter Institute of Theoretical Physics, Waterloo, April 30, 2008 PIRSA (recorded seminars archive)

13. **"Localization in semi-classical gravity"**
    "Quantum Information in Quantum Gravity", Perimeter Institute, December 8 - 10, 2007 (*invited*)

14. **"Regions of space as subsystems: entropy and semiclassical gravity"**
    – "DICE2008", Castiglioncello (Italy), September 22-26, 2008
    – "From Quantum to Emergent Gravity: Theory and Phenomenology", SISSA, Trieste, June 11-15, 2007

15. **"Measuring deviations from a cosmological constant: a slow-roll paradigm for dark energy"**
    "Facts and Fictions in Cosmology", Sils Maria (Switzerland), March 26-April 2, 2006 (*invited*)

16. **"Enhanced gravitational scattering from large extra dimensions"**
    "New Views of the Universe" Chicago, December 8-13, 2005

17. **"Regions of space as subsystems"**
    "XXVIII Spanish Relativity Meeting", Oviedo (Spain) September 2005

18. **"Baryons and Dark Matter: a modification of Gravity at subgalactic scales"**
    – "Exploring the Universe", Rencontres de Moriond, La Thuile (Italy), April 4-10, 2004
    – "Where Cosmology and Fundamental Physics meet", IUFM, Marseille (France), June 23-26, 2003
    – "Physical Cosmology", Blois (France), June 15-20, 2003

19. **"Cosmological and gravitational effects of the dilaton at strong coupling"**
    – "String/Brane Cosmology", IHES and Universitè de Paris-Sud, Orsay (France) Sept. 23-27, 2002 (*invited*)
    – "Current Problems in Theoretical Physics", Vietri sul Mare (Italy), March 2002
    – "International School of Sub-Nuclear Physics", Erice (Italy), September 2001

20. **"Dark Energy and α variations"**
    "Dark Energy Day", Milano-Bicocca University, November 22, 2002

21. **"Gravitational Waves from Charged Dilaton Black Holes"**
    "Current Problems in Theoretical Physics" Vietri sul Mare (Italy), April 2000

Selected Visiting

- Columbia University, NY (*June-September 2014, planned*)
- Centre de Physique Thèorique (CPT), Marseille. Host: Christian Marinoni (*13-20 October and 13-22 August 2013, 23 - 30 May 2008*)
- CERN, Switzerland. (*8 - 18 November 2012* and *11 - 30 April 2004*).
- Canadian Institute for Theoretical Astrophysics (CITA), Toronto. (*October 2009 - January 2010*).
- Department of Physics, University of Philadelphia. (*1 - 20 September 2009*).
- Galileo Galilei Institute, Florence, Italy. Workshop "New Horizons for Modern Cosmology". (*18 Jan – 10 Feb 2009*)
- Department of Physics, University of California Berkeley. Host: Raphael Bousso (*4 - 11 September 2008*).
- Perimeter Institute, Waterloo Ontario. (*15 - 30 January 2006*).
- Institute of Cosmology and Gravitation, University of Portsmouth, UK. Visiting fellowship "Della Riccia". Host: David Wands (*March - December 2003*).
- Observatoire Astronomique Marseille-Provence. Host: Christian Marinoni (*26 February - 15 March 2003*)
- Laboratoire de Physique Théorique, Université Paris Sud, Orsay, France. Host: Gabriele Veneziano (*January 2001 - November 2001*).

Referees

- Justin Khoury, University of Pennsylvania, Philadelphia, US
  `jkhoury@sas.upenn.edu`, Tel. +1-215-573-7152
- Gabriele Veneziano, CERN, Geneva and Collège de France, Paris
  `gabriele.veneziano@cern.ch`, Tel. +33-1-44271147
- Alberto Nicolis, Columbia University, New York, US
  `nicolis@phys.columbia.edu` , Tel. +1-212-854-3316
- David Langlois, Laboratoire APC, Université Paris Diderot-Paris 7
  langlois@apc.univ-paris7.fr ,Tel. +33-1-57276074
- Maxim Pospelov, University of Victoria, BC and Perimeter Institute, Waterloo, ON, Canada
  `mpospelov@perimeterinstitute.ca`, Tel. +1-250-721-7700 x7611
- Pierre Binetruy, Laboratoire APC, Université Paris Diderot-Paris 7
  `pierre.binetruy@apc.univ-paris7.fr`,
- George Smoot, University of California Berkley, US
  `gfsmoot@lbl.gov`,