Cover letter

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Centro de Fisica Teorica de Particulas
Universidade Tecnica de Lisboa
Av. Rovisco Pais, 1
1049-001 Lisboa, PORTUGAL

Dear Prof. Gustavo C. Branco,

I am writing to inquire about availability of postdoctoral positions at your institution. I learn about your position from SPIRES web site “http://www.slac.stanford.edu”. I am currently a Ph.D student at LAPTh (Laboratoire d'Annecy-le-Vieux de Physique Théorique), Annecy (France) and attached to the University of Grenoble (France). I expect to receive my doctorate in July or September 2013.

My thesis work is in the stream of the Golem project ("General One-Loop Evaluator for Matrix element") which is a tool which allows a numerical stable evaluation of multi-leg one-loop amplitudes for QCD, SM and BSM processes.

My research interests include:

- One-loop multi-leg amplitudes calculations in gauge theories
- Precision calculations in QCD, SM and BSM for the LHC
- Beyond next-to-leading order calculations.

Included with this letter my Curriculum Vitae, my research statement and a publication list.

Thank you very kindly for your consideration. I look forward to hearing from you.

Sincerely yours,

Mohamed Sadek ZIDI

First name: Mohamed Sadek
Last name: ZIDI
Date of birth: Janvier 1, 1984
Place of birth: Biskra, Algeria
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Research interest:

- Precision calculations in QCD for the LHC
- Construction of fully automated programs to calculate cross sections for QCD, SM and BSM processes at NLO order
- One-loop multi-leg calculations involving different mass scales in highly automated way
- Large Hadron Collider Phenomenology
- Study of singularities and divergences in gauge theories
- Beyond next-to-leading order calculations

Education:

2003-2007 **High Education Diploma, DES,** in Theoretical Physics

- L1, L2 and L3, Physics	**Rank:** First (1/19)	Biskra University, Algeria
- Fourth year, Theoretical Physics	**Rank:** First (1/9)	Jijel University, Algeria

2007-2010 **Magister Study** in Theoretical Physics, Jijel University, Algeria
Supervisor: Dr. Belghobsi Zouina, University of Jijel
Co-supervisor: Dr. Jean-Philippe Guillet, LAPTh, Annecy, France
Magister Thesis On: Structure of infrared divergences in gauge theories
Thesis Keywords: QED, QCD, NLO, infrared divergences and Landau singularities
Rank: First (1/8)

2010-present **Doctoral Study** in Theoretical Particle Physics
University: Grenoble University, France
Laboratory: LAPTh, Laboratoire d'Annecy-le-Vieux de Physique Théorique, Annecy, France
Thesis supervisor: Dr. Jean-Philippe Guillet, LAPTh, Annecy, France
Expected date of defence: July or September 2013
Thesis Subject: One-loop multi-leg calculations in Gauge theories: Basis integrals calculation for Golem library
Thesis Keywords: NLO, Multi-leg, Reduction methods, Landau singularities, gauge theories, QCD, LHC, Golem, POWHEG, Diphox and Parton Shower

Work experience and Training:

March-May 2009 **Magister Training at LAPTh** (Laboratoire d'Annecy le Vieux de Physique Théorique), Annecy, France.
Supervisor: Dr. Jean-Philippe Guillet, LAPTh Annecy, France.
Project title: Structure of infrared divergences in gauge theories.

June-August 2009 — **CERN Summer School Program**, Geneva, Switzerland.
Supervisor: Florian Hirsh, Dortmund University, Germany.
Project title Identification of "$t\bar{t}$" events with boosted decision trees in ATLAS.

February-March 2010 — **Magister Training at LAPTh** (Laboratoire d'Annecy le Vieux de Physique Théorique), Annecy, France.
Supervisor: Dr. Jean-Philippe Guillet, LAPTh Annecy, France.
Project title: Structure of infrared divergences in gauge theories.

June-August 2010 — **DESY Summer School**, Hambourg, Germany.
Supervisor: Dr. Guenter Grindhammer, D. Britzger. H1 Group, MPI Munich.
Project title: Extraction of α_s using data from H1.

Schools:

September 2009 — **Jijel school**, Jijel , Algeria
School title: Gravitation, Theory and Experiment.

October 2011 — **LPPP11 School**, Freiburg, Germany
School title: LHC Precision Predictions for Pedestrians

November 2011 — **JRJC meeting**: Journées de Rencontres de Jeunes Chercheurs, Annecy, France

September 2012 — **Parma school**, Parma, Italy
School title: Scattering Amplitudes in QCD, Supersymmetric Gauge Theories and Supergravity.

Teaching:

2010-present
- **Optics:** Practical works for L1 students, University of Savoie, Chambéry campus, France
- **Wave optics:** Tutorials for L3 students, University of Savoie, Chambéry campus, France
- **Electromagnetism:** Tutorials for L2 students, University of Savoie, Annecy campus, France
- **Classical mechanics:** Tutorials for L1 students, University of Savoie, Annecy campus, France

Seminars

- LAPTh student seminar: October 6, 2001 "Precision calculations in QCD for the LHC"
- JRJC talk: December 9, 2011 "Loop calculations in gauge theories"
- LAPTh student seminar : October 24, 2012 "Loop calculations in gauge theories
- RPP-2013: January 16-18, 2013: One-loop multi-leg calculations in gage theories: Golem library

Miscellaneous:

Languages — Arabic: Mother language; French and English

Computer skills: — Unix, Mac OS X, Windows
Mathematica, Maple, Form, Fortran77, Fortran95, Root and C^{++}

Statement of Research Interests

One-loop multi-leg calculations in gauge theories: Basis integrals calculation for Golem library "golem95"

Mohamed Sadek ZIDI
LAPTh, Annecy, France

The NLO calculations have many difficulties, especially for processes including multi-particle production, such as:

- Large number of Feynman diagrams due to many final state particles, even worse if the higher order are taken into account.
- Huge amount of terms in the outputs.
- Complicated structure of singularities: "in real and virtual corrections".
- Numerically unstable evaluation of the result when integrating over the multi-dimensional phase space.

To deal with these difficulties, we need: **a)** to construct a fully automated program to calculate the cross section at NLO order; **b)** to construct a library of one-loop integrals, finite as well as divergent ones, which can be used by anybody using a method which requires scalar master integrals. This last point is the main motivation of my Ph.D work.

My thesis work is in the stream of the Golem project ("General One-Loop Evaluator for Matrix element"). The Golem project contains a generator of Feynman diagrams, it uses a method for evaluating Feynman diagrams (T. Binoth et al, JHEP 0510 (2005) 015) and it contains a library "golem95" to compute one-loop integrals which aims to provide a stable and automatized numerical calculation of one-loop scattering amplitudes up to six external legs valid for QCD, SM and BSM processes.
In general, the reduction of higher rank three and four point functions to expressions containing only scalar integrals leads to some powers of inverse of the Gram determinants appearing in the coefficients of those scalar integrals. These determinants can become arbitrary small in some phase space regions which hamper the numerical stability.

The Golem method for the evaluation of Feynman diagrams uses the algebraic reduction of tensorial integrals based on the form factor approach. In this method, every amplitudes is expressed with a set of basic one-loop integrals, this set is not a basis in the mathematical sense but it is the end points of the reduction. The coefficients in front these basic integrals contain no power of the inverse of the Gram determinants. Such terms appear when the set of basic integrals is expressed in term of scalar integrals. My work focus on the Golem one-loop library "golem95" which is a library written in Fortran 95 which enables to compute numerically all the form factor up to six external legs. The Feynman diagram approach is not very efficient when the number of external legs is greater than five. More efficient approaches have been developed these last years such as generalized unitarity methods. Whatever the method used, the end point is the evaluation of scalar one-loop integrals weighted by some coefficients, so our library can be used for that. There are automated one-loop calculation programs using generalized unitarity methods on the market. Each program has a rescue system which enables to recompute in another way some phase space points which have been marked as "bad" (because of a loss of precision). The rescue system of the Gosam program which belongs to the list of automated loop calculation programs, relies on the ability of the Golem method to avoid the power of the inverse of the Gram determinants. Despite the fact that the initial Golem project has been left, the numerical one-loop library is still topical. The previous versions of golem95 treat only the non massive cases i.e. non massive particles in the loop. The purpose of my work is to generalize this library to loops containing massive (real or complex) virtual particles up to six external legs.

The set of basic integrals are: the 4-point functions in 6 dimensions I_4^6 with up to three Feynman parameters in the numerator (which are IR and UV finite), the 4-point function in $n+4$ dimensions with up to one Feynman parameter (which is UV divergent), the 3-point functions in n dimensions I_3^n with up to three Feynman parameters (which could be IR divergent), the 3-point functions in $n+2$ dimension with up to one Feynman parameter (which can be UV divergent) and various 2-point functions. With this choice of set, most of the integrals are in more then 4 dimensions, thus providing us with a very convenient separation of IR/UV divergences, as the IR poles are exclusively contained in the triangle functions. As I mentioned before, further reduction of these integrals to scalar basis integrals introduce the inverse of Gram determinants. A particular feature of golem95 is the fact that the tensorial integrals are not reduced to scalar basis integrals in cases where Gram determinant becomes small. In these cases, the tensorial integrals are evaluated numerically using a one dimensional integral representation. In cases where the Gram determinant is large, we reduce to the scalar basis and we use the analytical formula of these integrals which provides a fast evaluation.

The use of the analytical and the one-dimensional representation formula guaranties a fast and stable evaluation of these integrals. To find these representations, we must start from the definition of these integrals and integrate analytically over one/two variables (respectively for 3-point and 4-point integrals) and verify these two conditions: **a)** avoid the appearance of the inverse of Gram determinant in the first integrations, **b)** be able to continue analytically the one dimensional representation to cases including complex masses. Actually this was the hardest part of my work.

Briefly, we succeed to get the analytical formulas and the one-dimensional integral representations for the basic integrals: for all the set of 3-point integrals and for the scalar 4-point functions (I_4^6, I_4^8). The 3-point case has been implemented in golem95. I mention that these formulas work very well for cases with complex masses and for phase space regions where the Gram determinant is small. The results of golem95 have been compared with results of other one-loop libraries, it shows a very good agreement. To complete our library, it remains to implement the tensorial 4-point integrals (with Feynman parameters in the numerator). Formulas are under-construction for this case. A paper on the one dimensional integral representations is in preparation.
In the near future, I am going to complete the implementation of the remaining basis integrals in golem95 and apply it to study processes including vector-like quark production.

Also, I studied the production of pairs of isolated photons at the LHC. This work was about interfacing DiPhox, which is a program calculates the cross section of isolated photons at NLO order, with Parton Shower in POWHEG framework using Frixione-Kunzt-Signer (FKS) subtraction method for infrared and collinear singularities.

In general, my research interests include:

- Precision calculations in QCD, SM and BSM for the LHC
- One-loop multi-legs amplitudes calculations
- Construction a fully automated program calculating the cross sections for QCD, SM and BSM process at NLO order
- Beyond next-to-leading order calculations
- and Large Hadron Collider phenomenology

List of Publications:

Reports:

- CERN summer school report: Identification of “t tbar” events with boosted decision trees in ATLAS, September 2009.
- LAPTh training report: Structure of infrared divergences in gauge theories, June 2010 (not published).
- Desy summer school report: Extraction of “alpha_s” using data from H1 http://www.desy.de/f/students/2010/reports/zidi.pdf , September 2010.
- First year Ph.D report, LAPTh, October 2011 (not published)
- JRJC report : Loop calculations in gauge theories, December 2011, to appear in Proceedings JRJC 2011.
- Second year Ph.D report, LAPTh, October 2011 (not published).

Presentations and talks:

- LAPTh student seminar: October 6, 2001 “Precision calculations in QCD for the LHC” https://indico.in2p3.fr/getFile.py/access?resId=2&materialId=slides&confId=5902

- JRJC talk: December 9, 2011 “Loop calculations in gauge theories” https://indico.in2p3.fr/contributionDisplay.py?contribId=42&sessionId=7&confId=5729
- LAPTh student seminar : October 24, 2012 “Loop calculations in gauge theories“https://indico.in2p3.fr/conferenceDisplay.py?confId=7362
- RPP-2013 : One-loop multi-leg calculations in gauge theories : Golem library, January 2013 https://lpsc.in2p3.fr/Indico/contributionDisplay.py?sessionId=7&contribId=66&confId=770

Preprint:

- Basis integrals calculations for Golem Library, in progress.