

Roberto Contino

Curriculum Vitae et Studiorum

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General Information

Full Name Roberto Contino
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Languages Italian, English, Spanish

Research Interests

My interest goes to quantum field theory and the description that it gives of the fundamental interactions. I have been working, in particular, on building theories beyond the Standard Model and studying their phenomenology. My most significant contributions have been in the context of theories for the dynamical breaking of the electroweak symmetry, flavor physics, searches for new physics at colliders. The focus of my current research is on theories of Dark Matter.

Education

1992–1997 **Degree in Physics**, *University of Rome La Sapienza*.
1998–1999 **INFN Fellowship**, *Rome INFN Division*.
1999–2002 **PhD in Theoretical Physics**, *Scuola Normale Superiore, Pisa*.
2001–2002 **Della Riccia Fellowship**, *CERN, Theory division*.

Academic Appointments

2002–2003 **Postdoctoral Fellow**, *Universidad Autónoma, Madrid, Spain*.
2003–2006 **Postdoctoral Fellow**, *The Johns Hopkins University, Baltimore, MD (USA)*.
2006–2007 **INFN Researcher (tempo determinato)**, *Rome INFN Division*.
2007–2009 **Fellow**, *CERN, Theory Division*.
2009–2016 **Researcher**, *University of Rome La Sapienza*.
2013–2016 **Joint Scientific Staff**, *CERN and École Polytechnique Fédérale de Lausanne*.
2016–2021 **Associate Professor**, *Scuola Normale Superiore, Pisa*.
since 2021 **Full Professor**, *University of Rome La Sapienza, Roma*.

Teaching Experience

- 2018-2020 *Standard Model and Beyond* (for master students), Scuola Normale Superiore
- 2018-2020 *Advanced Topics in QFT* (for PhD students), Scuola Normale Superiore
- 2016-2017 *Elementary Particle Theory I* (for master students), Scuola Normale Superiore
- 2017 *Elementary Particle Theory II* (for PhD students), Scuola Normale Superiore
- 2016 *Topics in the SM and Beyond* (for PhD students), EPFL
- 2014 *Advanced QFT* (for PhD and master students), EPFL
- 2013 *Physics* (for bachelor students, Degree Course in Pharmacy), University of Rome La Sapienza
- 2008-2012 *Models of Electroweak Symmetry Breaking* (for PhD students), University of Milano Bicocca, University of Milan, University of Rome La Sapienza

Teaching Assistantship

- 2010-2012 *Mechanics* (for bachelor students, Degree Course in Physics), University of Rome La Sapienza

Invited Lectures

- 2021 *Effective Field Theories*, GGI School on the Theory of Fundamental Interactions, Galileo Galilei Institute, Florence (IT)
- 2018 *Effective Field Theories for BSM*, pre-SUSY Summer School, Barcelona (SP)
- 2018 *Theory of Higgs Physics and Beyond*, Cargèse Summer School (FR)
- 2014 *Effective Theories for Higgs Physics*, PSI Summer School, ZUOZ (CH)
- 2012 *Electroweak Symmetry Breaking*, Academic Training Lectures, CERN
- 2012 *Composite Higgs Models*, School on Strongly Coupled Physics Beyond the Standard Model, ICTP, Trieste (IT)
- 2009 *The Higgs as a pseudo Nambu-Goldstone boson*, TASI School *The Physics of the Large and the Small*, University of Colorado Boulder (USA)
- 2007 *The Composite Higgs*, International School of Theoretical Physics, Parma (IT)
- 2007 *Composite Higgs Models*, invited lectures at Louvain University (BE)

Outreach Activity

- 2018 Corso di orientamento universitario della Scuola Normale Superiore, Università Federico II, Napoli
- 2016 Corso di orientamento universitario della Scuola Normale Superiore, San Miniato

Mentoring

Master Students: D. Marzocca (now researcher at INFN Trieste), M. Salvarezza, A. Di Iura, A. Podo, F. Revello, L. Ciambriello

PhD students: N. Vignaroli (now postdoc at Pisa U.), M. Ghezzi (now postdoc at Tübingen U.), M. Salvarezza, Da Liu (as visiting student at EPFL - now postdoc at UC Davis), D. Greco, C. Machado (as visiting student at CERN - now postdoc at Mainz U.), A. Mitridate (now postdoc at CalTech), K. Max, A. Podo (now postdoc at Columbia U.), L.X. Xu (as visiting student at SNS), S. Bottaro, S. Verma

Postdocs: J. Galloway, A. Azatov (now associate professor at SISSA), M. Son (now faculty at KAIST, Korea), R. Mishra (now postdoc at Harvard)

Grants

Projects led as Principal Investigator

- 2019-2023 **PRIN2017**, *New Avenues in Strong Dynamics: from the Early Universe to the Lab*, (362k euro).
- 2017-2020 **Iniziativa Specifica INFN**, *AstroAlteEnergie*, participant divisions: Pisa, Trieste and LNGS, (Responsabile Nazionale).
- 2015 **Swiss National Fund**, *Higgs Boson Phenomenology and the Origin of Electroweak Symmetry Breaking*, (120k CHF).
- 2010–2012 **Fondi di Ateneo**, University of Rome La Sapienza, (88k euro).

Participation to other projects

- 2013 **PRIN2010**, Role: unit coordinator, University of Rome La Sapienza (PI: Guido Martinelli).
- 2011–2017 **ERC Advanced Grant**, *DaMeSyFla*, Role: team member (PI: Guido Martinelli).

Organization of Conferences and Schools

- 2016 **CERN Theory Workshop**, *Charting the Unknown: interpreting LHC data from the energy frontier*, CERN, 25 July – 12 August, 2016 [[webpage](#)].
- 2014–2016 **GGI Lectures on the Theory of Fundamental Interactions**, International School for PhD students in Theoretical Physics, Galileo Galilei Institute, Florence [[webpage](#)].
- 2009 **GGI Workshop**, *Searching for New Physics at the LHC*, 31 August – 30 October, 2009, Galileo Galilei Institute, Florence [[webpage](#)].
- 2009 **GGI Conference**, *The Search for New States and Forces of Nature*, 26-30 October, 2009, Galileo Galilei Institute, Florence [[webpage](#)].

Invited Plenary Talks

- [38] **Higgs Hunting 2019**, Orsay-Paris (FR), July 2019 [[webpage](#)].
- [37] **IFAE 2019**, *Incontri di Fisica delle Alte Energie*, Napoli (IT), April 2019 [[webpage](#)].
- [36] **Bound states in strongly coupled systems**, Galileo Galilei Institute, Firenze (IT), March 2018 [[webpage](#)].
- [35] **LFC17**, *Old and New Strong Interactions from LHC to Future Colliders*, ECT*, Trento (IT), September 2017 [[webpage](#)].
- [34] **A First Glance Beyond the Energy Frontier**, ICTP, Trieste, September 2016 [[webpage](#)].
- [33] **SEARCH 2016**, Oxford (GB), September 2016 [[webpage](#)].
- [32] **3rd NPKEI Workshop**, Korea University, Seoul (KR), June 2016 [[webpage](#)].
- [31] **HEFT2015**, *Higgs Effective Field Theories*, Chicago (USA), November 2015 [[webpage](#)].
- [30] **Gearing up for LHC 13**, Galileo Galilei Institute, Firenze (IT), October 2015 [[webpage](#)].

- [29] **HEPKIT2015**, *The High-Energy Physics Kit*, Karlsruhe Institute of Technology (DE), October 2015 [[webpage](#)].
- [28] **Johns Hopkins 39th Workshop**, Gothenburg (SE), August 2015 [[webpage](#)].
- [27] **CHIPP Annual Plenary Meeting**, Château de Bossey (CH), June 2015 [[webpage](#)].
- [26] **Workshop on Physics at the High-Luminosity LHC**, CERN (CH), May 2015 [[webpage](#)].
- [25] **Workshop on Higgs Pair Production at Colliders**, Mainz (DE), April 2015 [[webpage](#)].
- [24] **Zurich Phenomenology Workshop**, *The flavour of new physics*, Zurich (CH), January 2015 [[webpage](#)].
- [23] **Invisibles 14 Workshop**, Paris (FR), July 2014 [[webpage](#)].
- [22] **1st Future Hadron Collider Workshop**, CERN (CH), May 2014 [[webpage](#)].
- [21] **Planck 2014**, Paris (FR), May 2014 [[webpage](#)].
- [20] **Workshop on Physics at a 100 TeV Collider**, SLAC (USA), April 2014 [[webpage](#)].
- [19] **Les Rencontres de Physique de la Vallée d'Aoste**, *La Thuile (IT)*, March 2014 [[webpage](#)].
- [18] **SUSY 2013**, ICTP, Trieste (IT), August 2013 [[webpage](#)].
- [17] **SEARCH 2013**, *Stony Brook University, USA*, August 2013 [[webpage](#)].
- [16] **EPS-HEP 2013**, *The 2013 European Physical Society Conference on High Energy Physics*, Stockholm (SE), July 2013 [[webpage](#)].
- [15] **Beyond the SM after the first run of the LHC**, GGI, Firenze (IT), July 2013 [[webpage](#)].
- [14] **VI Workshop Italiano sulla Fisica p-p a LHC**, Genova (IT), May 2012 [[webpage](#)].
- [13] **From Strings to LHC - III**, Puri (IN), December 2012.
- [12] **Johns Hopkins 36th Workshop**, *Latest News on the Fermi scale from LHC and Dark Matter searches*, Firenze (IT), October 2012 [[webpage](#)].
- [11] **Planck 2012**, Warsaw (PL), 28 May – 1 June 2012 [[webpage](#)].
- [10] **ICTP Workshop on Strongly Coupled Physics Beyond the Standard Model**, Trieste (IT), January 2012 [[webpage](#)].
- [9] **Higgs Hunting 2011**, Orsay (FR), July 2011 [[webpage](#)].
- [8] **PLHC 2011**, *Physics at the LHC*, Perugia (IT), June 2011 [[webpage](#)].
- [7] **Planck 2010**, CERN (CH), 31 May–4 June 2010 [[webpage](#)].
- [6] **Hadron Collider Physics Symposium**, Evian (FR), November 2009 [[webpage](#)].
- [5] **IFAE 2009**, *Incontri sulla Fisica delle alte energie*, Bari (IT), April 2009.
- [4] **Workshop on Higgs Boson Phenomenology**, Zurich (CH), 2009.
- [3] **Workshop on Montecarlos and Simulations for the LHC**, Frascati (IT), 2008.
- [2] **European Midterm Meeting**, Pisa (IT), 2006.
- [1] **Workshop on Montecarlos and Simulations for the LHC**, Frascati (IT), 2006.

Research Activity

My research focuses on the study of the fundamental interactions among particles. The models and theoretical scenarios that I have explored are highly diverse, including supersymmetric models, strongly-coupled theories, extra-dimensional field theories, and models of flavor. I am interested both in their construction and in the investigation of their phenomenological consequences. To the latter aim, I have been always considering as particularly important to learn about experimental strategies and techniques that can put models under test. This led me quite naturally to collaborate with experimental colleagues in more than one project, and influenced as well the direction of my research.

Extra-dimensional Field Theories and the Holographic Higgs

The research that I performed on extra dimensional field theories explored different directions. In a series of papers I investigated the consistency of such class of theories, analyzing how symmetries are realized, when gauge anomalies arise, and the problem of finding appropriate procedures to regulate loop integrals. I then turned my attention to how some of the long-standing problems in high-energy physics could find a solution, or at least be formulated in new terms, within extra-dimensional field theories. For example, the novel way to realize local symmetries in presence of boundaries leads to a simple resolution of the doublet-triplet splitting problem. My worked helped to highlight the conditions under which one can have split multiplets without spoiling unification and showed that threshold corrections from Kaluza-Klein modes can improve the precision of gauge coupling unification in presence of Supersymmetry. The hierarchy problem also finds a notable resolution in warped extra-dimensional theories. In a series of papers I studied 5-dimensional Randall-Sundrum theories of gauge-Higgs unification, uncovering their equivalence to 4-dimensional composite Higgs theories. The latter were studied in the 1980's by Georgi and Kaplan, and realized the Higgs boson as a composite pseudo Nambu-Goldstone boson of new strongly-coupled gauge dynamics at the TeV scale. Besides establishing this remarkable connection, my work lead to the formulation of a fully realistic model (the Minimal Composite Higgs Model), that has been taken as a benchmark for subsequent studies.

Higgs compositeness

Progress on the construction of 5D warped models of gauge-Higgs unification led to re-consider the idea of Higgs compositeness. Holographic models showed that the main contribution to the Higgs potential, responsible for vacuum misalignment, can naturally come from the top quark, and that, consequently, the problem of too-fast flavor-changing neutral currents that plagued the original Georgi-Kaplan models can be elegantly resolved. This led to predict an entirely new phenomenological scenario at colliders. My work in this direction tried to identify the best signatures and strategies to test the nature of the Higgs boson, and probe the dynamics behind electroweak symmetry breaking. The most significant contributions I gave include studies of double Higgs production and vector boson fusion processes, and those on the discovery of top partners at colliders.

Electroweak and Higgs Precision Tests

Starting from an analysis of the LHC data that I performed during the exciting days preceding the Higgs discovery, I worked on several projects aimed at extracting the Higgs properties and interpreting the experimental results in the framework of beyond-the-SM theories. In the context of the SM effective field theory, I especially contributed to clarify the issue of the validity of the effective field theory approach. In a subsequent work I studied the helicity structure of scattering amplitudes, and found a novel set of helicity selection rules according to which, in the majority of $2 \rightarrow 2$ scattering processes at high energy, the SM and the leading BSM effects do not interfere.

Accidental Composite Dark Matter

My more recent research activity has been mostly focusing on Dark Matter (DM) and dark sectors. I am especially interested in theoretical scenarios where the DM candidate is stable on cosmological scales due to an accidental global symmetry. This has a close analog in the SM, where the proton is accidentally stable as a consequence of baryon number conservation. In this context, I have analyzed a new type of accidentally stable DM bound state, the gluequark, made of adjoint fermions and gluons from a new confining gauge force. I have also investigated a class of gauge theories with chiral representations where all scales are dynamical, including the DM mass, and the DM abundance is reproduced by the relic density of an accidentally stable pseudo Nambu-Goldstone boson. Extending the investigation of composite DM theories is one of the items in my research agenda for the near future.

Selected Publications

- [1] R. Contino, A. Mitridate, A. Podo, M. Redi, *Gluequark Dark Matter*, JHEP 1902 (2019) 187
- [2] A. Azatov, R. Contino, C. S. Machado, F. Riva, *Helicity Selection Rules and Non-Interference for BSM Amplitudes*, Phys. Rev. D 95 (2017) 065014
- [3] R. Contino, A. Falkowski, F. Goertz, C. Grojean, F. Riva, *On the Validity of the Effective Field Theory Approach to SM Precision Tests*, JHEP 1607 (2016) 144
- [4] A. Azatov, R. Contino, G. Panico, M. Son, *Effective field theory analysis of double Higgs boson production via gluon fusion*, Phys.Rev. D 92 (2015) no.3, 035001
- [5] A. Azatov, R. Contino and J. Galloway, *Model-Independent Bounds on a Light Higgs*, JHEP 1204 (2012) 127
- [6] R. Contino, C. Grojean, M. Moretti, F. Piccinini, and R. Rattazzi, *Strong Double Higgs Production at the LHC*, JHEP 1005 (2010) 089
- [7] R. Contino and G. Servant, *Discovering the top partners at the LHC using same-sign dilepton final states*, JHEP 06 (2008) 026
- [8] R. Contino, L. Da Rold and A. Pomarol, *Light custodians in natural composite Higgs models*, Phys. Rev. D 75 (2007) 055014
- [9] R. Contino, T. Kramer, M. Son and R. Sundrum, *Warped/Composite Phenomenology Simplified*, JHEP 0705 (2007) 074

- [10] K. Agashe, R. Contino, L. Da Rold and A. Pomarol, *A custodial symmetry for $Zb\bar{b}$* , Phys. Lett. B 641 (2006) 62
- [11] K. Agashe, R. Contino, *The Minimal Composite Higgs Model and Electroweak Precision Tests*, Nucl. Phys. B 742 (2006) 59
- [12] K. Agashe, R. Contino and R. Sundrum, *Top compositeness and precision unification*, Phys. Rev. Lett. 95 (2005) 171804
- [13] K. Agashe, R. Contino and A. Pomarol, *The minimal composite Higgs model*, Nucl. Phys. B 719 (2005) 165
- [14] R. Contino, Y. Nomura and A. Pomarol, *Higgs as a holographic pseudo-Goldstone boson*, Nucl. Phys. B 671 (2003) 148
- [15] R. Contino, L. Pilo, R. Rattazzi, E. Trincherini, *Running and matching from five-dimensions to four-dimensions*, Nucl. Phys. B 622 (2002) 227-239
- [16] R. Barbieri, R. Contino, P. Creminelli, R. Rattazzi, C.A. Scrucca, *Anomalies, Fayet-Iliopoulos terms and the consistency of orbifold field theories*, Phys. Rev. D 66 (2002) 024025

Roma, September 2021