Giovanni Ridolfi

Full professor

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Education and training

1989
PhD in Physics
Phenomenological aspects of supergravity theories
University of Genova - Geniva - IT

1983
Master degree in Physics
KL-KS mass difference and the quark model - 110/110 cum laude
University of Genova - Genova - IT

Academic experience

2005 - ONGOING
Full professor
University of Genova - Genova - IT
Teaching and research

2002 - 2005
Director of research
Istituto Nazionale di Fisica Nucleare - Genova - IT
Research

1996 - 2002
Second-level researcher
Istituto Nazionale di Fisica Nucleare - Genova - IT
Research

1990 - 1996
Researcher
Istituto Nazionale di Fisica Nicleare - Genova - IT
Research

Language skills

English
Proficient
Certificate of Proficiency in

French
Independent

English -
University of
Cambridge

Teaching activity

2004/2005 Elementary Particle Physics (relativistic processes; standard model at tree level); master, physics

2005/2006 Elementary Particle Physics; master, physics
Classical Mechanics; undergraduate, electrical engineering

2006/2007 Elementary Particle Physics; master, physics
Classical Mechanics; undergraduate, electrical engineering

2007/2008 Elementary Particle Physics; master, physics
Classical Mechanics; undergraduate, electrical engineering

2008/2009 Elementary Particle Physics; master, physics
Classical Mechanics; undergraduate, electrical engineering

2009/2010 Elementary Particle Physics; master, physics
Classical Mechanics; undergraduate, electrical engineering
Classical Electromagnetism; undergraduate, naval engineering

2010/2011 Elementary Particle Physics; master, physics
Quantum mechanics; undergraduate, physics

2011/2012 Elementary Particle Physics (relativistic processes; standard model at tree level); master, physics
Quantum mechanics; undergraduate, physics

2012/2013 Elementary Particle Physics (relativistic processes; standard model at tree level); master, physics
Quantum mechanics; undergraduate, physics

2013/2014 Elementary Particle Physics (relativistic processes; standard model at tree level); master, physics
Quantum mechanics; undergraduate, physics

2014/2015 Elementary Particle Physics (relativistic processes; standard model at tree level); master, physics
Quantum mechanics; undergraduate, physics

2015/2016 Quantum mechanics; undergraduate, physics
Classical mechanics and thermodynamics; undergraduate, maths

2016/2017 Elementary Particle Physics (relativistic processes; standard model at tree level); master, physics
Quantum mechanics; undergraduate, physics
Classical Electromagnetism and Optics; undergraduate, maths

2017/2018 Quantum mechanics; undergraduate, physics
Classical Electromagnetism and Optics; undergraduate, maths

From 1990 to 2005 I have been an employee of Istituto Nazionale di Fisica Nucleare (INFN), a position which does not involve compulsory teaching activities. During this period I have however carried on several teaching duties. Between 1992 and 2000 I have organized, together with Paolo Nason in Milan, a two-week intensive course on the standard model and QCD for PhD students of Universita di Milano and Universita di Genova, held by Nason and myself. and opened to students of other institutions. This course included intensive exercise sessions.

I was invited several times as a teacher at the Parma School of Theoretical physics, and at the CERN Academic
Training program. In both cases, I held courses in Standard Model of Electroweak interactions ans Supersymmetric theories. In 2001 I was a discussion leader at the CERN-JINR School in Caramulo (Portugal).
From 2004 to 2014 I have held a course in Elementary Particle Physics for undergraduate students at Universita' di Genova (relativistic scattering, standard model at tree level).
In 2016 I have given a series of lectures on Flavor Physics and Neutrino Physics to PhD students at University of Cambridge, UK.
II regularly teach different aspects of theoretical physics to PhD students.

Research interests

I have always been interested in the theory and phenomenology of fundamental interactions. Within this wide field of interest, I have mainly focussed on three subjects: the phenomenology of supersymmetric models, the calculation of perturbative corrections to observables in Quantum Chromodynamics, and all-order resummation of perturbative expansions. I have studied these subjects roughly in chronological order, with some overlap. In the following, I will provide a description of the main results I have obtained in each of these fields. In parallel, I have considered a few issues not directly related to any of these main lines; I will briefly describe some of these as well.
The first part of my research activity, roughly between 1986 and 1991, was mainly devoted to investigating the possibility of observing signals of a supersymmetric nature of fundamental interactions in high-energy experiments (LEP, SLC and Tevatron were starting their operation in that period). My earlier work was centered on the calculation of production cross sections for supersymmetric fermions and Higgs bosons in electron-positron collision, with the purpose of constraining the parameter space of simple supersymmetric extensions of the standard model. The best known result I have obtained in this context is the study of radiative electroweak symmetry breaking in supersymmetric models, and the related study of the Higgs spectrum including the dominant radiative effects. I have also studied rare B decays in the context of
supersymmetric models with radiative symmetry breaking.
In the following years I started being interested in strong interactions, mainly motivated by Tevatron results and by the earlier discussions on the LHC (and SSC, then cancelled) projects. The challenge in this field is obtaining reliable theoretical predictions for the cross sections for processes of interest; this is not straightforward, due to the confining nature of strong interaction dynamics, and to the poor convergence properties of the perturbative expansion. My first result in this field, the calculation of first-order perturbative corrections for the production of vector boson pairs in hadron collisions, is worth mentioning, both because of its intrinsic interest, and because it contains interesting ideas on the subtraction method of infrared singulatities in hadron physics. The same techniques were later applied to other processes, such as the

hadroproduction of heavy quark pairs in various experimental configurations. The discovery of the top quark in 1995 at the Tevatron has benefited from these studies. It is worth mentioning that an efficient implementation
of the subtraction method is also useful in the construction of Monte Carlo codes beyond leading order.
In the context of quantum chromodynamics, I have studied at lenghth the spin structure of the nucleon in the context of the parton model beyond leading order. My research activity in this field started arond 1995, and has produced a few remarkable result, such as the determination of the strong coupling and the related uncertainty from polarized deep-inelastic scattering. My interest in spin-dependent parton distribution functions has recently been revived in the context of neural network fits to
parton distribution functions.
More recently, I became interested in the QCD perturbative expansions at all order, a subject (usually referred to as resummations for brevity) which has many different aspects. It is interesting both for phenomenology and from
the conceptual point of view. My first contribution in the field was a study of the relationship between threshold resummation and the renormalization group. That work produced no new results, but it helped considerably in understanding how the resummation technique of threshold logarithms can be extended to non-abelian gauge theories.
Next, I have studied the role of the Landau pole of the QCD coupling in the behaviour of the resummed perturbative expansion, and I have
explored the phenomenological importance of all-order contributions.
Combining threshold resummation and high-energy resummation, it was possible to develop a technique for the approximate calculation of high-order perturbative corrections, which was recently applied to
Higgs hadroproduction and heavy quark priduction. Resummation issues were also useful to understand some specific features of Higgs production cross section at the LHC.
There are a few more contributions in my research activity I would like to mention. The first is a study of the
role of renormalons in the measurement of the strong coupling from tau decays; the second is the calculation of the
lower bound on the Standard Model Higgs boson mass from vacuum metastability. This last subject is still of interest, because of its relationshiop with cosmology, and I am currently working on it in the context of general relativity.

Grants

2013 - 2016

Symmetries masses and mysteries

Ministery of Education University and Scientific Research - IT
161000 euro - Participant
The project is mainly focussed on calculations of cross sections for

Standard Model processes, with special reference to hadron colliders. This interest is motivated by the current operation of the LHC at CERN. All the participants have been involved in this sector for many years, and have given important contributions to the field. Precise theoretical predictions are needed in the analysis process of high-energy collider data, in order to improve the capability of distinguishing rare non-standard physics phenomena from Standard Model background. The group has considerable experience in the calculation of fixed higher-order corrections to strong interaction processes, in the context of Quantum Chromodynamics. The group has also a longstanding tradition in resummation of the perturbative expansion in particular kinematics configurations. Resummation techniques are available both for the computation of production cross sections of heavy systems in the threshold region, and in the regime of extremely high energies. Precision calculations of production cross sections of heavy systems are especially important in view of the search for the Higgs boson. Studies in both the threshold and the high-energy sectors are in the plans of the group; the possibility of performing joint resummations is also under investigation. Related research activities are the study of the role of parton distribution functions (PDF) of heavy quarks, and the study of PDF in processes with polarized beams, aimed at the clarification of the spin structure of hadrons. Fixed-order and all-order resummation of strong interaction effects are performed also with computer codes that implement the simulation of complex, short-distance collisions of high-energy hadrons. One researcher in the group has been among the originators of one such generator, today widely used by the LHC experimental collaborations. Furthermore, the two most popular methods to improve the shower generators with the inclusion of higher-order strong interaction corrections have been developed by our group, and are now being adopted widely for the simulation of signal and background processes at the LHC. Ongoing work on these generators aim at the inclusion of more complex processes that are of interest for the LHC physics, at the automation of the calculation of these processes, at the extension for the inclusion of weak-interactions higher-order corrections, and at the improvement of the methods in several other directions.

2010 - 2012

Particle physics in the LHC time theoretical models precision calculations and simulation methods.

Ministery of Education University and Scientific Research - IT

58000 euro - Participant

The Milano 1-Genova team will concentrate on the following topics:

1) Partonic Distributions.

The main development line in this field is the construction of a set of partonic densities out of the neuronal-network method NNPDF1.0, from the analysis of all available experimental data.

2) Second order electroweak corrections.

We plan to complete the order alpha-alphas corrections to the inclusive single-boson production in parton-parton scattering.

3) Small-x resummation.
We shall first determine the impact of the resummation in on the parton densities, by working out the corresponding K-factors of the evolved PDFs. We shall then provide resummed expressions for specific hadronic processes, based on the general theory for Drell-Yan processes and Higgs production, and extending it to other processes, like direct photon production.
4) Sudakov resummation.
The so-called Borel prescription for Sudakov resummation of inclusive cross-sections and rapidity- and transverse-momentum-
distributions will be implemented by efficient numerical methods, in view of phenomenological applications.
5) Combined resummation.
Combining small-x and large-x resummation has interesting consequences for LHC phenomenology. The combined resummation will be studied for some LHC processes, like heavy-quark and Higgs boson production.
6) Event generators.
We shall study the combined strong-electroweak corrections in event generators, in particular by including the NLO gluon emission according to the procedure POWHEG [20] in the event generator HORACE. The techniques just mentioned will be applied to the most interesting LHC processes, like Drell-Yan ones, heavy quark production, Higgs production in gluon fusion, direct photon production, triple gauge boson production.
Finally, even if our program is mostly devoted to LHC physics, we intend to pursue further research lines, like polarized structure functions (collaboration MI1 Forte, GE Ridolfi, RM3 Altarelli), high-energy neutrino scattering and physics at future e-p accelerators (e.g. LHeC).

2007 - 2009

Field theory techniques and numerical tools for applications in high-energy physics

Ministery of Education University and Scientific Research - IT
40000 euro - Participant
The purpose of our research project is the development of analytical and numerical techniques suited for the interpretation of experimental data in high energy physics which are going to be available in the next future, and for their comparison with known field theories and their extensions. Special attention will be devoted to experimental observations from the LHC at CERN, and the last data taking periods of the Tevatron and the B factories. The main goal of LHC experiments is the clarification of the mechanism of spontaneous breaking of the electroweak gauge symmetry and the possible discovery of new phenomena. Such investigations require the extraction of weak signals from a large background of standard phenomena. For this reason an accurate theoretical understanding of strong interaction phenomena at high energies is required. In many cases, ordinary fixed order perturbation theory is not an appropriate tool, and more refined techniques are required, such as renormalization group and all-order resummations of the perturbative expansions. In the contex of the analysis

of data from high-energy hadronic accelerators, a central role is played by simulation computer codes which reproduce by numerical methods the experimental situation, taking both physical processes and detector features into account. The construction of Monte Carlo codes that exploit state-of-the-art theoretical calculation poses severe problems, both from the conceptual and numerical points of view. Different approaches to this problem have appeared in the literature in recent years. In the future, before and after the first LHC runs, data taking and data analysis at the B-factories will continue. These machines are designed to produced B mesons at a large rate, with the purpose of investigating in detail the sector of interactions among different quark generations. This class of phenomena is usually referred to as flavour physics, and although correctly described by the standard model of electroweak interactions, the mechanism of generation mixing is still mysterious. B-factory data allow an accurate determination of some of the fundamental standard model parameters, and possibly show deviation from standard model predictions. Also in this case, the accuracy of theoretical predictions must be pushed to the highest possible level. It is necessary to employ, in addition to ordinary perturbation theory, the tool of effective field theories, that exploit the large value of the b quark mass.