Alexander A. Razborov

Personal data
Born on Feb 16, 1963 in the town Belovo, USSR.

Education

- 1985-87: graduate student at the Steklov Mathematical Institute, Moscow. Advisor: Prof. S.I.Adian.

- 1980-85: undergraduate student of the Moscow University, Department of Mechanics and Mathematics.

Degrees

- 1991: doctoral thesis, *Lower bounds in the Boolean Complexity.*

- 1987: PhD, *On systems of equations in free groups.*

Employment

- 2008-current: Andrew MacLeish Distinguished Service Professor, University of Chicago.

- 2000-2008: principal researcher, Steklov Mathematical Institute.

- 1991-2000: leading researcher, Steklov Mathematical Institute.

- 1987-1991: researcher, Steklov Mathematical Institute.

Part-time positions

- 2008-current: Professor, Toyota Technological Institute at Chicago.

- 2008-current: principal researcher, Steklov Mathematical Institute.

Visiting positions

- 2003-2008: Visiting Professor, Institute for Advanced Study, Princeton

- 2000-2003: Member, Institute for Advanced Study, Princeton

- 1999-2000: Visiting Researcher, Department of Computer Science, Princeton University

- 1993-1994: Member, Institute for Advanced Study, Princeton

Honors

- 2007: Göedel Prize of the European Association for Theoretical Computer Science and the Special Interest Group on Algorithms and Computation Theory of the Association for Computing Machinery.

- 1990: Rolf Nevanlinna Prize of the International Mathematical Union.

Membership

- 2000: corresponding member of the Russian Academy of Science

- 1993: Academia Europea

Editorial Boards

- Izvestiya of the Russian Academy of Sci., ser. mathem.

- Combinatorica.

- Computational Complexity.

- Theoretical Computer Science.

- Combinatorics, Probability and Computing.

- Electronic Colloquium on Computational Complexity.

Current community service

- Ackermann Annual Award for Outstanding Dissertation (jury member)

- European Association for Computer Science Logic (executive member of the Board)

- Banff International Research Station (member of the scientific board)

Program Committees

- IEEE Conference on Computational Complexity 2009

- International Conference on Logic for Programming, Artificial intelligence, and Reasoning 2008

- International Conference "Computer Science Symposium in Russia" 2008 **chair of Theory Track**

- Symposium on Foundations of Computer Science 2007

- International Conference "Computer Science Symposium in Russia" 2007

- Workshop on Logic, Language, Information and Computation 2007

- 13th International Congress of Logic, Methodology and Philosophy of Science 2007

- International Conference "Computer Science Symposium in Russia" 2006

- 2nd International Conference "Methods of logic in mathematics" 2005

- International Conference Dedicated to the 100th Anniversary of P.S.Novikov 2001

- Workshop on Circuit and Proof Complexity 2001

- Workshop on Complexity of Proofs and Computations 2000

- Logic Colloquium 2000

- Computational Complexity 2000

- Computer Science Logic 1998

- Workshop on Complexity Theory 1997

- Random97 conference

- Computer Science Logic 1994

Former students

- A. Nogin.

- O. Verbitsky (joint advisor with S.I.Adian).

- M. Alekhnovich (undergraduate)

- V. Podolski (undergraduate)

Some invited talks and lectures

- China Theory Week, Beijing, 2007, *Complexity of Propositional Proofs*

- Workshop on Computational, Descriptive and Proof Complexity, and Algorithms, Moscow, 2007, *Grand Challenges of Proof Complexity*

- Symposium on Logical Foundations of Computer Science, New York, 2007, *Natural Proofs: Ten Years After*

- Pacific Institute for the Matematical Sciences, 10th Anniversary Lecture, Vancouver, 2006, *Feasible Proofs and Computations*

- European Mathematical Society weekend, Prague, 2004, *Feasible Proofs and Computations.*

- Joint meeting of 31st International Colloquium on Automata, Languages and Programming and 19th Annual IEEE Symposium on Logic in Computer Science, Turku, 2004, *Feasible Proofs and Computations: Partnership and Fusion.*

- International Workshop on Logic and Complexity in Computer Science Dedicated to the 60th Anniversary of A. Slissenko, Paris, 2001, *Proof Complexity of pigeonhole principles.*

- 5th Developments of Language Theory Conference, Vienna, 2001, *Propositional Proof Complexity.*

- International Conference Dedicated to the 100th Anniversary of P.S.Novikov, Moscow, 2001, *Complexity of Propositional Proofs.*

- Alfred Tarsky lectures, Berkeley, 2000.

- Vision in Mathematics, Tel-Aviv, 1999, *Complexity of Proofs and Computations.*

- Collegium Logicum, Vienna, 1998, *Complexity of Resolution Proofs.*

- Logic Colloquium, Prague, 1998, *Complexity of Resolution Proofs.*

- Proof Theory and Complexity, Aarhus, 1998, *Lower Bounds for Algebraic Proof Systems.*

- Paul Erdös Lectures, Jerusalem, 1998.

- Coxeter Lectures, Fields Institute, Toronto, 1998.

- 23rd International Colloquium on Automata, Languages and Programming, Paderborn, 1996, *Lower bounds for propositional proofs and independence results in Bounded Arithmetic.*

- DIMACS Distinguished Lectures Series, Rutgers University, 1996, *Lower bounds for propositional proofs and independence results in Bounded Arithmetic.*

- Mathematical Foundations of Computer Science, Prague, 1995, *Lower Bounds for Propositional Proofs and Independence Results in Bounded Arithmetic.*

- The seventh International Conference on Random Structures and Algorithms, Atlanta, 1995, *Pseudorandom Function Generators in Proof Theory and Complexity Theory.*

- Workshop on Geometrical and Combinatorial Methods in the Group Theory, Edinburgh, 1993, *On systems of equations in free groups.*

- SWAT 92, Helsinki, 1992, *On small depth threshold circuits.*

- Feasible Mathematics II, Cornell University, 1992, *Bounded arithmetic and lower bounds in Boolean complexity.*

- 8th Foundamentals of Complexity Theory, Gosen, 1991, *Lower bounds for deterministic and nondeterministic branching programs.*

- International Congress of Mathematicians at Berkeley, 1986, *Lower Bounds for Monotone Complexity of Boolean Functions.*

Journal Publications

[1] A. A. Razborov. On systems of equations in a free group. *Izvestiya AN SSSR, ser. matem.*, 48(4):779–832, 1984. English Translation in *Math. USSR Izvestiya*, 25(1):115-162, 1985.

[2] A. A. Razborov. Lower bounds for the monotone complexity of some boolean functions. *Doklady Academii Nauk SSSR*, 281(4):798–801, 1985. English Translation in *Soviet Math. Dokl.*, 31:354-357, 1985.

[3] A. A. Razborov. Lower bounds of monotone complexity of the logical permanent function. *Matematicheskie Zametki*, 37(6):887–900, 1985. English Translation in *Mathem. Notes of the Academy of Sci. of the USSR*, 37:485-493, 1985.

[4] A. Razborov. Lower bounds on the size of bounded-depth networks over a complete basis with logical addition. *Mathematical Notes of the Academy of Sciences of the USSR*, 41(4):598–607, 1987. English translation in 41:4, pages 333-338.

[5] S. I. Adian and A. A. Razborov. Periodical groups and Li algebras. *Russian Mathematical Surveys*, 42(2):3–68, 1987.

[6] A. Razborov. The gap between the chromatic number of a graph and the rank of its adjacency matrix is superlinear. *Discrete Mathematics*, 108:393–396, 1992.

[7] A. Razborov. On the distributional complexity of disjointness. *Theoretical Computer Science*, 106:385–390, 1992.

[8] A. Razborov. Kolmogorov and the complexity of algorithms. *Bull. London. Math. Soc.*, 22:79–82, 1990.

[9] A. Razborov. Lower bounds on the size of switching-and-rectifier networks for symmetric Boolean functions. *Mathematical Notes of the Academy of Sciences of the USSR*, 48(6):79–91, 1990.

[10] A. Razborov. Applications of matrix methods to the theory of lower bounds in computational complexity. *Combinatorica*, 10(1):81–93, 1990.

[11] M.S. Paterson and A. A. Razborov. The set of minimal braids is $co-NP$-complete. *Journal of Algorithms*, 12:393–408, 1991.

[12] A. Borodin, A. Razborov, and R. Smolensky. On lower bounds for read-k times branching programs. *Computational Complexity*, 3(1):1–18, 1993.

[13] M. Goldmann, J. Hastad, and A. Razborov. Majority gates vs. general weighted threshold gates. *Computational Complexity*, 2:277–300, 1992.

[14] J. Hastad, A. Razborov, and A. Yao. On the shrinkage exponent for read-once formulae. *Theoretical Computer Science*, 141:269–282, 1995.

[15] A. Razborov and A. Wigderson. $n^{\Omega(\log n)}$ lower bounds on the size of depth 3 threshold circuits with AND gates at the bottom. *Information Processing Letters*, 45:303–307, 1993.

[16] A. Razborov, E. Szemerédi, and A. Wigderson. Constructing small sets that are uniform in arithmetic progressions. *Combinatorics, Probability and Computing*, 2:513–518, 1993.

[17] A. Razborov. On the parameterization of solutions for equations in free groups. *International Journal of Algebra and Computation*, 3(3):251–273, 1993.

[18] A. Razborov. Unprovability of lower bounds on circuit size in certain fragments of Bounded Arithmetic. *Izvestiya of the RAN*, 59(1):201–222, 1995. See also *Izvestiya: Mathematics 59:1, 205-227*.

[19] A. Razborov and S. Rudich. Natural proofs. *Journal of Computer and System Sciences*, 55(1):24–35, 1997.

[20] S. Buss, R. Impagliazzo, J. Krajček, P. Pudlák, A. Razborov, and J. Sgall. Proof complexity in algebraic systems and bounded depth Frege systems with modular counting. *Computational Complexity*, 6(3):256–298, 1996/1997.

[21] S. Jukna and A. Razborov. Neither reading few bits twice nor reading illegally helps much. *Discrete Applied Mathematics*, 85(3):223–238, 1998.

[22] A. Razborov, A. Wigderson, and A. Yao. Read-once branching programs, rectangular proofs of the pigeonhole principle and the transversal calculus. *Combinatorica*, 22(4):555–574, 2002.

[23] A. Razborov. Lower bounds for the polynomial calculus. *Computational Complexity*, 7:291–324, 1998.

[24] B. Kashin and A. Razborov. Improved lower bounds on the rigidity of Hadamard matrices. *Matematicheskie Zametki*, 63(4):535–540, 1998.

[25] S. Jukna, A. Razborov, P. Savicky, and I. Wegener. On P versus $NP \cap co - NP$ for decision trees and read-once branching programs. *Computational Complexity*, 8(4):357–370, 1999.

[26] D. Grigoriev and A. Razborov. Exponential complexity lower bounds for depth 3 arithmetic circuits in algebras of functions over finite fields. *Applicable Algebra in Engineering, Communication and Computing*, 10(6):465–487, 2000.

[27] M. Alekhnovich, E. Ben-Sasson, A. Razborov, and A. Wigderson. Space complexity in propositional calculus. *SIAM Journal on Computing*, 31(4):1184–1211, 2002.

[28] M. Alekhnovich, E. Ben-Sasson, A. Razborov, and A. Wigderson. Pseudorandom generators in propositional proof complexity. *SIAM Journal on Computing*, 34(1):67–88, 2004.

[29] M. Alekhnovich and A. Razborov. Lower bounds for the polynomial calculus: non-binomial case. *Proceedings of the Steklov Institute of Mathematics*, 242:18–35, 2003.

[30] A. Razborov. Resolution lower bounds for the weak functional pigeonhole principle. *Theoretical Computer Science*, 303(1):233–243, 2003.

[31] A. Razborov. Resolution lower bounds for perfect matching principles. *JCSS*, 69(1):3–27, 2004.

[32] A. Razborov. Quantum communication complexity of symmetric predicates. *Izvestiya of the Russian Academy of Science, Mathematics*, 67(1):159–176, 2003.

[33] A. Razborov. An upper bound on the threshold quantum decoherence rate. *Quantum Computation and Information*, 4(3):222–228, 2004.

[34] A. Razborov. Guessing more secrets via list decoding. *Internet Mathematics*, 2(1):21–30, 2005.

[35] V. Lifschitz and A. Razborov. Why are there so many loop formulas? *ACM Transactions on Computational Logic*, 7(2):261–268, 2006.

[36] A. Razborov. Flag algebras. *Journal of Symbolic Logic*, 72(4):1239–1282, 2007.

[37] A. Razborov and S. Yekhanin. An $\Omega(n^{1/3})$ lower bound for bilinear group based private information retrieval. *Theory of Computing*, 3:221–238, 2007.

Conference Proceedings, Collections etc.: original results not (yet) published in journals

[1] A. A. Razborov. Bounded-depth formulae over $\{\wedge, \oplus\}$ and some combinatorial problems. In S. I. Adian, editor, *Problems of Cybernetics. Complexity Theory and Applied Mathematical Logic*, pages 149–166. VINITI, Moscow, 1988. In Russian.

[2] A. Razborov. On the method of approximation. In *Proceedings of the 21st ACM Symposium on Theory of Computing*, pages 167–176, 1989.

[3] A. Razborov. On submodular complexity measures. In M. S. Paterson, editor, *Boolean Function Complexity. London Math. Soc., Lecture Note Series* 169, pages 76–83. Cambridge University Press, 1992.

[4] A. Razborov. An equivalence between second order bounded domain bounded arithmetic and first order bounded arithmetic. In P. Clote and J. Krajček, editors, *Arithmetic, Proof Theory and Computational Complexity*, pages 247–277. Oxford University Press, 1992.

[5] A. Razborov. Bounded Arithmetic and lower bounds in Boolean complexity. In P. Clote and J. Remmel, editors, *Feasible Mathematics II. Progress in Computer Science and Applied Logic, vol.* 13, pages 344–386. Birkhaüser, 1995.

[6] M. Alekhnovich and A. Razborov. Resolution is not automatizable unless $W[P]$ is tractable. In *Proceedings of the 42nd IEEE Symposium on Foundations of Computer Science*, pages 210–219, 2001.

[7] M. Alekhnovich and A. Razborov. Satisfiability, branch-width and Tseitin tautologies. In *Proceedings of the 43nd IEEE Symposium on Foundations of Computer Science*, pages 593–603, 2002.

[8] V. Guruswami, J. Lee, and A. Razborov. Almost euclidean subspaces of ℓ_1^N via expander codes. In *Proceedings of the 19th Annual ACM-SIAM Symposium on Discrete Algorithms*, pages 353–362, 2008.

Preprints, Submutted Manuscripts etc.

[1] A. A. Razborov. On rigid matrices. Manuscript in Russian, June 1989.

[2] A. Razborov. On provably disjoint **NP**-pairs. Technical Report RS-94-36, Basic Research in Computer Science Center, Aarhus, Denmark, 1994. Available at http://www.brics.aau.dk/RS/94/36/BRICS-RS-94-36.ps.gz.

[3] A. Razborov. Improved resolution lower bounds for the weak pigeonhole principle. Technical Report TR01-055, Electronic Colloquium on Computational Complexity, 2001.

[4] A. Razborov. Pseudorandom generators hard for k-DNF resolution and polynomial calculus resolution. Manuscript available at http://www.genesis.mi.ras.ru/˜razborov, 2002.

[5] A. Razborov. On the minimal density of triangles in graphs. Manuscript, available at `http://www.mi.ras.ru/~razborov/triangles.pdf`. To appear in *Combinatorics, Probability and Computing*, 2006.

[6] A. Razborov. A product theorem in free groups. Manuscript, available at `http://www.mi.ras.ru/~razborov/`, 2007.

[7] A. Razborov and A. Sherstov. The sign-rank of AC^0. Technical Report TR08-016, Electronic Colloquium on Computational Complexity, 2008.

Conference Proceedings: survey talks

[1] A. A. Razborov. Lower bounds for monotone complexity of boolean functions. In *Proceedings of the International Congress of Mathematicians*, volume 2, pages 1478–1487, Berkeley, California, USA, 1986. In Russian. For the English translation see *Amer. Math. Soc. Transl.*, 147(2):75-84, 1990.

[2] S. I. Adian, A.A. Razborov, and N.N Repin. Upper and lower bounds for nilpotency classes of Lie algebras with Engel conditions. In *Group Theory, Proceedings of the Singapore Group Theory Conference held at the National University of Singapore, June* 8-19,1987, pages 57–75. Walter de Gruyter, 1989.

[3] A. Razborov. Lower bounds for deterministic and nondeterministic branching programs. In *Proceedings of the 8th FCT, Lecture Notes in Computer Science,* 529, pages 47–60, New York/Berlin, 1991. Springer-Verlag.

[4] A. Razborov. On small depth threshold circuits. In *Proceedings of the SWAT 92, Lecture Notes in Computer Science,* 621, pages 42–52, New York/Berlin, 1992. Springer-Verlag.

[5] A. Razborov. On systems of equations in free groups. In Combinatorial and Geometric Group Theory, Edinburgh 1993. London Mathematical Society Lecture Note Series, 204, pages 269–283. Cambridge University Press, 1995.

[6] A. Razborov. Lower bounds for propositional proofs and independence results in Bounded Arithmetic. In F. Meyer auf der Heide and B. Monien, editors, *Proceedings of the* 23*rd ICALP, Lecture Notes in Computer Science,* 1099, pages 48–62, New York/Berlin, 1996. Springer-Verlag.

[7] A. Razborov. Proof complexity of pigeonhole principles. In *Proceedings of the 5th DLT, Lecture Notes in Computer Science,* 2295, pages 100–116, New York/Berlin, 2002. Springer-Verlag.

[8] A. Razborov. Propositional proof complexity. *Journal of the ACM,* 50(1):80–82, 2003.

[9] A. Razborov. Feasible proofs and computations: partnership and fusion. In *Proceedings of the* 31*st International Colloquium, Lecture Notes in Computer Science,* 3142, pages 8–14, New York/Berlin, 2004. Springer-Verlag. Also appeared in Proceedings of the 19th LICS conference.