LEONARDO DI GIUSTINO

PERSONAL DETAILS

- ✓ Birth place: Avezzano (AQ) (Abruzzo, Italy)
- ✓ Birth date: November 23rd, 1973.
- ✓ Nationality: Italian.
- ✓ Working Address:

Università di Parma, Dipartimento di Fisica,
Viale G.P. Usberti 7/A, 43100, Parma, Italy.

- ✓ Telephone :+39 339 6088484.
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- ✓ Driving License "B".
- ✓ Military Service, Accomplished in 2000.

EDUCATION

✓ 2007-2009 May 29th 2009 – High School **Professor Qualification** in Mathematics and Physics. SSIS Specialization Course of 2 years length: 2007-2009. University of Parma, Italy.

✓ March 7th,2005 – **Ph.D Degree in Physics.**

Ph.D Thesis Title:"**Ab inizio study of NiO-Fe interfaces: electron states and magnetic configurations**", Advisor Prof. Franca Manghi
University of Modena and Reggio Emilia, Italy.

✓ May 28th , 2001 **Laurea Degree in Physics (M.Sc.)** ,
Laurea Thesis in Theoretical Physics of Elementary Particles,
Title : "**Semileptonic Inclusive Decays of Heavy Flavors**",
University of Rome "La Sapienza", final mark 105/110.
Supervisor Prof. Guido Martinelli.

✓ July 1992 School Leaving Certificate in Scientific Studies , Statal Scientific Liceum , Avezzano (AQ), Abruzzo, Italy, final mark 56/60.

LANGUAGES

- ✓ Italian mother tongue
- ✓ English fluent (both written and oral),
- ✓ French (elementary level),

From 1986 till 1989 During the summer I have attended English courses at different english schools in Canterbury, Weymouth, Bournemouth and London.
Summer 1991 and 1992 ELS-English course at the Wagner College, Staten Island, New York, ACE level certificate.

AWARDS

2010-2011 SLAC Visiting Scientist, grant by the Foundation "Angelo Della Riccia" for research activity in: Regularization Procedures in the QCD. Duration: from January 14th to Aug 11th 2011. Reference: Prof. S. J. Brodsky.

2006-2007 1-year Postdoctoral Fellowship, for research activity in the field of the Phenomenology of the Strong –Interactions (QCD) at the Physics Department of Parma University, Italy.

WORKSHOPS/CONFERENCES/SCHOOLS AND LECTURES

- ✓ 12th – Dec 2012 Max Planck Institute for Physics, Theory Seminar.
- ✓ 28th- Nov 2012 Max Planck Institute for Physics, invited ATLAS talk.
- ✓ 21th - July 2011 **SLAC Experimental Seminars,** invited Talk on:"Setting the Renormalization Scale in QCD - The Principle of Maximum Conformality - PMC" , at SLAC - Stanford University, CA, USA.
- ✓ 27th-June 2011 **CP3-Origins Lecture**, invited Talk on:" Mass Effects and Scale Setting in QCD", at CP3-Origins, Odense, Denmark.
- ✓ 9th-to 13th May 2011 "**Origin of Mass 2011",** Conference**,** University of Southern Denmark in Odense, Denmark.
- ✓ 11th-March 2011 **SLAC Theoretical Physics Seminars** – held Lecture on: "Mass effects in Jet distributions" at SLAC - Stanford University, CA, USA.
- ✓ 5-7 July 2010, Third Workshop on **Theory, Phenomenology and Experiments in Heavy Flavour Physics** ,Capri, Italy.
- ✓ 11-13 April 2007, Talk Presentation at the "**IFAE 2007**" Conference, Centro Congressi dell' Ateneo Federico II , Naples, Italy.
- ✓ 13-14 February 2007: Talk Presentation at the "**IV Meeting on B Physics**", Science Academy, Bologna, Italy.
- ✓ 29 August-09 September 2005: **XIV National Seminar of Theoretical Physics,** topics :"Beyond the Standard Model: XDIM and String phenomenology/ Lattice QCD: confinement and QCD vacuum", Parma, Italy.
- ✓ April 2003 attended the school : "**Linux System Administrator**", at CICAIA, Modena, Italy.
- ✓ 15-18 March 2003: Workshop and Poster presentation at : "**Spin Mesoscopics**", University of Twente, Enschede , Holland.
- ✓ 23-26 April 2003: Workshop and Poster presentation at:"**L/APW+lo calculations with the WIEN2k code**", University of Technology, Wien, Austria.
- ✓ 23-25 June 2003: Conference and Poster presentation at the "**INFM Meeting"**, Magazzini del Cotone, Genova, Italy.
- ✓ 27 July–01 August 2003: Conference and Poster presentation at the ICM "**International Conference on Magnetism**", Palazzo dei Congressi, Rome, Italy.
- ✓ 17-21 June 2002: Workshop on: "**Correlation Effects in Electronic Structure Calculations**", at the Abdus Salam Center ICTP, Trieste, Italy.

WORK EXPERIENCE

- ✓ 2012 – Max Planck Institute for Physics – Visiting Scientist from Oct 23th 2012
- ✓ 2011-2012 Professor of Physics at the High School: Liceo Scientifico G.Marconi, Parma.
- ✓ 2010-2011 SLAC Visiting Scientist, from 14th Jan to 11th Aug 2011..
- ✓ 2010-2011 Professor of Physics at the High Technical School "ITSOS" of Parma.
- ✓ 2008-2009 Professor of Computer Science at High Technical School "ITIS Berenini" of Parma.
- ✓ 2007-2008 Professor of Electronics at High Technical School "IPSIA -P.LEVI" of Parma.
- ✓ 2006-2007 Researcher with Postdoc Position at the Physics Department of Parma University.
- ✓ 2003-2005, Lecturer of "Mechanichs and Thermodynamics", at the Faculty of Physics of the University of Modena and Reggio Emilia, Italy.

RELEVANT SKILLS

IT SKILLS

Operative Systems:	Windows , Linux , Unix , Mac OS.
Programming languages	C/C++, c-shell scripts, Fortran, Basic, Pascal, Visual Basic, HTML, LaTeX.
Software :	Mathematica, Office, Matlab and other Unix/Linux /Windows packages
Special Codes:	**Wien2k*** software package: http://www.wien2k.at/ **3BS*** code: www.s3.infm.it/3bs. Experience in serial and parallel calculation on IBM AIX SP5 and IBM Linux clusters in collaboration with CINECA – Bologna - Italy. Experience in Linux, Unix and Win servers administration.

SCIENTIFIC SKILLS

Theoretical Particle Physics

Experience in Quantum Field Theories of Basic Interactions Calculations (QED, QCD, Standard Model).

Experienced in the perturbative techniques (OPE, LEET, HQET, Parton model and Jet distributions) for theoretical calculations in the framework of the weak (inclusive/exclusive) decays .

Condensed Matter Physics

Experience in the field of the theoretical simulation from first principles (Density Functional Theory and Many-Body Theory, FLAPW Method) of the structural, electron and magnetic properties of highly correlated materials and of their Surface and Interface systems.

Topics dealt during my scientific career:

Theoretical Particle Physics

- ✓ Regularization Procedures in QCD.
- ✓ Introduction of the Minimal Prescription Formula to the mass corrected spectra of Beauty and Top decays ($b \to c\, l\, \nu_l$, $t \to b\, l\, \nu_l$).
- ✓ Introduction of mass effect corrections in Heavy Quark decay spectra.
- ✓ Threshold Resummation of the infrared logarithmic divergences in Jet distributions produced by a massive Quark.
- ✓ A brief feasibility study on the calculation of the 4th order coefficient of the beta function on the Lattice.
- ✓ Measurement of the Shape-Function from the inclusive semileptonic decays of heavy flavors ($b \to u\, l\, \nu_l$, $c \to s\, l\, \nu_l$).
- ✓ Evaluation of the theoretical error on the CKM matrix element Vub.

Condensed Matter Physics

- ✓ Ab initio study of Exchange Bias systems: ultra thin layers of Fe on NiO substrates, in the framework of the DFT Theory .
- ✓ Correlation effects on photoemission spectra of highly correlated materials: Ni, Fe in the interface systems Fe/NiO.
- ✓ Model Heisenberg Hamiltonians and extraction of the exchange integrals J1 and J2 in the NiO bulk e NiO [100] surface.

PUBLICATIONS

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1. Stanley J. Brodsky, L. Di Giustino,
Setting the Renormalization Scale in QCD: The Principle of Maximum Conformality,
*Phys. Rev. D **86,** 085026 (2012) : arXiv:1107.0338 [hep-ph]*

2. L. Di Giustino, G. Ricciardi, L. Trentadue,
Minimal prescription corrected spectra in heavy quark decays,
*Phys. Rev. D **84**, 034017 (2011) ; arXiv:1102.0331 [hep-ph]*

3. Stanley J. Brodsky, L. Di Giustino,
The Principle of Maximum Conformality,
Proceedings of the Workshop on "**Precision Measurements of α_S**", Munich, Germany, 9-11 Feb 2011, *SLAC-PUB-14425.*

4. L. Di Giustino, G. Ricciardi, L. Trentadue,
Resummed Massive Spectra in Heavy Quark Decays,
Proceeding of the: **Third Workshop on Theory, Phenomenology and Experiments in Heavy Flavour Physics ,** *Nucl. Phys. Proc. Suppl. 209:123-128,2010*.

5. U. Aglietti, L. Di Giustino, G. Ferrera and L. Trentadue,
Comment on Resummation of Mass Distribution for Jets Initiated by Massive Quarks,
Physics Letters B 670:367-368,2009;

6. L. Di Giustino,
Resummation and Mass Effects in b Decays,
*Proceedings Conference **IFAE 2007: Italian Meeting on High Energy Physics,*** p. 165-168, (2008)**,** *edited by Springer*.

7. U. Aglietti, L. Di Giustino, G. Ferrera, A. Renzaglia, G. Ricciardi and L. Trentadue,
Threshold Resummation in B ---> Xc l ν_l Decays,
Physics Letters B 653:38-52,2007.

8. U. Aglietti, L. Di Giustino, G. Ferrera and L. Trentadue,
Resummed Mass Distribution for Jets Initiated by Massive Quarks,
Physics Letters B 651: 275-292, 2007;

9. V. Bellini, L. Di Giustino and F. Manghi
Ab initio study of the NiO/Fe interface: Structural and magnetic properties,
Physical Review B 76, 214432 (2007);

10. P. Luches, V. Bellini, S. Colonna, L. Di Giustino, F. Manghi, S. Valeri, and F. Boscherini,
Iron Oxidation, Interfacial Expansion, and Buckling at the Fe/NiO(001) Interface,
Physical Review Letters 96, 106106 (2006);

11. P. Luches, V. Bellini, S. Colonna, L. Di Giustino, F. Manghi, S. Valeri and F. Boscherini,
Structure at the Fe/NiO(001) interface probed by polarization dependent XAFS,
ESRF Highlights 2006, Edited by G. Admans, ESRF, Grenoble (2007).

REFERENCES

Prof. Stanley J. Brodsky
Full Professor at SLAC, Stanford University, CA, USA
sjbth@slac.stanford.edu

Prof. Wolfgang Hollik
Director of the Theory Group,
Max-Planck-Institut für Physik, München, Germany.
hollik@mpp.mpg.de

Prof. Luca Trentadue,
Full Professor at Parma University, Italy.
luca.trentadue@cern.ch

Dr. Giulia Ricciardi ,
Researcher at Naples University, Italy.
giulia.ricciardi@na.infn.it

My main interests are in the field of:

- Phenomenology, Heavy Flavors;
- QCD: perturbative, non perturbative and Effective Theories;

and in the short term my prospects are to continue to work on the Standard Model Phenomenology, in particular in testing the QCD to high accuracy, but also topics related to the study of the Physics Beyond the Standard Model and connected to the LHC experiments.

My Scientific Experience in Physics covers different fields of Theoretical Physics: Theoretical Particle Physics and Condensed Matter Physics.

0.1 THEORETICAL PARTICLE PHYSICS

To date I worked in the Theoretical Particle Physics area during my M.Sc. Degree Thesis at Rome University "La Sapienza", as Post doc at Parma University , as Visiting Scientist at SLAC - Stanford CA ,USA and at the Max Planck Institute for Physics, Munich, Germany . In particular my research has focused on Quantum Field Theories of Basic Interactions (QED, QCD, and the Standard Model). I have studied the phenomenology of semileptonic inclusive weak decays using several computational techniques both analytic and numerical (such as perturbative/non perturbative techniques in QCD and Effective Theories - OPE, LEET, HQET, Lattice).
Briefly my research in this field has focused on the following topics:

- Regularization Procedures of the strong coupling in QCD [1],[3] ;
- Introduction of the Minimal Prescription Formula to the mass corrected spectra of Beauty and Top decays ($b \to c l \nu_l$, $t \to b l \nu_l$) [4][2];
- Resummation of the infrared logarithmic divergences in Jet distributions produced by a massive quark. [8][7] [6][5] ;
- Measurement of the shape-function(i.e. function which includes non perturbative dynamical effects at large distances) from the inclusive semileptonic decay of heavy flavors ($b \to u l \nu_l$,$c \to s l \nu_l$) ; Evaluation of the theoretical error on the CKM matrix element Vub [13].

1 Regularization Procedures in QCD

1.1 The renormalization scale in pQCD and the PMC

A key problem in making precise perturbative QCD predictions is the uncertainty in determining the renormalization scale μ of the running coupling $\alpha_s(\mu^2)$. The purpose of the running coupling in any gauge theory is to sum all terms involving the β function; in fact, when the renormalization scale is set properly, all non-conformal $\beta \neq 0$ terms in a perturbative expansion arising from renormalization are summed into the running coupling. The remaining terms in the perturbative series are then identical to that of a conformal theory. Several methods have been proposed so far but nevertheless without achieving the required results. In fact if, on one hand, the guess of the correct renormalization scale and its consequently variation over a range of a factor of two gives scheme-dependent results, leaves the non-convergent perturbative series and gives the wrong result when applied to QED processes; on the other hand the PMS method [3] violates the transitivity property of the renormalization group, depends on the choice of scheme, is wrong for QED, and as shown by Kramer and Lampe [4], leads to unphysical results. Then the need of a consistent method for setting the renormalization scale properly has motivated me and my colleagues, Stanley J. Brodsky and Xing-Gang Wu to develop a new method: the PMC - the Principle of Maximum Conformality [1][6][7][8]. This method provides a consistent procedure for setting the optimal renormalization scale in pQCD. It guarantees results to be free from renormalons and in agreement with QED scale-setting in the Abelian limit. The PMC is also the theoretical principle underlying the BLM [2] procedure, commensurate scale relations between observables, and the scale-setting method used in lattice gauge theory. Besides PMC scale determines also the number of active flavors n_f in the QCD β function correctly and is scheme independent, it observes the RG invariance, a key requirement of the renormalization scheme. The PMC renormalization scale is particularly useful for very complex processes; one only requires the dependence of the calculated subprocess amplitudes on the initial renormalization scale μ_0^2 and n_f, the number of quark flavors appearing from quark loops associated with renormalization.
PMC provides a consistent scheme independent method to fix the renormalization scale eliminating the scale ambiguity increasing the precision of QCD predictions. To date precision tests of the QCD are mandatory in order to increase the sensitivity of the SM to New Physics at the LHC collider.

1.2 Recent PMC applications

Recently PMC has been applied to several QCD processes giving rise to radical improvements:

- A consistent application of the BLM/PMC procedure to B-decays, including $B \to X_s + \gamma$, has been developed including resummation to all orders in the strong coupling constant. A review and extension of this procedure is given by Melnikov and Mitov [5]

- The PMC procedure has recently been extended to the four-loop level, [6] demonstrating that it provides a consistent, systematic and scheme-independent procedure for setting the renormalization scales up to NNLO.
  The explicit application for determining the renormalization scale of $R_{e^+e^-}(Q)$ up to four loops has also been presented [6].

- It has been shown that Principle of Maximum Conformality satisfies all of the consequences of

renormalization group invariance - reflectivity, symmetry, and transitivity [12].

- The PMC procedure has recently been applied to the $t\bar{t}$ hadroproduction cross section [7, 8]: and the $\bar{t}t$ asymmetry [9] major tests of the Standard Model at colliders [7, 8]. The PMC prediction for the total cross-section $\sigma_{t\bar{t}}$ agrees well with the present Tevatron and LHC data. The initial scale-independence of the PMC prediction is found to be satisfied to high accuracy at the NNLO level: the total cross-section remains almost unchanged even when taking very disparate initial scales. After PMC scale setting, the PQCD predictions are within $1\,\sigma$ of the CDF [10] and D0 measurements [11] since the relevant renormalization scale is less than conventional estimate; the large discrepancy of the top quark forward-backward asymmetry between the Standard Model prediction and the data is thus greatly reduced.

2 Research Proposal

My research proposal provides in the short term:

- **Implementation of the PMC in some QCD processes: Higgs production and W+jets.** The determination of the renormalization scale for the Higgs production and W+jets cross section is a mandatory request in order to eliminate the scheme ambiguity and increase the sensitivity of measurements at the LHC and Tevatron to new physics beyond the Standard Model.

  The cross section of the Higgs production is affected by a large error due to the renormalization scale ambiguity and the scale dependence is of the order of the 15%[13]. In the case of the W+jets cross section it has been shown that a wrong choice of the renormalization scale leads to unphysical predictions even at the NNLO: including the NNLO corrections the cross section becomes negative [14];
  and

- Determination of the PMC in γ + b/c jet production and c-quark mass corrections in DGLAP [17]. The D0 data at the Tevatron have recently shown a big excess beyond NNLO[15] ;

- **the development of a consistent method for the determination of the factorization scale in QCD and of its relation with the renormalization scale**.

  Determination of the factorization scale and of its relation with the renormalization scale. It is a common conjecture in QCD to fix the renormalization equal to the factorization scale, this has no physical reason and it gives also wrong predictions. The factorization scale, in contrast, is the scale entering the structure and fragmentation functions. Unlike the renormalization scale, a factorization scale ambiguity occurs even in a conformal theory. The factorization scale should be chosen to match the nonperturbative bound state dynamics with the perturbative DGLAP evolution. This could be done explicitly using nonperturbative models such as AdS/QCD and light-front holography where the light-front wavefunctions of the hadrons are known [16].

2.1 B physics

- I am also active in resummation of large logs in jet distributions including mass correction effects in collaboration with Prof. Luca Trentadue at Parma University [17][18][20]. The aim

of this work is to compare with experiments, for instance with $B \to X_c l \nu_l$ decay at the highest accuracy, including resummation with mass effects corrections i.e. mass corrections resulting from a jet initiated by a massive quark and analyzing a regularization prescription for the strong coupling eliminating or at least reducing the sources of uncertainty. The uncertainties can be reduced using recent developed techniques: resummation of large infrared logarithms in form factors and shape variables is essential in order to predict accurate cross sections in many phenomenologically relevant processes; recent developments in eliminating the renormalization scale ambiguity has also been achieved by means of the PMC/BLM method; the possible use of different regularization prescriptions (MP formula, effective couplings) for the running coupling could be also included and discussed.

3 CONDENSED MATTER PHYSICS

During my PhD course at Modena University I studied the Many-Body Theory, the Density Functional Theory in relation with Spin-Based Nano-Technologies. In particular I have studied structural, electron and magnetic properties of highly correlated materials and their Surface and Interface systems using the approach based on theoretical simulation from first principles (Density Functional Theory and Many-Body Theory, FLAPW Method as implemented in the Wien2k* code). I have worked in collaboration with CINECA (Bologna) for serial and parallel calculations on IBM AIX SP5 and IBM Linux clusters.
Main products of this research are:

- Ab initio study of Exchange Bias systems (Surface and Interface Systems): ultra thin layers of Fe on NiO substrates[24, 23, 25, 22];

- Correlation effects in photoemission spectra of highly correlated materials: Ni, Fe in the interface systems Fe/NiO [23, 22];

- Model Heisenberg Hamiltonians and extraction of the exchange integrals J1 and J2 in the NiO bulk and NiO [100] surface [22]

References

[1] Stanley J. Brodsky, L. Di Giustino, Phys. Rev. D **86**, 085026 (2012).

[2] S. J. Brodsky, G. P. Lepage and P. B. Mackenzie, Phys. Rev. D **28**, 228 (1983).

[3] P. M. Stevenson, Phys. Rev. D **23**, 2916 (1981).

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[11] V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. D **84**, 112005 (2011) [arXiv:1107.4995 [hep-ex]].

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[21] M.Sc. L.D.G. Degree Thesis. Title: Semileptonic Inclusive Decays of Heavy Flavors.

[22] L.D.G. Ph.D Thesis. Title : Ab inizio study of NiO-Fe interfaces: electron states and magnetic configurations, Advisor Prof. Franca Manghi.

[23] V. Bellini, L. Di Giustino and F. Manghi, Ab initio study of the NiO/Fe interface: Structural and magnetic properties, Physical Review B 76, 214432 (2007);

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