

**Final Report for Period:** 06/2008 - 05/2009

**Submitted on:** 07/10/2009

**Principal Investigator:** Garoufalidis, Stavros .

**Award ID:** 0505445

**Organization:** GA Tech Res Corp - GIT

**Submitted By:**

Garoufalidis, Stavros - Principal Investigator

**Title:**

The Geometry and Topology of the Jones Polynomial

### Project Participants

#### Senior Personnel

**Name:** Garoufalidis, Stavros

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

**Name:** Le, Thang T. Q.

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

#### Post-doc

#### Graduate Student

#### Undergraduate Student

#### Technician, Programmer

#### Other Participant

#### Research Experience for Undergraduates

### Organizational Partners

### Other Collaborators or Contacts

### Activities and Findings

#### Research and Education Activities:

During the 2005-08, the PI and co-PI published a plethora of papers, and were invited in numerous international conferences, invited colloquia and seminar talks. In addition, the investigators organized an 'International Conference in Quantum Topology' in Hanoi Vietnam in August 2007, partially funded by NSF, and well-attended by graduate students, and followed by refereed conference proceedings that appeared in the January 2009 volume of Acta Mathematica Vietnamica. In addition, T.L. was a grader for the International Mathematical Olympiad held in Hanoi in July 2007.

Here is a list of activities for Stavros Garoufalidis.

Scholarly Visiting Positions:

IHES, France October 07  
 Universite Orsay, France October-November 06  
 Universite Paris VII, France June-July 05

Invited Conference Lectures:

8th Panhellenic Conference in Algebra, Athens, Greece  
 plenary talk May 08  
 Journées ANR sur la Conjecture du Volume, Strasbourg, France  
 (2 talks) September 07  
 International Conference on Quantum Topology, Hanoi, Vietnam  
 August 07  
 CTQM Workshop, Aarhus University, Denmark (2 talks)  
 June 07  
 Around the Volume Conjecture, Luisiana State University  
 May 07  
 Barrett Lectures, University of Tennessee, Knoxville  
 April 06  
 International Conference on the Volume Conjecture,  
 Columbia University, New York (2 talks)  
 March 06  
 Workshop on the Volume Conjecture, Columbia University, New York  
 September 05  
 Workshop on Classical and Quantum Gravity in 3-dimensions,  
 Pisa, Italy September 05  
 Oberwolfach Topology Conference, Germany  
 June 05  
 Quantum Topology Conference, Snowbird, Utah (2 lectures)  
 June 05

Invited Colloquia and Seminar Lectures:

Columbia University, New York,  
 Geometry-Topology Seminar  
 May 08  
 Northwestern University, Chicago,  
 Mathematical Physics and Geometry Seminar  
 May 08  
 University of Pennsylvania, Philadelphia,  
 Probability Seminar  
 May 08  
 Universite Geneve, Switzerland, Geometry Seminar  
 March 08  
 Gatech, Analysis Seminar  
 February 08  
 Gatech, Geometry-Topology Seminar  
 February 08  
 Gatech, Gombinatorics-Algebra seminar  
 September 07  
 Gatech, Geometry-Topology seminar  
 September 07  
 Rutgers, Experimental Mathematics Seminar  
 March 07  
 University of Chicago, Algebraic Geometry Seminar  
 March 07  
 University of Miami, Algebraic Geometry Seminar  
 February 07

Georgia Institute of Technology, Research Horizons Seminar  
February 07

University of Pennsylvania, Philadelphia, Geometry Seminar  
January 07

University of Maryland, Geometry and Math. Physics Seminar,  
Washington DC December 06

Georgia Institute of Technology, Topology Seminar, Atlanta  
November 06

Georgia Institute of Technology, Algebra Seminar, Atlanta  
November 06

Universite Orsay, Harmonic analysis seminar, France (two talks)  
November 06

Universite Paris VII, Topology seminar, Paris  
November 06

Columbia University, Geometry Seminar, New York  
September 06

CUNY, Einstein Chair Seminar, New York  
September 06

Columbia University, Topology seminar, New York  
September 06

Georgia Institute of Technology, Analysis Seminar, Atlanta  
September 06

Ohio State University, Analysis seminar, Columbus, Ohio  
August 06

Universite Geneve, Switzerland, Topology Seminar  
June 06

University of Athens, Athens, Greece, Colloquium May 06

Ohio State University, Topology Seminar, Columbus  
May 06

Georgia Institute of Technology, Analysis Seminar, Atlanta  
April 06

University of Aarhus, Denmark, Geometry Seminar March 06

Georgia Institute of Technology, Geometry/Topology Seminar, Atlanta  
March 06

Universite Grenoble, France  
July 05

Universite Paris VII, France (4 lectures)  
June-July 05

Here is a list of activities for Thang Le.

#### Scholarly Visiting Positions:

1 month visiting professorship,  
Hanoi Institute of Mathematics and Hochiminh National  
university, July 2007

1 month visiting professorship, Universite Grenoble, June 2006

1 month visiting professorship, University of Geneva, June 2005

#### Invited Conference Lectures-Invited Colloquia and Seminar Lectures:

2009

June 2009, Interactions Between Hyperbolic Geometry, Quantum Topology  
and Number Theory, Columbia university. Workshop: 3 lectures, conference, 1 talk.

May 2009, ICTP Conference on Knot Theory, Trieste, Italy. Plenary  
Speaker.

March 2009, 'Low dimensional topology and number theory' Fukuoka, Japan.

2008

November 2008, GaTech, Topology seminar.  
 October 2008, Univ of Aarhus, Denmark, Math physics seminar.  
 April 2008, Univ Of Utah, Colloquium talk.  
 March 2008, Buffalo Geometry and Topology Conference, invited speaker.

2007

November 2007, ETH Zurich, Math Physics seminar.  
 October 2007, Banff workshop Low-dimensional Topology and number Theory. 1-hour talk.  
 October 2007, Topology seminar, Gatech\*.\*  
 June 2007, Arhus, Workshop 'Geometry and TQFT'  
[www.ctqm.au.dk/June2007/](http://www.ctqm.au.dk/June2007/)  
 June 2007, Hochiminh city univerisity  
 May 2007, Columbus, OSU, Topology seminar (again!)  
 February 2007, Columbus, OSU, Topology seminar

2006

October 2006, The quantum MacMahon Master theorem/, Colloquium, Tulane Uni.  
 October 2006, On a determinant formula for the colored Jones polynomial, Topology Seminar, Columbia Uni.  
 June 2006, Colloquium, ETH Zurich.  
 June 2006, Strong integrality of quantum invariants, Universite Paris 7.  
 June 2006, On the colored Jones polynomial, Conference The Volume conjectures 2 talks, U. of Grenoble.  
 April 2006, The quantum MacMahon Master theorem, Colloquium, Oklahoma State Univ.  
 March 2006, On the colored Jones polynomial, Conference around the Volume Conjectures, Columbia Uni. Two lectures.  
 March 2006, On the Jones and the A polynomials, Topology Seminar, Univ of Georgia, Athens.  
 March 2006, Quasi-crystal, Research Horizon seminar, Georgia Institute of Technology, Atlanta.  
 January 2006, Strong integrality of quantum invariants, Annual AMS meeting, San Antonio.

2005

September 2005, On determinant formulas for the colored Jones polynomial and the volume of knot complements, Conference 'Classical and quantum gravity in 3 dimensions, Pisa, Italy.  
 June 2005, On Relation between the colored Jones polynomial and the fundamental group, Joint AMS-DMV-OeMG meeting, Mainz (Germany).  
 June 2005, An analytic version of the Melvin-Morton-Rozansky conjecture Conference Braid groups, quantum invariants and geometry of 3 manifolds, Marseille, France.  
 May 2005, 3 lectures on Quantum and finite type invariants, University of Geneva.  
 May 2005, Colloquium, University of Geneva.

### Findings:

Findings are detailed in the list of publications.

### Training and Development:

**Outreach Activities:****Journal Publications**

Thang Le, "The Colored Jones Polynomial and the A-Polynomial of Knots", *Adv. Math.*, p. 782-804, vol. 207, (2006). Published,

Thang Le and V. Huynh, "On the Colored Jones Polynomial and the Kashaev invariant", *Prikl. Mat.*, p. 57-78, vol. 11, (2005). Published,

Thang Le, "Finite type invariants of 3-manifolds", *Encyclopedia of Mathematical Physics*, p. 384-356, vol. , (2006). Published,

S. Garoufalidis and T. Le, "Asymptotics of the colored Jones function of a knot", *Acta Mathematica*, p. , vol. , ( ). Submitted,

D. Cheptea and T. Le, "A TQFT associated to the LMO invariant of three-dimensional manifolds", *Comm. Math. Phys.*, p. 601-634, vol. 272, (2007). Published,

A. Beliakova, C. Blanchet and T. Le, "Laplace transform and universal  $sl(2)$  invariants", preprint math.QA/0509394, p. , vol. , ( ). ,

Thang Le, "Strong Integrality of Quantum Invariants of 3-manifolds", *Trans. AMS*, p. 2941-2963, vol. 360, (2008). Published,

S. Garoufalidis and T. Le, "Is the Jones polynomial of a knot really apolynomial?", *Journal Knot Theory and Its Ramifications*, p. 983-1000, vol. 15, (2006). Published,

S. Garoufalidis and M. Marino, "On Chern-Simons Matrix Models", in preparation, p. , vol. , ( ). ,

S. Garoufalidis and X. Sun, "The C-polynomial of a knot", *Alg. Geom. Topology*, p. 1001-1031, vol. 6, (2006). Published,

S. Garoufalidis and Y. Lan, "Experimental evidence for the Volume Conjecture of the simplest hyperbolic non-2-bridge knot", *Algebr. Geom. Topol.*, p. 379-403, vol. 5, (2005). Published,

S. Garoufalidis and M. Loebl, "A non-commutative formula for the colored Jones function", *Math. Annalen*, p. 867-900, vol. 336, (2006). Published,

S. Garoufalidis and J. Geronimo, "Asymptotics of q-difference equations", *Contemporary Math AMS*, p. 83-114, vol. 416, (2006). Published,

S. Garoufalidis and M. Loebl, "Random Walks and the colored Jones function", *Combinatorica*, p. 651-671, vol. 25, (2005). Published,

S. Garoufalidis, T. Le and D. Zeilberger, "The quantum MacMahon Master Theorem", *Proc. Natl. Academy USA*, p. 13928, vol. 103, (2006). Published,

S. Garoufalidis and T. Le, "The colored Jones function is q-holonomic", *Geom. and Topology*, p. 1253-1293, vol. 9, (2005). Published,

S. Garoufalidis and Y. Lan, "Experimental evidence for the Volume Conjecture of the simplest hyperbolic non-2-bridge knot", *Algebr. Geom. Topol.*, p. 379-403, vol. 5, (2005). Published,

S. Garoufalidis, "Difference and differential equations for the colored Jones function", *Journal of Knot Theory and its Ramifications*, p. 495-510, vol. 17, (2008). Published,

N. Dunfield, S. Garoufalidis, A. Shumakovitch and M. Thislethwaite, "Behavior of knot invariants under genus 2 mutation", *Alg. Geom. Topology*, p. , vol. , ( ). Submitted,

- O. Costin and S. Garoufalidis, "Resurgence of 1-dimensional sums of quantum factorials", Preprint, p. , vol. , (2007). ,
- O. Costin and S. Garoufalidis, "Resurgence of the fractional polylogarithms", Preprint, p. , vol. , (2007). ,
- O. Costin and S. Garoufalidis, "Resurgence of the Euler-MacLaurin summation formula", Preprint, p. , vol. , (2006). ,
- S. Garoufalidis, "Resurgence conjectures in Chern-Simons theory", Preprint, p. , vol. , (2007). ,
- Qi Chen and T. Le, "Almost integral TQFTs from simple Lie algebras", *Algebr. Geom. Topol.*, p. 1291-1314, vol. 5, (2005). Published,
- V. Huynh and T. Le, "Twisted Alexander Polynomial of links in the projective space", *J. Knot Theory and its Ramifications*, p. 411-438, vol. 17, (2008). Published,
- D. Cheptea and T. Le, "3-cobordisms with their rational homology on the boundary", preprint math.GT/0602097, p. , vol. , ( ). ,
- A. Beliakova and T. Le, "Integrality of quantum 3-manifold invariants and rational surgery formula", *Composito Mathematica*, p. 1592-1612, vol. 143, (2007). Published,
- S. Garoufalidis and T. Le, "Gevrey series in quantum topology", *J. Reine Angew. Math*, p. 169-195, vol. 618, (2008). Published,
- S. Garoufalidis, "An extended version of additive K-theory", *Journal of K-Theory*, p. , vol. , (2008). Accepted,
- S. Garoufalidis, "An ansatz for the asymptotics of hypergeometric multisums", *Advances in Applied Mathematics*, p. 423-451, vol. 41, (2008). Published,
- O. Costin and S. Garoufalidis, "Resurgence of the Kontsevich-Zagier series", *Annales de l'Institut Fourier*, p. 893-914, vol. 58, (2008). Published,
- A. Beliakov, C. Blanchet, T. Le, "Unified quantum invariants and their refinements for homology 3-spheres with 2-torsion", *Fund. Math*, p. 217-239, vol. 201, (2008). Published,
- Thang Le, S. Garoufalidis and M. Marino, "Analyticity of the free energy of a closed 3-manifold", *Integrability and Geometry: Methods and Applications*, p. 20pp elec, vol. 080, (2008). Published,

### **Books or Other One-time Publications**

### **Web/Internet Site**

**URL(s):**

[www.math.gatech.edu/~stavros/publications/publications.html](http://www.math.gatech.edu/~stavros/publications/publications.html)

**Description:**

This link lists the publications resulting from this award.

These postings reinforce the commitment to disseminate the research supported by this funding.

### **Other Specific Products**

### **Contributions**

**Contributions within Discipline:**

**Contributions to Other Disciplines:****Contributions to Human Resource Development:****Contributions to Resources for Research and Education:**

The PIs organized an International Conference in Hanoi Vietnam with many young participants and students. We are editing refereed conference proceedings.

Le also served as a coordinator (grading the papers) for the International Mathematical Olympiad, held in Hanoi (July 2007).

**Contributions Beyond Science and Engineering:****Conference Proceedings****Categories for which nothing is reported:**

Organizational Partners

Activities and Findings: Any Training and Development

Activities and Findings: Any Outreach Activities

Any Book

Any Product

Contributions: To Any within Discipline

Contributions: To Any Other Disciplines

Contributions: To Any Human Resource Development

Contributions: To Any Beyond Science and Engineering

Any Conference