

## Curriculum Vitae

Samuel R. Buss  
Professor of Mathematics and Computer Science

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### Academic Employment

UNIVERSITY OF CALIFORNIA, SAN DIEGO; MATHEMATICS AND COMPUTER SCIENCE:

1993-Present. Professor, Mathematics & Computer Science  
and Engineering.  
Spring 2016. Visiting Professor, St. Petersburg State University.  
2014-2015. Simons Foundation Fellow.  
Fall 2014. Visiting Professor, Stanford University.  
2006-2010. Chair, Department of Mathematics.  
2003-2006. Vice-chair for undergraduate affairs, Mathematics.  
1995-1997. Vice-chair for graduate affairs, Mathematics.  
1990-1993. Associate Professor, Mathematics and Computer Science.  
1988-1990. Assistant Professor, Mathematics and Computer Science.

UNIVERSITY OF CALIFORNIA, BERKELEY; DEPT OF MATHEMATICS:  
1986-1988. Lecturer and NSF Postdoctoral Fellow.

MATHEMATICAL SCIENCES RESEARCH INSTITUTE: Berkeley, California,  
1985-1986. NSF Postdoctoral Fellow. Participated in the year-long  
program in computational complexity.

### Education

PRINCETON UNIVERSITY: Ph.D Mathematics (June 1985) and M.A. Mathe-  
matics (January 1983).

EMORY UNIVERSITY: B.S. Mathematics and B.S. Physics (1979). Summa Cum  
Laude.

### Primary Grant Support

- N.S.F. GRANT. 2012-2017. Funds joint research in theory of computer science. Investigators, R. Impagliazzo, S. Buss, R. Paturi, R. Williams (Stanford).
- N.S.F. GRANT. 2016. Travel support for graduate students to Moscow and St. Petersburg.
- N.S.F. GRANTS. 1988-2016. Personal grants on topics in logic, theories of arithmetic, proof theory, and computational complexity.
- N.S.F. AND CZECHOSLOVAKIAN ACADEMY OF SCIENCE Cooperative Research Grant 1996-1999. Investigators: S. Buss (P.I.), R. Impagliazzo, J. Krajíček, T. Pitassi, P. Pudlák, S. Rudich, J. Sgall.
- U.S. AND CZECH REPUBLIC JOINT RESEARCH GRANT 1993-1996. Investigators are: S. Buss, P. Clote, R. Impagliazzo, J. Krajíček(P.I.), P. Pudlák, J. Sgall, and G. Takeuti. Funds cooperative research in the U.S. and in Czechoslovakia.
- N.S.F. AND CZECHOSLOVAKIAN ACADEMY OF SCIENCE Cooperative Research Grant 1989-1991. Investigators: J. Becvar(P.I.), S. Buss (P.I.), P. Clote, P. Hájek, J. Krajíček, P. Pudlák, G. Takeuti.
- N.S.F. GRANT. 1988-1989. Supported as a supplement to Prof. Solovay's grant.

### **Fellowships and Awards**

- SIMONS FOUNDATION FELLOW. July 2014 – June 2015.
- BEST PAPER AWARD. SAT 2013 conference. Joint with M. Bonet.
- N.S.F. POSTDOCTORAL FELLOWSHIP: Fulltime support in 1985-1986 and half-time support in 1986-1988 supplementing Lectureship at UC Berkeley.
- SLOAN FOUNDATION DOCTORAL DISSERTATION FELLOWSHIP. 1984-1985.
- N.S.F. GRADUATE FELLOWSHIP. 1979-1980 and 1982-1984 (first three years of graduate study at Princeton).

### **Ph.D. Students**

- MARIA BONET 1991.
- STEVE BLOCH 1992.
- DAVID ROBINSON 1993.
- CHRIS POLLETT 1997.
- NATE SEGERLIND 2003.
- ALAN JOHNSON 2011.

JAMES AISENBERG 2016.

**Other Professional Activities**

EDITOR, SIAM JOURNAL ON COMPUTING. 2014-Present.

MEMBER, ASL COMMITTEE ON LOGIC IN NORTH AMERICA. 2014-Present

EDITOR, PROGRESS IN COMPUTER SCIENCE AND APPLIED LOGIC. Birkhäuser,  
2013-Present.

EDITOR, LOGIC JOURNAL OF THE IGPL. (Interest Group in Pure and Applied  
Logics, section “Algorithms in Logic and Decision Procedures”). 2009-  
Present.

EDITOR, NOTRE DAME JOURNAL OF FORMAL LOGIC. 2006-Present.

EDITOR, ANNALS OF PURE AND APPLIED LOGIC 1999–Present.

EDITOR, ACM TRANSACTIONS ON COMPUTATIONAL LOGIC 1999–Present.

EDITOR, JOURNAL OF MATHEMATICAL LOGIC 1998–Present.

EDITOR, JOURNAL OF APPLIED LOGIC 2003–Present.

EDITOR, JOURNAL OF ALGORITHMS IN COGNITION, INFORMATICS AND LOGIC.  
2008-2009.

EDITOR, STUDIES IN LOGIC: MATHEMATICAL LOGIC AND FOUNDATIONS. 2007-  
2014. (Book series.)

ADVISORY BOARD. THEORY AND APPLICATIONS OF COMPUTABILITY. 2009–Present.  
Springer book series in cooperation with the Association for Computability  
in Europe.

MANAGING EDITOR, ASL LECTURE NOTES IN LOGIC. 2000–2004.  
Editor, 1994-2000.

ADVISORY EDITOR. LOGICAL METHODS OF COMPUTER SCIENCE. 2004–2015.  
Electronic journal.

EDITOR, ARCHIVE FOR MATHEMATICAL LOGIC 1995–2005.

PUBLISHER, ASSOCIATION FOR SYMBOLIC LOGIC. Managed book and journal  
publications of the ASL. 2005-2006.

VICE-PRESIDENT, ASSOCIATION FOR SYMBOLIC LOGIC. 2004-2007.

CO-ORGANIZER Workshop on Theoretical Foundations of SAT Solving, Fields  
Institute, Toronto. August 2016.

CO-ORGANIZER Workshop on Proof Complexity. St. Petersburg, Russia, May  
2016.

CO-ORGANIZER Special Semester on Complexity Theory. Moscow and St.  
Petersburg, Russia, Spring 2016.

PROGRAM COMMITTEE MEMBER. Computer Science Logic (CSL). Marseille, France, August-September 2016.

PROGRAM COMMITTEE MEMBER. Theory and Applications of Satisfiability Testing (SAT). Bordeaux (Labri), France, 2016.

PROGRAM COMMITTEE MEMBER. Logical Foundations of Computer Science (LFCS). Deerfield Beach, Florida, January 2016.

CO-ORGANIZER. OBERWOLFACH WORKSHOP. Workshop on Mathematical Logic, Proof Theory and Constructive Mathematics. Oberwolfach, Germany, November 2014.

CO-ORGANIZER. BIRS-PIMS WORKSHOP. Workshop on Theoretical Foundations of Applied SAT Solving, Banff, Canada, January 2014.

PROGRAM COMMITTEE MEMBER. Theory and Applications of Satisfiability Testing, SAT 2013, Helsinki, July 2013.

CO-ORGANIZER. ASL Special Session on Effective Algebra and Model Theory, Joint Mathematics Meetings, San Diego, January 2013

PROGRAM COMMITTEE MEMBER. Logical Foundations of Computer Science (LFCS). San Diego, January 2013.

CO-ORGANIZER. OBERWOLFACH WORKSHOP. Workshop on Mathematical Logic, Proof Theory and Constructive Mathematics. Oberwolfach, Germany, November 2011.

CO-ORGANIZER. BIRS-PIMS WORKSHOP. Workshop on Proof Complexity. Banff, Canada, October 2011.

PROGRAM COMMITTEE MEMBER. Conference on Computer Graphics Theory and Applications (GRAPP 2011), Algarve, Portugal, March 2011.

PROGRAM COMMITTEE MEMBER. Workshop on Logic, Language, Information, and Computation (WoLLIC 2011), Philadelphia, May 2011.

PROGRAM COMMITTEE MEMBER. ASL Annual Meeting, Washington, DC, March 2011.

PROGRAM COMMITTEE MEMBER. Conference on Mathematical Logic and Set Theory, Satellite conference of ICM 2010, Chennai, India, August 2010.

PROGRAM COMMITTEE MEMBER. Conference on Computer Graphics Theory and Applications (GRAPP 2010), Angers, France, May 2010.

PROGRAM COMMITTEE MEMBER. Conference on Logical Approaches to Barriers in Computing and Complexity, Greifswald, Germany, February 2010.

PROGRAM COMMITTEE MEMBER. Logical Foundations of Computer Science (LFCS'09), Deerfield Beach, January 2009.

PROGRAM COMMITTEE MEMBER. Conference on Computer Graphics Theory and Applications (GRAPP 2008), Madeira, Portugal, May 2008.

CO-ORGANIZER, OBERWOLFACH WORKSHOP. Workshop on Mathematical Logic, Proof Theory and Constructive Mathematics. Oberwolfach, Germany, April 2008.

PROGRAM COMMITTEE MEMBER. Conference on Computer Graphics Theory and Applications (GRAPP 2007), Barcelona, Spain, May 2007.

CO-ORGANIZER, WORKSHOP ON NEW DIRECTIONS IN PROOF COMPLEXITY. Newton Institute, Cambridge, April 2006.

PROGRAM COMMITTEE MEMBER. Logical Foundations of Computer Science (LFCS'07), New York, June 2007.

PROGRAM COMMITTEE MEMBER. Conference on Computer Graphics Theory and Applications (GRAPP 2006), Setúbal, Portugal, February 2006.

ADVISORY COMMITTEE MEMBER, LOGIC AND ALGORITHMS. Special program at the Newton Institute, Cambridge, Winter-Spring 2006.

CO-ORGANIZER, OBERWOLFACH WORKSHOP. Workshop on Mathematical Logic, Proof Theory, Type Theory and Constructive Mathematics, Oberwolfach, Germany, March 2005.

PROGRAM COMMITTEE MEMBER. Logic, Computability and Arithmetic, St. Petersburg, June 2005.

PROGRAM COMMITTEE MEMBER, LICS 2004. Logic in Computer Science, Turku, Finland, July 2004.

PROGRAM COMMITTEE MEMBER, ICC WORKSHOP. Implicit Computational Complexity Ottawa, June 2003.

PROGRAM COMMITTEE MEMBER, STOC'02. ACM Symposium on Theory of Computing, Montreal, May 2002.

PROGRAM COMMITTEE MEMBER, CCC'02. IEEE Conference on Computational Complexity, Montreal, May 2002.

PROGRAM COMMITTEE MEMBER Workshop on Bounded Arithmetic and Complexity Classes, Lisbon, June 2002.

PROGRAM COMMITTEE MEMBER, ICC WORKSHOP. Implicit Computational Complexity Santa Barbara, June 2000.

PROGRAM COMMITTEE MEMBER, WoLLIC'2000. Seventh Workshop on Logic, Language, Information and Computation, Natal, Brazil, August 2000.

PROGRAM COMMITTEE MEMBER, ICC WORKSHOP, FLoC'99. Implicit Computational Complexity, Federated Logic Conference, Trento, Italy, July 1999.

PROGRAM COMMITTEE CHAIR, ASL ANNUAL MEETING, San Diego, 1999.

ORGANIZING COMMITTEE MEMBER, ASL ANNUAL MEETING, San Diego, 1999.

PROGRAM COMMITTEE MEMBER, INTERNATIONAL CONGRESS OF LOGIC, METHODOLOGY AND PHILOSOPHY OF SCIENCE, CHAIR OF SUBCOMMITTEE FOR PROOF THEORY. Cracow, Poland, 1999.

PROGRAM COMMITTEE CHAIR, ASL EUROPEAN SUMMER MEETING. Prague, Czech Republic, 1998.

CO-ORGANIZER, LOGIC, COMPUTABILITY, COMPLEXITY CONFERENCE Amsterdam, February 1998.

PROGRAM COMMITTEE MEMBER, ASL EUROPEAN SUMMER MEETING. Leeds, England, July 1997.

CO-ORGANIZER. DIMACS WORKSHOP ON FEASIBLE ARITHMETICS AND PROOF COMPLEXITY. April 1996.

PROGRAM COMMITTEE MEMBER FOR LICS'96. IEEE Conference on Logic in Computer Science, Rutgers, July 1996.

PROGRAM COMMITTEE MEMBER, ASL ANNUAL MEETING. Madison, Wisconsin, March 1996.

STEERING COMMITTEE MEMBER. DIMACS Special Year in Logic and Algorithms. 1995-1996.

PROGRAM COMMITTEE MEMBER, ASL ANNUAL MEETING. U.C. Irvine, March 1995.

CO-ORGANIZER & CHAIR, SAN DEIGO HIGH SCHOOL HONORS MATHEMATICS CONTEST. An annual UCSD-sponsored contest for high school students. 1990-1994.

CONFERENCE CO-CHAIR FOR LICS'95. IEEE Conference on Logic in Computer Science, San Diego, June 1995.

PROGRAM COMMITTEE MEMBER, CONFERENCE ON PROOF THEORY AND COMPUTER SCIENCE. Luminy, France, July 1993 in honor of G. Takeuti.

PROGRAM COMMITTEE MEMBER, ASL WINTER MEETING. Held in conjunction with the AMS-MAA Annual Meetings, San Antonio, Texas, 1993.

MEMBER OF THE ORGANIZING COMMITTEE FOR THE IEEE LOGIC IN COMPUTER SCIENCE (LICS) CONFERENCES. 1991-1997.

CO-ORGANIZER: WORKSHOP AND CONFERENCE ON PROOF THEORY, ARITHMETIC AND COMPLEXITY. A month-long workshop and an associated three-day conference held in Prague, Czechoslovakia, June-July 1991. Funded by the NSF and the Czechoslovakian Academy of Sciences.

PRINCIPAL ORGANIZER: WORKSHOP AND CONFERENCE ON PROOF THEORY, ARITHMETIC AND COMPLEXITY. A month-long workshop and an associated three-day conference held at the University of California, San Diego, June-July 1990. Funded by the NSF, the Czechoslovakian Academy of Sciences and UCSD.

CO-ORGANIZER: WORKSHOP IN FEASIBLE MATHEMATICS. Held in Cornell, June 1989, funded by the Mathematical Sciences Institute.

PROGRAM COMMITTEE MEMBER FOR LICS'91. IEEE Conference on Logic in Computer Science, Amsterdam, July 1991.

PROGRAM COMMITTEE MEMBER FOR KLEENE'90. Held in Bulgaria, June 1990.

MEMBERSHIPS: AMS, MAA, ASL, ACM, IEEE Computer Society.

### **Selected Industry Work Experience**

1996-2007 Consultant for Rockstar Studios. (Formerly Angel Studios.) Designing computer algorithms for physically realistic dynamics of rigid bodies and articulated bodies in a 3-D environment. Software developed for the following games: Grand Theft Auto: Episodes from Liberty City (Rockstar Games, 2010); Grand Theft Auto IV: The Lost and Damned (Rockstar Games, 2009); Grand Theft Auto: The Ballad of Gay Tony (Rockstar Games, 2009); Grand Theft Auto IV (Rockstar Games, 2008); Smuggler's Run: Warzones (Rockstar Games, 2002); Transworld Surf (Infogrames, 2002); Smuggler's Run 2: Hostile Territory (Rockstar Games, 2001); Midnight Club: Street Racing (Rockstar Games, 2000); Midtown Madness 2 (Microsoft, 2000); Smuggler's Run (Rockstar Games, 2000); Midtown Madness (Microsoft, 2000).

MAY 1994-DEC. 1994. Consultant for Science Applications International Corporation (SAIC). Primary designer of vehicle dynamics software for a virtual reality simulation of Indy race cars. This software was deployed by Illusion, Inc. at the Sahara Hotel in Las Vegas.

JUNE 1980-SEPT. 1982. Engineer at Proximity Designs Corp (later Proximity Technology Inc, and now a subsidiary of Franklin Computer).

## Publications

### Ph.D. dissertation:

- [1] Samuel R. Buss, *Bounded Arithmetic*. Ph.D. thesis, Princeton University, 1985.

### Books authored:

- [2] Samuel R. Buss, *Bounded Arithmetic*. Bibliopolis, 1986. Revision of Princeton University Ph.D. thesis.
- [3] Samuel R. Buss, *3D Computer Graphics: A Mathematical Introduction with OpenGL*. Cambridge University Press, 2003.

### Books edited:

- [4] Samuel R. Buss and Phillip J. Scott, editors, *Feasible Mathematics, a Mathematical Sciences Institute Workshop held in Ithaca, New York, June 1989*, Progress in Computer Science and Applied Logic, volume 9, Birkhäuser, 1990.
- [5] Paul W. Beame and Samuel R. Buss, editors, *Proof Complexity and Feasible Arithmetics* Proceedings of a DIMACS Workshop held April 1996, American Mathematical Society, 1998.
- [6] Samuel R. Buss, editor, *Handbook of Proof Theory*, Elsevier Science Publishers, 1998.
- [7] Samuel R. Buss, Petr Hájek, and Pavel Pudlák, editors, *Logic Colloquium'98, Proc. of the Annual ASL European Summer Meeting*, Lecture Notes in Logic #13, Association for Symbolic Logic, 1999.

### Patents:

- [8] Peter N. Yianilos and Samuel R. Buss, “Associative memory circuit system and method, continuation-in-part.” U.S. Patent #4490811, December 1984. European Patent #83903352.9, January 1986.
- [9] Samuel R. Buss and Peter N. Yianilos, “Linear and near-linear time methods for minimum-cost matching on quasiconvex tours.” U.S. Patent #5841958, November 1998.



## Articles:

- [10] Peter N. Yianilos, Robert A. Harbort, Samuel R. Buss, “The application of a pattern matching algorithm to searching medical record text.” In *IEEE Symposium on Computer Applications in Medical Care*, pages 308–313, 1978.
- [11] Samuel R. Buss, “The polynomial hierarchy and fragments of Bounded Arithmetic.” In *Proceedings of the 17-th Annual ACM Symposium on Theory of Computing*, pages 285–290, 1985.
- [12] Samuel R. Buss, “A conservation result concerning bounded theories and the collection axiom.” *Proceedings of the American Mathematic Society*, 100 (1987) 709-716.
- [13] Samuel R. Buss, “The polynomial hierarchy and intuitionistic Bounded Arithmetic.” In *Structure in Complexity, Lecture Notes in Computer Science #223*, pages 77–103, Springer Verlag, 1986.
- [14] Samuel R. Buss, “Polynomial size proofs of the propositional pigeonhole principle.” *Journal of Symbolic Logic* 52 (1987) 916-927.
- [15] Samuel R. Buss, “The Boolean formula value problem is in ALOGTIME.” In *Proceedings of the 19-th Annual ACM Symposium on Theory of Computing*, pages 123–131, May 1987.
- [16] Samuel R. Buss, “Axiomatizations and conservation results for fragments of Bounded Arithmetic.” In *Logic and Computation*, Proceedings of a Workshop held at Carnegie Mellon University, June 30-July 2, 1987. *AMS Contemporary Mathematics* 106 (1990) 57-84.
- [17] Samuel R. Buss and György Turán, “Resolution proofs of generalized pigeonhole principles.” *Theoretical Computer Science* 62 (1988) 311-317.
- [18] Samuel R. Buss and Louise Hay, “On truth-table reducibility to SAT and the difference hierarchy over NP.” *Proceedings of the Structure in Complexity Conference*, pages 224–233, June 1988.
- [19] Samuel R. Buss, Stephen A. Cook, Arvind Gupta and Vijaya Ramachandran, “An optimal parallel algorithm for formula evaluation.” *SIAM Journal on Computing* 21 (1992) 755-780.
- [20] Samuel R. Buss, “The modal logic of pure provability.” *Notre Dame Journal of Formal Logic* 31 (1990) 225-231.
- [21] Samuel R. Buss and Louise Hay, “On truth-table reducibility to SAT.” *Information and Computation* 91 (1991) 86-102. This is extracted from [18].
- [22] Samuel R. Buss, “The undecidability of  $k$ -provability.” *Annals of Pure and Applied Logic* 53 (1991) 75-102.

- [23] Samuel R. Buss, "Propositional consistency proofs." *Annals of Pure and Applied Logic* 52 (1991) 3-29.
- [24] Samuel R. Buss, "A note on bootstrapping intuitionistic Bounded Arithmetic." In *Proof Theory: a selection of papers from the Leeds Proof Theory Programme 1990*, Cambridge Univ. Press, 1992, pp.149-169.
- [25] Samuel R. Buss, "On model theory for intuitionistic Bounded Arithmetic with applications to independence results." In *Feasible Mathematics: a Mathematical Sciences Institute Workshop held in Ithaca, New York, June 1989*, pages 27-47, Birkhäuser, 1990.
- [26] Samuel R. Buss, "Intuitionistic validity in  $T$ -normal Kripke structures." *Annals of Pure and Applied Logic* 59 (1993) 159-173.
- [27] Samuel R. Buss, Christos H. Papadimitriou and John N. Tsitsiklis, "On the predictability of coupled automata: an allegory about chaos." *Complex Systems* 5 (1991) 525-539. An earlier draft appeared in *Proceedings of the 31st Annual Symposium on Foundation of Computer Science, Volume II*, IEEE-Computer Society Press, 1990, pp 788-793.
- [28] M. Luisa Bonet and Samuel R. Buss, "On the deduction rule and the number of proof lines." *Proceedings of the Sixth Annual IEEE Symposium on Logic in Computer Science*, IEEE Computer Society Press, 1991, pp. 286-297.
- [29] Samuel R. Buss, "The graph of multiplication is equivalent to counting." *Information Processing Letters* 41 (1992) 199-201.
- [30] Samuel R. Buss, Jan Krajíček and Gaisi Takeuti, "Provably total functions in bounded arithmetic theories  $R_3^i$ ,  $U_2^i$  and  $V_2^i$ ." In *Proof Theory, Complexity and Arithmetic*, edited by P. Clote and J. Krajíček, Oxford University Press, 1993, pp. 116-161.
- [31] Samuel R. Buss and Jan Krajíček, "An application of boolean complexity to separation problems in bounded arithmetic." *Proceedings of the London Mathematical Society* 69 (1994) 1-21.
- [32] Samuel R. Buss, "Algorithms for Boolean formula evaluation and for tree-contraction." In *Proof Theory, Complexity and Arithmetic*, edited by P. Clote and J. Krajíček, Oxford University Press, 1993, pp. 95-115.
- [33] Samuel R. Buss, "The witness function method and provably recursive functions of Peano arithmetic", *Proceedings of the Ninth International Congress on Logic, Methodology and Philosophy of Science*, edited by D. Prawitz, B. Skyrms, and D. Westerståhl, Elsevier Science North-Holland, 1994, pp. 29-68.

- [34] M. Luisa Bonet and Samuel R. Buss, “The deduction rule and linear and near-linear proof simulations.” *Journal of Symbolic Logic* 58 (1993) 688-709. This consists of half of [28] plus new results.
- [35] M. Luisa Bonet and Samuel R. Buss, “On the serial transitive closure problem.” *SIAM Journal on Computing* 24 (1995) 109-122. This contains the other half of [28] plus new results.
- [36] Samuel R. Buss, “On Gödel’s theorems on lengths of proofs I: number of lines and speedup for arithmetics.” *Journal of Symbolic Logic* 39 (1994) 737-756.
- [37] Samuel R. Buss, “On Gödel’s theorems on lengths of proofs II: lower bounds for recognizing  $k$  symbol provability.” *Feasible Mathematics II*, Birkhäuser, 1995, pages 57-90.
- [38] Samuel R. Buss, “Some remarks on lengths of propositional proofs.” *Archive for Mathematical Logic* 34 (1995) 377-394.
- [39] M. Luisa Bonet and Samuel R. Buss, “Size-depth tradeoffs for Boolean formulae.” *Information Processing Letters* 11 (1994) 151-155.
- [40] Samuel R. Buss, “Relating the bounded arithmetic and polynomial-time hierarchies.” *Annals of Pure and Applied Logic* 75 (1995) 67-77.
- [41] Samuel R. Buss and Peter N. Yianilos, “Linear and  $O(n \log n)$  time minimum-cost matching algorithms for quasiconvex tours.” In *SIAM Journal on Computing* 27 (1998) 170-201. This is an expanded version of a paper which appeared in *Proceedings of the Fifth Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*, pages 65-76, 1994.
- [42] Samuel R. Buss and Aleksandar Ignjatović, “Unprovability of consistency statements in fragments of bounded arithmetic.” *Annals of Pure and Applied Logic* 74 (1995) 221-244.
- [43] Maria Luisa Bonet, Samuel R. Buss, Toniann Pitassi, “Are there hard examples for Frege systems?” *Feasible Mathematics II*, Birkhäuser, 1995, pages 31-56.
- [44] Samuel R. Buss and Peter Clote, “Cutting planes, connectivity and threshold logic.” *Archive for Mathematical Logic* 35 (1996) 33-62.
- [45] Pavel Pudlák and Samuel R. Buss, “How to lie without being (easily) convicted and the lengths of proofs in propositional calculus.” In: *8th Workshop on Computer Science Logic, Kazimierz, Poland, September 1994*, Springer-Verlag Lecture Notes in Computer Science #933, 1995, pp. 151-162
- [46] Samuel R. Buss, “On Herbrand’s Theorem.” In: *Logic and Computational Complexity*, Lecture Notes in Computer Science #960, Springer-Verlag, 1995, pp. 195-209.

- [47] Samuel R. Buss, "Introduction to Proof Theory." In *Handbook of Proof Theory*, edited by S. Buss, Elsevier North-Holland 1998, pp. 1-78.
- [48] Samuel R. Buss and Toniann Pitassi, "Good degree bounds on Nullstellensatz refutations of the induction principle." In *Journal of Computer and System Sciences* 57 (1998) 162-171. Preliminary version appeared in *Complexity '96, Proceedings of Eleventh Annual IEEE Conference on Computational Complexity*, 1996, IEEE Press, pp. 233-242.
- [49] Samuel R. Buss, Russell Impagliazzo, Jan Krajíček, Pavel Pudlák, Alexander Razborov and Jiří Sgall, "Proof complexity in algebraic systems and constant depth Frege systems with modular counting." In *Computational Complexity*, 6 (1995/1996) 256-298.
- [50] Samuel R. Buss and Toniann Pitassi, "Resolution and the weak pigeonhole principle." In *Computer Science Logic (CSL'97)*, Lecture Notes in Computer Science 1414, Springer-Verlag, 1998, pp. 149-156.
- [51] Samuel R. Buss, "Lower bounds on Nullstellensatz proofs via designs." In *Proof Complexity and Feasible Arithmetics*, P. Beame and S. Buss, eds., American Mathematical Society, Providence, R.I., 1998, pp. 59-71.
- [52] Samuel R. Buss, "Bounded arithmetic, cryptography and complexity." In *Theoria*, 63 (1997) 147-167.
- [53] Samuel R. Buss, "Bounded arithmetic and propositional proof complexity." In *Logic of Computation*, H. Schwichtenberg, ed., Springer-Verlag, 1997, pp.67-122.
- [54] Samuel R. Buss, "Alogtime algorithms for tree isomorphism, comparison, and canonization." In *Computational Logic and Proof Theory, 5th Kurt Gödel Colloquium'97*, Lecture Notes in Computer Science #1289, Springer-Verlag, 1997, pp. 18-33.
- [55] Samuel R. Buss, "Bounded arithmetic, proof complexity and two papers of Parikh." In *Annals of Pure and Applied Logic* 96 (1999) 43-55.
- [56] Samuel R. Buss, "First-order proof theory of arithmetic." In *Handbook of Proof Theory*, edited by S. Buss, Elsevier North-Holland, 1998, pp. 79-147.
- [57] Misha Alekhnovich, Samuel R. Buss, Shlomo Moran, Toniann Pitassi, "Minimum Propositional Proof Length is NP-Hard to Linearly Approximate." In *Journal of Symbolic Logic* 66 (2001) 171-191. An extended abstract of this paper appeared earlier in *Mathematical Foundations of Computer Science, MFCS'98*, Lecture Notes in Computer Science #1450, Springer-Verlag, 1998, pp. 176-184.
- [58] Samuel R. Buss, *Propositional Proof Complexity: An Introduction*, in *Computational Logic*, edited by U. Berger and H. Schwichtenberg, Springer-Verlag, 1999, pp. 127-178.

- [59] Samuel R. Buss and Grigori Mints, “The Complexity of the Disjunction and Existence Properties in Intuitionistic Logic,” in *Annals of Pure and Applied Logic*, 99 (1999) 93-104.
- [60] Samuel R. Buss and Jay P. Fillmore, “Spherical Averages and Applications to Spherical Splines and Interpolation,” *ACM Transactions on Graphics*. 20 (2001) 95-126.
- [61] Samuel R. Buss, Dima Grigoriev, Russell Impagliazzo and Toniann Pitassi, “Linear Gaps Between Degrees for the Polynomial Calculus Modulo Distinct Primes,” *Journal of Computer and System Sciences* 62 (2001) 267-289. An earlier version appeared in *Proceedings of the Thirty-First Annual ACM Symposium on Theory of Computation (STOC’99)*, 1999, pp. 547-556. A one-page abstract appeared in *Proceedings of the Fourteenth Annual IEEE Conference on Complexity Conference (CCC’99)*, 1999, pp. 5-5.
- [62] Samuel R. Buss, “Accurate and Efficient Simulations of Rigid Body Rotations,” *Journal of Computational Physics* 164 (2000) 377-406.
- [63] Samuel R. Buss and Grigore Rosu, “Incompleteness of Behavioral Logics,” in *Proceedings, Coalgebraic Methods in Computer Science (CMCS’00)*, *Electronic Notes in Theoretical Computer Science*, 33 (2000) 61-79.
- [64] Samuel R. Buss and Bruce Kapron, “Resource-bounded Continuity and Sequentiality for Type-two Functionals,” *ACM Transactions on Computational Logic* 3 (2002) 402-417. Earlier version in *Proceedings of the 15th IEEE Symposium on Logic in Computer Science (LICS)*, IEEE Computer Science Press, 2000, pp. 77-83.
- [65] Samuel R. Buss and Pavel Pudlák, “On the Computational Content of Intuitionistic Propositional Proofs,” *Annals of Pure and Applied Logic* 109 (2001) 9-14.
- [66] Arnold Beckmann, Samuel R. Buss and Chris Pollett, *Ordinal notations and well-orderings in bounded arithmetic*, *Annals of Pure and Applied Logic* 120 (2002) 197-223.
- [67] Samuel R. Buss, Alexander S. Kechris, Anand Pillay and Richard A. Shore, “The prospects for mathematical logic in the twenty-first century.” *Bulletin of Symbolic Logic* 7 (2001) 169-196.
- [68] Nate Segerlind, Samuel R. Buss and Russell Impagliazzo, “A Switching Lemma for Small Restrictions and Lower Bounds for k-DNF Resolution (Extended Abstract)”, *Proc. IEEE Foundations of Computer Science (FOCS)*, IEEE Computer Science Press, 2003 pp. 604-613.
- [69] Nate Segerlind, Samuel R. Buss and Russell Impagliazzo, “A Switching Lemma for Small Restrictions and Lower Bounds for k-DNF Resolution”,

- SIAM Journal on Computing* 33, 5 (2004) 1171-1200. An expanded version of 68 with additional results.
- [70] Samuel R. Buss, “Polynomial-size Frege and Resolution Proofs of  $st$ -Connectivity and Hex Tautologies,” *Theoretical Computer Science* 357, 1-3, (2006) 35-52.
  - [71] Samuel R. Buss and Peter G. Clote, “Solving the Fisher-Wright and Coalescence Problems with a Discrete Markov Chain Analysis”, *Advances in Applied Probability* 36 (2004) 1175-1197.
  - [72] Samuel R. Buss and Jin-Su Kim, “Inverse Kinematics and Selectively Damped Least Squares”, *Journal of Graphics Tools* 10 (2005) 37-49.
  - [73] Samuel R. Buss, “Collision Detection with Relative Screw Motion”, *The Visual Computer* 21 (2005) 41-58.
  - [74] Arnold Beckmann and Samuel R. Buss, “Separation Results for the Size of Constant-Depth Propositional Proofs”, *Annals of Pure and Applied Logic* 136 (2005) 30-55.
  - [75] Samuel R. Buss, “Bounded Arithmetic and Constant Depth Frege Proofs,” In *Complexity of Proofs and Computation*, J Krajíček, ed., Quaderni di Matematica, 2005, pp. 153-175.
  - [76] Samuel R. Buss, “Nelson’s Work on Logic and Foundations and Other Reflections on Foundations of Mathematics”, in *Diffusions, Quantum Theory and Radically Elementary Mathematics*, W. Faris, ed., Princeton University Press, 2006, pp. 183-208.
  - [77] Samuel R. Buss, “The Computational Power of Bounded Arithmetic From the Predicative Viewpoint”, in *New Computational Paradigms*, B. Cooper, B. Löwe, A. Sorbi, eds., 2008, Springer, pp. 213-222.
  - [78] Samuel R. Buss and Jan Hoffmann, “The NP-hardness of finding a directed acyclic graph for regular resolution”, *Theoretical Computer Science* 396 (2008) 271-276.
  - [79] Samuel R. Buss, Jan Hoffmann and Jan Johannsen, “Resolution Trees with Lemmas: Resolution Refinements that Characterize DLL Algorithms with Clause Learning”, *Logical Methods of Computer Science* 4, 4:13 (2009), 29 pages.
  - [80] Samuel R. Buss and Roman Kuznets, “The NP-Completeness of Reflected Fragments of Justification Logics”, in *Logical Foundations of Computer Science, LFCIS’09*, Lecture Notes in Computer Science #5407, Springer-Verlag, 2009, pp. 122-136.
  - [81] Daniel Tracy, Samuel R. Buss, and Brian Woods, “Efficient Large-Scale Sweep and Prince Methods with AABB Insertion and Removal”, in *IEEE Virtual Reality (VR2009)*, 2009, pp. 191-198.

- [82] Samuel R. Buss, “Pool Resolution is NP-Hard to Recognize”, *Archive for Mathematical Logic*, 48 (2009) 122-136.
- [83] Samuel R. Buss and Arnold Beckmann, “Polynomial Local Search in the Polynomial Hierarchy and Witnessing in Fragments of Bounded Arithmetic”, *Journal of Mathematical Logic* 9 (2009) 103-138.
- [84] Samuel R. Buss and Alan Johnson, “The Quantifier Complexity of Polynomial-Size Iterated Definitions in First-Order Logic”, *Mathematical Logical Quarterly* 56, 6 (2010) 573-590.
- [85] Arnold Beckmann and Samuel R. Buss, “Characterizing Definable Search Problems in Bounded Arithmetic via Proof Notations”, in *Ways of Proof*, ONTOS Series in Mathematical Logic, pp. 65-134, 2010.
- [86] Samuel R. Buss, “Towards NP-P via Proof Complexity and Search”, *Annals of Pure and Applied Logic*, 163,7 (2012) 906-917. Also in: *Foundational Adventures: Essays in Honor of Harvey Friedman*, Templeton Press, 2013, Article 13.
- [87] Samuel R. Buss and Arnold Beckmann, “Corrected Upper Bounds for Free-Cut Elimination”, in *Theoretical Computer Science*, 412,39 (2011) 5433-5445.
- [88] Samuel R. Buss, “Sharpened Lower Bounds for Cut-Elimination”, *Journal of Symbolic Logic*, 77,2 (2012) 656-668.
- [89] Samuel R. Buss, Yijia Chen, Jörg Flum, Sy Friedman, and Moritz Müller, “Strong Isomorphism Reductions in Complexity Theory”, *Journal of Symbolic Logic*, 76,4 (2011) 1381-1402.
- [90] Samuel R. Buss and Roman Kuznets, “Lower Complexity Bounds in Justification Logic”, *Annals of Pure and Applied Logic* 163, 2 (2012) 888-905.
- [91] Samuel R. Buss and Alan Johnson, “Propositional Proofs and Reductions Between NP Search Problems”, *Annals of Pure and Applied Logic*, 163,9 (2012) 1163-1182.
- [92] Samuel R. Buss and Ryan Williams, “Limits on Alternation-Trading Proofs for Time-Space Lower Bounds”, in *Proc. 27th IEEE Conference on Computational Complexity (CCC’2012)*, pp. 181-191, 2012.
- [93] Maria Luisa Bonet and Samuel R. Buss, “An Improved Separation of Regular Resolution from Pool Resolution and Clause Learning”, in *Theory and Applications of Satisfiability Testing (SAT 2012)*, Springer-Verlag Lecture Notes in Computer Science 7317, pp. 44-57, 2012.
- [94] Samuel R. Buss, “Cut Elimination in Situ”, In *Gentzen’s Centenary: The Quest for Consistency*, Springer Verlag, 2015, pages 245-277.

- [95] Samuel R. Buss, Leszek Kołodziejczyk and Neil Thapen, “Fragments of Approximate Counting”, *Journal of Symbolic Logic* 29 (2014) 496-525.
- [96] Arnold Beckmann and Samuel R. Buss, “Improved Witnessing and Local Improvement Principles for Second-Order Bounded Arithmetic”, *ACM Transactions on Computational Logic* 15, 1 (2014) Article 2, 35 pages.
- [97] Samuel R. Buss and Mia Minnes, “Probabilistic Algorithmic Randomness”, *Journal of Symbolic Logic* 78, 2 (2013) 579-601.
- [98] Samuel R. Buss, Leszek Kołodziejczyk, and Konrad Zdanowski, “Collapsing Modular Counting in Bounded Arithmetic and Constant Depth Propositional Proofs”, *Transactions of the American Mathematical Society*, 367 (2015) 7517-7563.
- [99] Samuel R. Buss and Ryan Williams, “Limits on Alternation-Trading Proofs for Time-Space Lower Bounds”, *Computational Complexity*, 24, 3 (2015) 533-600.
- [100] Arnold Beckmann, Samuel R. Buss, and Sy Friedman, “Safe Recursive Set Functions”, *Journal of Symbolic Logic* 80, 3 (2015) 730-762.
- [101] Maria Luisa Bonet, Samuel R. Buss and Jan Johannsen, “Improved Separations of Regular Resolution from Clause Learning Proof Systems”, *Journal of Artificial Intelligence Research* 49 (2014) 669-703.
- [102] Samuel R. Buss and Leszek Kołodziejczyk, “Small Stone in Pool”, *Logical Methods of Computer Science* 10, 2 (2014) Paper 16.
- [103] Samuel R. Buss and Michael Soltys, “Unshuffling a Square is NP-Hard”, *Journal of Computer and System Sciences* 80, 4 (2014) 766-776.
- [104] Maria Luisa Bonet and Samuel R. Buss, “An Improved Separation of Regular Resolution from Pool Resolution and Clause Learning (Extended Abstract)”, 23rd International Joint Conference on Artificial Intelligence (IJCAI’13), AAAI Press, pp. 2972-2976, 2013.
- [105] Samuel R. Buss, “Alternation Trading Proofs and Their Limitations”, Proc. 38th International Symposium on Mathematical Foundations of Computer Science (MFCS 2013), Lecture Notes in Computer Science 8087, Springer-Verlag, pp. 1-7, 2013.
- [106] Samuel R. Buss, Douglas Cenzer, and Jeff Remmel, “Sub-computable bounded pseudorandomness”, *Logical Methods of Computer Science*, 10, 4 (2014) paper 15.
- [107] James Aisenberg, Maria Luisa Bonet, and Samuel R. Buss, “Quasipolynomial size proofs of Frankl’s theorem on the trace of sets”, *Journal of Symbolic Logic*, 81, 2 (2016) 1-24.



- [108] Samuel R. Buss, “Quasipolynomial size proofs of the propositional pigeonhole principle”, *Theoretical Computer Science*, 576, C (2015) 77-84.
- [109] James Aisenberg, Maria Luisa Bonet, Samuel R. Buss, Adrian Crăciun, and Gabriel Istrate, “Short proofs of the Kneser-Lovász coloring principle”, To appear in *Information and Computation*. Earlier version appeared in Proc. 42nd International Colloquium on Automata, Languages and Programming (ICALP 2015), Springer Verlag Lecture Notes in Computer Science 9135, pp 44-55. July 2015.
- [110] Samuel R. Buss, “Propositional proofs in Frege and extended Frege systems (abstract)”, Proc. 10th International Computer Science Symposium in Russia (CSR), Lecture Notes in Computer Science 9139, Springer Verlag, 2015, pp. 1-6.
- [111] Arnold Beckmann, Sam Buss, Sy David Friedman, Moritz Müller and Neil Thapen, “Cobham Recursive Set Functions”, *Annals of Pure and Applied Logic* 167, 3 (2016) 335-369.

**Submitted for publication:**

- [112] Sam Buss, “Uniform Proofs of ACC Representations”, submitted for publication.
- [113] Arnold Beckmann, Sam Buss, Sy David Friedman, Moritz Müller and Neil Thapen, “Cobham Recursive Set Functions and Weak Set Theories”, submitted for publication.
- [114] Arnold Beckmann, Sam Buss, “The NP Search Problems of Frege and Extended Frege Proofs”, submitted for publication.
- [115] Sam Buss, Douglas Cenzer, Mia Minnes, Jeffrey B. Remmel, “Injection Structures Specified by Finite State Transducers”, submitted for publication.

**Other Publications:**

- [116] Samuel R. Buss, A review of three papers of N. Immerman. *Journal of Symbolic Logic* 54 (1989) 287-288.
- [117] Samuel R. Buss A review of “Exponential lower bounds for the pigeonhole paper” by Beame, Impagliazzo, Krajíček, Pitassi, Pudlák and Woods. *Computing Reviews* 34 (May 1993) 261. Reprinted in *SIGACT News* 24 (1993) 41.
- [118] Samuel R. Buss, A review of the biography of K. Gödel, “Logical Dilemmas” by John W. Dawson, Jr. In *SIAM Review*, 40 (1998) 397-400.

**Software packages available online, all open source:**

- [119] OpenGL Computer graphics software accompanying the book *3D Computer Graphics: A Mathematical Introduction with OpenGL*.
- [120] Raytrace software, accompanying the same book and subsequently extended.
- [121] Inverse Kinematics demos. (with Jin-Su Kim).
- [122] Spherical Averages and Spherical Splines. Software for the Buss-Fillmore spherical averages algorithms.
- [123] `bussproofs.sty`. The “Buss proofs” LaTeX/TeX style file for creating proof trees.
- [124] `qcmatch`. Quasiconvex minimum-cost matching algorithm in ANSI C. (joint with D. Robinson, K. Kanzelberg, P. Yianilos).

**Technical Reports and Unpublished Items:**

More unpublished items available on my web page.

- [125] Samuel R. Buss, “Neighborhood metrics on  $n$ -dimensional blocks of characters”, MSRI Technical Report. Submitted to PAMI back in 1986. Never obtained a final answer after several queries to the editor and the editor-in-chief (neither accepted nor rejected!) and I have not gone back to it in years.
- [126] Samuel R. Buss, Stephen A. Cook, Patrick W. Dymond and Louise Hay, “The log space oracle hierarchy collapses.” Technical report #CS87-103, University of California, San Diego. September 1987.
- [127] Samuel R. Buss, Kirk G. Kanzelberger, David Robinson and Peter N. Yianilos, “Solving the minimum-cost matching problem for quasi-convex tours: an efficient ANSI C implementation,” Technical Report #370, Department of Computer Science Engineering, UCSD, April 1994.
- [128] Samuel R. Buss and Peter Clote, “Threshold Logic Proof Systems”, Unpublished manuscript, May 1995.
- [129] Samuel R. Buss, “Lectures on Proof Theory”, Tech. report no. SOCS-96.1, School of Computer Science, McGill University, 117 pages.
- [130] Samuel R. Buss and Peter N. Yianilos, “A bipartite matching approach to approximate string comparison and search.” Typeset manuscript, 1996.
- [131] Samuel R. Buss and Peter N. Yianilos, “Secure Short-Key Cryptosystems: Forty Bits is Enough.” Unpublished manuscript, 1998.
- [132] Samuel R. Buss and Rosalie Iemhoff, “The Depth of Intuitionistic Cut-Free Proofs”, Unpublished manuscript, 2004.

- [133] Samuel R. Buss, "Introduction to Inverse Kinematics with Jacobian Transpose, Pseudoinverse, and Damped Least Squares Methods", Unpublished survey article, 2004.

## Talks at Conferences

1. “The Polynomial Hierarchy and Fragments of Bounded Arithmetic,” Mid-Atlantic Mathematical Logic Conference, Institute for Advanced Study, Princeton, March 1984 (20 minutes).
2. “The Polynomial Hierarchy and Fragments of Bounded Arithmetic,” Logic Colloquium '84, the ASL European summer meeting, Manchester University, England, July 1984 (Contributed).
3. “The Polynomial Hierarchy and Fragments of Bounded Arithmetic,” 17-th Annual ACM Symposium on Theory of Computing, Providence, Rhode Island, May 1985.
4. “Connections between Bounded Arithmetic and Computational Complexity,” Joint AMS-IMS-SIAM Summer Research Conference on Applications of Mathematical Logic to Finite Combinatorics, Humboldt State University, Arcata, California, August 1985 (Contributed).
5. “Connections between Bounded Arithmetic and Computational Complexity (a survey),” Open Days in Model Theory and Set Theory, Jachranka, Poland, May 1986.
6. “The Polynomial Hierarchy and Intuitionistic and Classical Bounded Arithmetic,” Open Days in Model Theory and Set Theory, Jachranka, Poland, May 1986.
7. “The Polynomial Hierarchy and Intuitionistic Bounded Arithmetic,” Structure in Complexity Conference, Berkeley, June 1986.
8. “The Polynomial Hierarchy and Intuitionistic Bounded Arithmetic,” Logic Colloquium '86, the ASL European summer meeting, University of Hull, England, July 1986.
9. “Intuitionistic Bounded Arithmetic and Polynomial Time Computation,” MAA-AMS Annual Meeting, San Antonio, Texas, January 1987.
10. “The Boolean Formula Value Problem is in ALOGTIME,” 19-th Annual ACM Symposium on Theory of Computing, New York, New York, May 1987.
11. “Weak Axioms for Arithmetic and Connections to Computational Complexity,” Workshop on Logic and Computation, Carnegie-Mellon University, July 1987.
12. “On Lengths of Sentential Proofs,” Very Informal Gathering, University of California, Los Angeles, January 1988.

13. "On Truth-table Reducibility to SAT and the Difference Hierarchy over NP," Structure in Complexity Conference, Washington, D.C., June 1988.
14. "Short Self-Consistency Proofs in Weak Proof Systems," International Symposium '88 on Mathematical Logic and Its Applications, Nagoya, Japan, November 1988.
15. "Feasible Theories of Arithmetic," Interdisciplinary Conference on Axiomatic Systems, Columbus, Ohio, December 1988.
16. "Feasibly Constructive Theories of Arithmetic," Workshop on Feasible Mathematics, Ithaca, New York, June 1989.
17. "Subsystems of Arithmetic", Three two-hour-long talks at Logic Colloquium '89, Berlin, July 1989.
18. "The Undecidability of  $k$ -Provability for the Sequent Calculus," Workshop on Logic from Computer Science, Mathematical Sciences Research Institute, Berkeley, November, 1989.
19. "The Undecidability of  $k$ -Provability for the Sequent Calculus," Leeds Proof Theory Conference, Leeds, England, August 1990.
20. "The Method of Witnessing Functions applied to Fragments of Peano Arithmetic," Fourth Asian Logic Conference, Tokyo, Japan, September, 1990.
21. "The Boolean Formula Value Problem is in ALOGTIME", Workshop on Logic and Complexity Theory, Barbados, February 1991.
22. "The Deduction Rule and Number of Proof Lines", Workshop on Proof Theory, Complexity and Arithmetic, Prague, Czechoslovakia, June 1991.
23. "New and Improved Algorithms for the Boolean Formula Value Problem", Conference on Proof Theory, Complexity and Arithmetic, Prague, Czechoslovakia, June 1991.
24. "The Witness Function Method: Applications to Peano Arithmetic and Bounded Arithmetic", Ninth International Congress of Logic, Methodology and Philosophy of Science, Uppsala, Sweden, August 1991.
25. "On Gödel's Theorems and Lengths of Proofs", ASL Annual Meeting, Durham, North Carolina, March 1992.
26. "On Gödel's Theorems and Lengths of Proofs", Second Workshop on Feasible Mathematics, Ithaca, New York, May 1992.
27. "On Gödel's Theorems and Lengths of Proofs", Computer Science Logic Workshop, Dagstuhl, Germany, July 1992.

28. “Bounded Arithmetic, Propositional Proofs and Complexity” Workshop on Constructivity and Computation, Driebergen, The Netherlands, June 1993.
29. “Provability and Unprovability of Consistency Statements in Theories of Arithmetic,” Conference on Proof Theory, Provability and Computation (PPC’94), Bern, Switzerland, March 1994.
30. “A Generalization of Herbrand’s Theorem in the Sequent Calculus,” Logic and Computational Complexity Conference, Indianapolis, Indiana, October 1994.
31. Seven lectures (15 hours) on propositional proof complexity, Gödel’s theorems on lengths of proofs, interpolation theorems, bounded arithmetic, natural proofs, Boolean formula value problem and cutting plane proof systems. 1995 Barbados Workshop on Complexity Theory, Holetown, Barbados, March 1995.
32. “Bounded Arithmetic and Propositional Proofs,” NATO International Summer School on Logic of Computation, Marktoberdorf, Germany, July-August 1995. Five hours of lectures.
33. Seven lectures (7 hours) on computational complexity, bounded arithmetic, interpolation theorems, and natural proofs. DIMACS Summer School on Bounded Arithmetic and Complexity of Proofs. New Brunswick, New Jersey, August 1995.
34. “Designing Lower Bounds,” Workshop of Feasible Arithmetics and Complexity of Proofs. DIMACS, Rutgers, New Brunswick, New Jersey, April 1996.
35. “Algebraic Proof Systems,” Sixth Asian Logic Conference, Beijing, China, May 1996.
36. “Interpolation, Arithmetic and Complexity,” Sixth CSLI Workshop on Logic, Language and Computation, Stanford, California, May 1997.
37. “Interpolation, Arithmetic and Complexity,” Workshop: Special Year on Logic and Algorithms – One Year Later, DIMACS, Rutgers, New Brunswick, New Jersey, July 1997.
38. “Complexity of Proofs,” NATO International Summer School on Logic of Computation, Marktoberdorf, Germany, July-August 1997. Four hours of lectures.
39. “Resolution, The Pigeonhole Principle and Proof Complexity,” Computer Science Logic ’97, Basic Research in Computer Science Institute (BRICS), Aarhus, Denmark, August 1997.

40. "Alogtime Algorithms for Tree Isomorphism, Comparison and Canonization," Fifth Kurt Gödel Colloquium (KGC'97), Vienna, Austria, August 1997.
41. Four lectures on "Proof Complexity," Dutch Research Logic School tutorials, Workshop on Logic, Computability and Complexity, Amsterdam, March 1988
42. "The NP-Hardness of Approximating Shortest Proof Length," Workshop on Logic, Computability and Complexity, Amsterdam, March 1998.
43. "Complexity of Proofs and Complexity of Computation" two hour tutorial lecture at 5th Workshop on Logic, Language, Information and Computation, São Paulo, Brazil, July 1998.
44. "Complexity of the Disjunction and Existential Properties," 5th Workshop on Logic, Computability and Complexity, São Paulo, Brazil, July 1998.
45. "On the Complexity of Propositional Algebraic Proofs," Mid-Atlantic Mathematical Logic Seminar, New York, April 1999.
46. "On the Computational Complexity of Intuitionistic Logic," Workshop on Intrinsic Complexity of Computation, DIMACS, Rutgers, April 2000.
47. "Ordinal Notations and Well-Orderings in Bounded Arithmetic," Workshop in Honour of Steve Cook, Fields Institute, Toronto, April 2000.
48. "Prospects for the Mathematical Logic in the Next Century", Panel discussion (panel chair and panel member), ASL Annual Meeting, Urbana-Champaign, June 2000.
49. "Definability and Complexity in Bounded Arithmetic," ASL Summer Meeting, Paris, July 2000.
50. "Extracting feasible algorithms from intuitionistic proofs," Tarski Centenary Conference, Warsaw, May 2001.
51. "Recent Developments in Proof Complexity and Computational Complexity," Panhellenic Logic Symposium (PLS-3), Crete, July 2001.
52. "Results on  $k$ -provability," Workshop on Circuit and Proof Complexity, Edinburgh, Scotland, October 2001.
53. "Taylor Series Methods for Rigid Body Simulation and Extensions to Lie Groups", SIAM Conference on Geometric Design and Computing, Sacramento, November 2001.
54. "Polynomial-size Frege and Resolution Proofs of st-Connectivity and Hex Tautologies", Workshop on Proof Theory: Workshop on Logic, Methodology and Metamathematics, Muenster, Germany, October 2003.

55. “Bounded Arithmetic and Bounded Depth Propositional Proofs”, Takeuti Symposium: Symposium on Mathematical Logic '03, Kobe, Japan, December 2003.
56. “Polynomial-size Frege and Resolution Proofs of st-Connectivity and Hex Tautologies”, 12th Latin American Symposium in Mathematical Logic, Costa Rica, January 2004.
57. “Ed Nelson’s Work on Foundations and Logic: Radical Constructivism”, Analysis, Probability and Logic, A Conference in Honor of Ed Nelson Pacific Institute of Mathematical Sciences, Vancouver, British Columbia, May 2004.
58. “Bounded Arithmetic and Constant Depth Propositional Proofs”, Workshop on Complexity Theory, Banff International Research Station, Banff, July 2004.
59. “Bounded Arithmetic, Constant Depth Proofs and st-Connectivity”, Very Informal Gathering, UCLA Logic Center, February 2005.
60. “Proof Complexity and Computational Hardness”, Computability in Europe (CiE 2006), Swansea, Wales, June-July 2006.
61. “Propositional Proof Systems and Search”, Connections II: Fundamentals of Network Science, Pasadena, August 2006.
62. “Provably Total Functions and Bounded Arithmetic”, Parikh Workshop, CUNY, New York, December 2006.
63. “The Computational Power of Bounded Arithmetic from the Predicative Viewpoint”, Winter Meeting of the Association for Symbolic Logic, Joint Mathematics Meetings, San Diego, January 2007.
64. “SAT Solver Trials”, Annual Meeting of the Association for Symbolic Logic, Irvine, May 2008.
65. “Polynomial Local Search Higher in the Polynomial Hierarchy and Bounded Arithmetic”, BIRS Workshop on Computability, Reverse Mathematics and Combinatorics, Banff, Canada, December 2008.
66. “Polynomial Local Search Higher in the Polynomial Hierarchy and Bounded Arithmetic”, Annual Meeting of the Association for Symbolic Logic, Notre Dame, May 2009.
67. “Towards NP-P and Satisfiability via Proof Complexity and Proof Search”, Plenary talk, Logical Foundations of Computer Science (LFCS’09), Deerfield Beach, January 2009.
68. “The NP-Completeness of Reflected Fragments of Justification Logics”, Logical Foundations of Computer Science (LFCS’09), Deerfield Beach, January 2009.



69. “Lengths of proofs and self-reference”, Foundational Adventures Conference, Columbus, Ohio, May 2009.
70. “Polynomial Local Search Higher in the Polynomial Hierarchy and Bounded Arithmetic”, Workshop on Proof Theory and Constructivity, Leeds, England, July 2009.
71. “Introduction to NP Functions and Local Search”, Fall School on Logic and Complexity, Prague, September 2009. First of four talks.
72. “Introduction to Bounded Arithmetic and Witnessing”, Fall School on Logic and Complexity, Prague, September 2009. Second of four talks.
73. “Bounded Arithmetic, Paris-Wilkie Translations, and Witnessing in P and PLS”, Fall School on Logic and Complexity, Prague, September 2009. Third of four talks.
74. “Polynomial Local Search higher in the Bounded Arithmetic Hierarchy”, Fall School on Logic and Complexity, Prague, September 2009. Fourth of four talks.
75. “Proof Complexity and the Complexity of SAT Solvers”, First International SAT/SMT Solver Summer School, Boston, June 2011.
76. “Bounded Arithmetic and Local Search”, “30th Journées sur les Arithmétiques Faibles (JAF 2011)”, Paris, June 2011. (Contributed)
77. “Limits on Alternation-Trading Proofs for Time-Space Lower Bounds”, Journées Complexité et Modèles Finis, Paris, June 2011. (Contributed)
78. “An Improved Separation Between Regular Resolution and Pool Resolution” BIRS Workshop on Proof Complexity, Banff, Canada, October 2011.
79. “Total NP Functions I: Complexity and Reducibility”, Semantics and Semantics, A Legacy of Alan Turing, Newton Institute, Cambridge, England, March 2012.
80. “Total NP Functions II: Provability and Reducibility”, Semantics and Semantics, A Legacy of Alan Turing, Newton Institute, Cambridge, England, March 2012.
81. “Algorithmic Randomness via Probabilistic Algorithms” The Constructive in Logic and Applications, New York City, April 2012.
82. “An Improved Separation of Regular Resolution from Pool Resolution and Clause Learning”, Theory and Applications of Satisfiability Testing (SAT 2012), Trento, Italy 2012.

83. “Collapsing Modular Counting in Bounded Arithmetic and Constant Depth Propositional Proofs”, Limits of Theorem Proving conference, Rome, Italy, September 2012.
84. “Limits on Alternation-Trading Proofs for Time-Space Lower Bounds”, From Mathematical Logic to Applications (MALOA), CIRM, Luminy, France, May 2013.
85. “On Clause Learning Algorithms for Satisfiability”, Sy-David Friedman’s 60th Birthday Conference, Kurt Goedel Research Center, Austria, Vienna, July 12, 2013.
86. “Alternation Trading Proofs and Their Limitations”, 38th Intl. Symp. on Mathematical Foundations of Computer Science (MFCS 2013), Klosterneuberg, Austria, August 27, 2013.
87. “Mini-Tutorial on Proof Complexity”, Workshop on Theoretical Foundations of Applied SAT Solving, BIRS Research Station, Banff, Canada, January 2014.
88. “Cobham Recursive Set Functions”, Infinity Workshop, Kurt Gödel Research Center, Vienna, July 2014.
89. “Search Problems, Proof Complexity, and Second-Order Bounded Arithmetic”, Conference on Logic and Computational Complexity (LCC’14), Vienna, July 2014.
90. “Cobham Resursive Set Functions”, Workshop on Sets and Computations, National University of Singapore, April 2015
91. “Proof Systems Connected to SAT Solvers”, Workshop on Theory and Practice of SAT Solving, Dagstuhl, Germany, April 2015
92. “Provably Total Search Problems of Second-Order Bounded Arithmetic”, 34th Journées sur les Arithmétiques Faibles (JAF 2014) and Mid-Atlantic Mathematical Logic conference, New York City, July 2015.
93. “Propositional Proofs in Frege and Extended Frege Systems”, Computer Science in Russia (CSR 2015), Listvyanka, Russia, July 2015.
94. “Nelson’s Formalist Approach to Feasible Arithmetic and the Foundations of Mathematics”, American Philosophical Association, Western Division Meeting, San Francisco, March 2016.
95. “Tutorial on Bounded Arithmetic and Proof Complexity I & II”, Proof Complexity Workshop, St. Petersburg, Russia, May 2016. 4 hours of lectures.
96. “The Kneser-Lovász Theorem and Avoiding Topological Arguments”, Special Program in Complexity Theory, St. Petersburg, Russia, June 2016.

## Talks at Academic Institutions

1. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," Harvard University, February 1985.
2. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," Duke University, February 1985.
3. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," Massachusetts Institute of Technology, March 1985.
4. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," Purdue University, March 1985.
5. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," University of Toronto, March 1985.
6. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," Mathematical Sciences Research Institute, August 1985.
7. "A Logical Restatement of the NP/co-NP Question," Mathematical Sciences Research Institute, October 1985.
8. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," University of California, Los Angeles, February 1986.
9. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," Stanford University, February 1986.
10. "The Polynomial Hierarchy and Fragments of Bounded Arithmetic," University of California, Berkeley, February 1986.
11. "Polynomial Size Proofs of the Proposition Pigeonhole Principle," University of California, Berkeley, September 1986.
12. "Short Proofs of the Propositional Pigeonhole Principle," University of Illinois, Chicago, March 1987.
13. "The Boolean Formula Value Problem is in ALOGTIME," University of Illinois, Urbana-Champaign, March 1987.
14. "Short Proofs of the Propositional Pigeonhole Principle," University of Illinois, Urbana-Champaign, March 1987.
15. "The Boolean Formula Value Problem is in ALOGTIME," Stanford University, March 1987.
16. "The Boolean Formula Value Problem is in ALOGTIME," University of Toronto, May 1987.

17. "The Boolean Formula Value Problem is in ALOGTIME," University of California, Berkeley, June 1987.
18. "The Boolean Formula Value Problem is in ALOGTIME," Yale University, June 1987.
19. "Weak Axioms for Arithmetic and Connections to Computational Complexity," Ohio State University, November 1987.
20. "On the Lengths of Sentential Proofs," Purdue University, January 1988.
21. "On the Lengths of Propositional Proofs," Georgia Institute of Technology, January 1988.
22. "Short Proofs of the Pigeonhole Principle" University of California, San Diego, February 1988.
23. "On the Lengths of Propositional Proofs," Duke University, February 1988.
24. "On the Lengths of Propositional Proofs," Emory University, February 1988.
25. "On the Lengths of Propositional Proofs," University of Maryland, College Park, March 1988.
26. "The Undecidability of  $k$ -Provability," University of California, Los Angeles, February 1989.
27. "On Gödel's Theorem on Lengths of Proofs," University of Illinois, Urbana-Champaign, January 1991.
28. "Separations and Conservations for Fragments of Bounded Arithmetic," Stanford University, May 1991.
29. "The Witness Function Method and Provably Recursive Functions of Peano Arithmetic," Stanford University, November 1991.
30. "The Witness Function Method and Provably Recursive Functions of Peano Arithmetic," UCLA, November 1991.
31. "Propositional Proofs and their Lengths," NEC Research Institute, Princeton, New Jersey, January 1993.
32. "Lengths of Propositional Proofs of Combinatorial Principles," University of Toronto, June 1993.
33. "On Gödel's Theorems on Lengths of Proofs," Carnegie-Mellon University, January 1994.
34. "A Simplified Proof of Razborov's Theorem," Mathematics Institute, Academy of Sciences of the Czech Republic, Prague, July 1995.

35. "Interpolation, Arithmetic and Cryptography," University of Chicago, May 1997.
36. "Spherical Averages and Applications to Spherical Splines," UC Davis, November 1998.
37. "Proofs with Polynomials", Trevor Evans/Marshall Hall Lecture, Emory University, August 1999.
38. "Bounded Proofs, Bounded Arithmetic and  $\text{st}$ -Connectivity and Hex Tautologies", Wesleyan University, November 2004.
39. "Complexity of Proofs and Computation", Department Colloquium, University of Arizona, Tucson, February 2005.
40. "Power Series Methods for Rigid Body Motion and for Motion in a Lie Group", University of Arizona, Tucson, February 2005.
41. "What Makes the World Go 'Round?", High Schools Honors Awards Banquet, San Diego, May 2005.
42. "SAT Solver Trials", University of Toronto, December 2007.
43. "SAT Solver Trials: Experiments with a SAT Solver", Templeton Foundation Infinity Project, Centre de Recerca Matemàtica, Barcelona, Spain, December 2009.
44. "Bounded Arithmetic and Proof Complexity", Prague, September 2010.
45. "Limits on Alternation-Trading Proofs for Time-Space Bounds for Satisfiability" Centre de Recerca Matemàtica, Barcelona, Spain, February 2011
46. "High Accuracy Rigid Body Dynamics and Extensions to Lie Algebras", Swansea, Wales, March 2011.
47. "Limits on Alternation-Trading Proofs for Time-Space Bounds for Satisfiability" Swansea, Wales, March 2011.
48. "Derivability and Expressibility, and the Complexity of Proofs", PhilMath Intersem 2011, Paris 7 Diderot, June 2011.
49. "Upper Bounding Time-Space Lower Bounds for Satisfiability Algorithms", Department of Mathematics, UCLA, September 2011.
50. "Upper Bounding Time-Space Lower Bounds for Satisfiability Algorithms", Department of Computer Science, University of Toronto, May 2013.
51. "Towards (Non)-Separations in Propositional Proof Complexity", Department of Computer Science, Stanford University, February 2014.

52. "Alternation Trading Proofs and Their Limitations", CUNY Graduate Center, New York, October 2014.
53. "Cobham recursion and polynomial time computability for sets", Department of Mathematics, Stanford University, October 2014.
54. "Complexity of propositional proofs: some theory and examples", Department of Computer Science, Swansea University, March 2015.
55. "Complexity of propositional proofs: some theory and examples", Department of Computer Science, Universitat Politecnica de Catalunya (UPC), Barcelona, April 2015
56. "The Power of Diagonalization for Separating Complexity Classes", Yandex, Moscow, Russia, July 2015.
57. "Polynomial Time Computability for Set Functions" Steklov Institute, Moscow, Russia, July 2015.
58. "Bounded Arithmetic and Propositional Inconsistency Search Functions" Czech Academy of Science, Prague, Czech Republic, July 2015.
59. "Nonconstructive Proofs of Existence for Provably Total Search Problems", Conference on Theoretical Computer Science, Moscow, Russia, April 2016.
60. "Introduction to Bounded Arithmetic", Special Program in Complexity Theory, St. Petersburg, Russia, April-May 2016, 5 lectures (biweekly schedule).

## Expository/Outreach Talks for K-12 and Undergraduate

1. “What makes the World Go Round?”, San Diego High Schools Honors Banquet Talk, May 3, 2005.
2. “A Two-Player Game”, San Diego High Schools Honors Banquet Talk, May 2, 2006.
3. Title unknown, Undergraduate Colloquium, UCSD Mathematics Department, Date unknown.
4. “It is a easy to ‘discover’ as to ‘verify’?”, San Diego Math Circles (Euclid group), May 22, 2004.
5. “Large Numbers, Busy Beavers, Noncomputability, and Incompleteness”, Food for Thought Seminar, UCSD, November 2007.
6. “Existence and Unique Existence”, San Diego Math Circles (Cauchy group), October 22, 2011. 2.5 hour presentation.
7. “Existence and Unique Existence”, Undergraduate Colloquium, UCSD Mathematics Department, November 22, 2011.
8. “Rotations, Complexes, and Quaternions”, San Diego Math Circles, (Cauchy group), February 25, 2012. 2.5 hour presentation.
9. “Dot and Cross Products: Uses in the Plane”, San Diego Math Circles, (Cauchy group), October 6, 2012. 2.5 hour presentation.
10. “Spline Curves”, San Diego Math Circles, (Cauchy group), October 5, 2013. 2.5 hour presentation.
11. “Introduction to Proof Complexity”, Dept. of Mathematics and Mechanics, St. Petersburg, Russia, May 2016.