# Curriculum Vitae of Bojko N. Bakalov

Department of Mathematics
North Carolina State University

June 1, 2020

## Education

• Ph.D. in Mathematics, Massachusetts Institute of Technology, 2000.
Dissertation Title: *An algebraic approach to the operator product expansion.*
Advisor: Prof. Victor G. Kac.

• Diploma in Mathematics (equivalent to M.S.), Sofia University, 1996.

Research Interests: Mathematical physics, Lie algebras, vertex algebras, integrable systems.

## Experience

• Professor, Mathematics, North Carolina State University, 08/2019 to present.

• Associate Professor, Mathematics, North Carolina State University, 08/2009–08/2019.

• Assistant Professor, Mathematics, North Carolina State University, 08/2003–08/2009.

• Research Fellow, Miller Institute for Basic Research in Science, University of California, Berkeley, 08/2000–07/2003.

• Liftoff Mathematician, Clay Mathematics Institute, Cambridge MA, 06/2000–07/2000.

• Visitor, Institut des Hautes Études Scientifiques, Bures-sur-Yvette, 02/1999–08/1999.

## Awards

• PI on Simons Foundation grant "Vertex Algebras and Logarithmic Conformal Field Theory," 09/01/2018–08/31/2023, $42,000.

• PI on Simons Foundation grant "Frobenius Manifolds and $W$-Algebras," 09/01/2013–08/31/2018, $35,000.

• PI on NSF grant "International Conference Symmetries in Mathematics and Physics II," 04/01/2013–03/31/2014, $32,421.

• PI on NSA grant "$W$-Algebras, Integrable Systems, and Singularity Theory," 02/23/2011–09/30/2013, $29,992.

• Co-PI on NSF grant "Conference on Bifurcation Theory, Integrable Systems and the Bispectral Problem," 02/01/2010–01/31/2011, $24,800.

• Co-PI on NSF grant "Conference on: Quantum Groups, Algebraic Groups and Related Topics; Summer 2009, Beijing, China," 04/01/2009–03/31/2011, $43,000.

• PI on NSF grant "Algebraic Structures Related to Quantum Field Theory," 08/01/2007–07/31/2011, $109,661.

• AMS Travel grant to attend the International Congress of Mathematicians, Madrid, Spain, Aug. 22–30, 2006, $2,150.

• Hermann Weyl Prize awarded by the International Colloquia on Group Theoretical Methods in Physics, for original work of significant scientific quality in the area of the understanding of physics through symmetries, 2006.

• Faculty Research and Professional Development grant, North Carolina State University, 2005, $4,000.

• Miller Research Fellowship, University of California, Berkeley, 2000–2003.

• Liftoff Fellowship, Clay Mathematics Institute, Cambridge MA, 2000.

• Charles W. and Jennifer C. Johnson Prize for best research paper by MIT graduate student in Mathematics, 2000.

• A. P. Sloan Doctoral Dissertation Fellowship, MIT, 1999–2000.

• Silver Medal at the International Mathematical Olympiad, Sigtuna, Sweden, Aug. 1991.

### Plenary Talks since 2003

1. Workshop on Vertex Algebras and Infinite-Dimensional Lie Algebras, University of Split, Croatia, Nov. 22–25, 2018;

2. International Workshop on Vertex Operator Algebras and Symmetries, RIMS, Kyoto, Japan, July 9–13, 2018;

3. International Conference on Affine, Vertex, and W-algebras, INdAM, Rome, Italy, Dec. 11–15, 2017;

4. International Conference Representation Theory XIV, Inter-University Centre, Dubrovnik, Croatia, June 21–27, 2015;

5. Conference on Representation Theory and Related Topics, University of Connecticut, May 11–12, 2015;

6. International Conference on Hamiltonian PDEs, Frobenius Manifolds

and Geometry of Deligne–Mumford Moduli Spaces, SISSA, Trieste, Italy, Sept. 16–20, 2013;

7. Southeastern Lie Theory Workshop, Charleston, SC, Dec. 16–18, 2012;

8. International Conference on Algebraic Structures in Integrable Systems, Moscow, Russia, Dec. 3–7, 2012;

9. CRM-Fields Workshop on Infinite Dimensional Lie Theory, Montreal, Canada, Aug. 21–24, 2012;

10. AIM Workshop on Integrable Systems in Gromov–Witten and Symplectic Field Theory, Palo Alto, CA, Jan. 30–Feb. 3, 2012;

11. International Workshop on Lie Theory and Its Applications in Physics, Varna, Bulgaria, June 20–26, 2011;

12. ICM Satellite Conference on Algebraic and Combinatorial Approaches to Representation Theory, Bangalore, India, Aug. 12-16, 2010;

13. International Workshop on Quantized Algebras and Physics, Nankai University, China, July 23-26, 2009;

14. International Workshop on Lie Theory and Its Applications in Physics, Varna, Bulgaria, June 15-21, 2009;

15. International Conference on Vertex Operator Algebras and Related Areas, Illinois State University, Normal, IL, 07/11/2008;

16. International Conference on Symmetries in Mathematics and Physics, Cortona, Italy, 06/24/2008;

17. Workshop on Quantum Affine Lie Algebras, Extended Affine Lie Algebras, and Applications, Banff International Research Station, Banff, Canada, 03/06/2008;

18. Mid-Atlantic Algebra Conference, North Carolina Central University, Durham, NC, 04/21/2007;

19. Hermann Weyl Prize Lecture at the International Colloquium on Group Theoretical Methods in Physics, New York, NY, 06/27/2006;

20. Workshop on Infinite Dimensional Lie Algebras and Local von Neumann Algebras in CFT, Banff International Research Station, Banff, Canada, May 6–20, 2006;

21. Workshop on Representations of Kac–Moody Algebras and Combinatorics, Banff International Research Station, Banff, Canada, 03/30/2005;

22. The 2004 Twente Conference on Lie groups, University of Twente, Netherlands, 12/15/2004.

Invited Talks since 2003

1. Infinite-Dimensional Algebra seminar, MIT, Cambridge, MA, 05/22/2019;

2. ICM Satellite Conference on Algebras, Representations and Applications, Cusco, Peru, Aug. 27–31, 2018;

3. Infinite-Dimensional Algebra seminar, MIT, Cambridge, MA, 05/11/2018;

4. Special session on Lie Algebras, Superalgebras, and Applications at AMS meeting in Denton, TX, 09/09/2017;

5. Infinite-Dimensional Algebra seminar, MIT, Cambridge, MA, 05/05/2017;

6. Special session on Representation Theory and Algebraic Mathematical Physics at AMS meeting in Charleston, SC, 03/12/2017;

7. Special session on Geometry and Symmetry in Integrable Systems at AMS meeting in Charleston, SC, 03/11/2017;

8. Mini-conference on Vertex Algebras, University of Denver, Oct. 10-11, 2016;

9. Special session on Vertex Algebras and Geometry at AMS meeting in Denver, CO, 10/08/2016;

10. Dynamical Systems and Number Theory Seminar, Faculty of Mathematics, Sofia University, Bulgaria, 07/19/2016;

11. Special Session on Vertex Algebras and Related Algebraic and Geometric Structures at AMS Meeting in Stony Brook, NY, 03/20/2016;

12. Infinite-Dimensional Algebra Seminar, MIT, Cambridge, MA, 11/06/2015;

13. Mathematics and String Theory Seminar, Kavli Institute for the Physics and Mathematics of the Universe, Kashiwa, Japan, 08/05/2014;

14. Special Session on Geometric and Algebraic Aspects of Representation Theory at AMS Meeting in New Orleans, LA, 10/14/2012;

15. Infinite-Dimensional Algebra Seminar, MIT, Cambridge, MA, 05/11/2012;

16. Seminar on Geometric Methods in Representation Theory, UNC Chapel Hill, 04/27/2012;

17. Mathematics Colloquium, College of Charleston, SC, 03/23/2012;

18. Mathematics Colloquium, University of Texas, Arlington, 02/11/2011;

19. Special Session on Lie Algebras, Algebraic Groups, and Related Structures at the Joint Mathematics Meetings, New Orleans, LA, 01/07/2011;

20. Physically Inspired Mathematics Seminar, UNC Chapel Hill, 11/12/2010;

21. Special Session on Kac–Moody Algebras, Vertex Operator Algebras, and Applications at AMS Meeting in Richmond, VA, 11/06/2010;

22. Special Session on Lie Algebras and Representation Theory at AMS Meeting in Syracuse, NY, 10/02/2010;

23. Mathematics Colloquium, Louisiana State University, Baton Rouge, LA, 02/18/2010;

24. Future Scientists Club, Enloe High School, Raleigh, NC, 10/22/2009;

25. Infinite-Dimensional Algebra Seminar, MIT, Cambridge, MA, 05/08/2009;

26. Quantum Field Theory Seminar, Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, Sofia, Bulgaria, 07/03/2008;

27. Mathematics Colloquium, San Jose State University, CA, 04/30/2008;

28. Special Session on Geometric and Combinatorial Methods in Representation Theory at AMS Meeting in Davidson, NC, 03/04/2007;

29. Quantum Field Theory Seminar, Institute for Theoretical Physics, University of Göttingen, Germany, 01/03/2006;

30. Algebra Seminar, Illinois State University, Normal, IL, 12/01/2005;

31. Representation Theory Seminar, University of Illinois at Urbana-Champaign, 11/30/2005;

32. Special Session on Infinite-Dimensional Lie Algebras, Vertex Operator Algebras, and Related Topics at AMS Meeting in Annandale-on-Hudson, NY, 10/08/2005;

33. Algebraic Geometry Seminar, Queens University, Kingston, Canada, 04/04/2005;

34. Infinite-Dimensional Algebra Seminar, MIT, Cambridge, MA, 03/11/2005;

35. Mathematics Colloquium, Virginia Polytechnic Institute and State University, Blacksburg, VA, 02/11/2005;

36. Algebra Seminar, NC State University, 04/14/2004;

37. Special Session on Algebras and Their Representations at AMS Meeting in Chapel Hill, NC, 10/24/2003;

38. Algebra Seminar, NC State University, 09/17/2003;

39. Algebra Seminar, NC State University, 09/10/2003.

### Contributed Talks since 2003

1. First Year Research Seminar, NC State University, 08/23/2019;
2. First Year Research Seminar, NC State University, 02/16/2018;
3. SUM Series, NC State University, 03/02/2017;
4. AMS von Neumann Symposium, Charlotte, NC, July 4–8, 2016;
5. First Year Research Seminar, NC State University, 02/05/2016;
6. SUM Series, NC State University, 10/01/2015;
7. Algebra and Combinatorics Seminar, NC State University, 09/21/2015;
8. Algebra and Combinatorics Seminar, NC State University, 09/14/2015;
9. First Year Research Seminar, NC State University, 02/21/2014;

10. International Conference Symmetries in Mathematics and Physics II, IMPA, Rio de Janeiro, Brazil, June 24–28, 2013;

11. Math Circle in the Triangle, NC State University, 11/17/2012;

12. SUM Series, NC State University, 01/27/2010;

13. Algebra and Combinatorics Seminar, NC State University, 11/13/2009;

14. Algebra and Combinatorics Seminar, NC State University, 08/29/2008;

15. Algebra Seminar, NC State University, 11/03/2006;

16. International Congress of Mathematicians, Madrid, Spain, 08/25/2006;

17. Algebra Seminar, NC State University, 02/10/2006;

18. Algebra Seminar, NC State University, 10/14/2005;

19. Algebra Seminar, NC State University, 09/01/2004.

## Publications in Refereed Journals

1. Computation of cohomology of vertex algebras (with A. De Sole and V.G. Kac), *submitted* (2020), 56 pp.; arXiv:2002.03612.

2. Irreducible modules over finite simple Lie pseudoalgebras III. Primitive pseudoalgebras of type $H$ (with A. D'Andrea and V.G. Kac), *submitted* (2020), 62 pp.; arXiv:2001.04104.

3. Computation of cohomology of Lie conformal and Poisson vertex algebras (with A. De Sole and V.G. Kac), *submitted* (2019), 42 pp.; arXiv:1903.12059.

4. Chiral versus classical operad (with A. De Sole, R. Heluani and V.G. Kac), *accepted in IMRN* (2020), 18 pp.; arXiv:1812.05972.

5. Darboux transformations and Fay identities for the extended bigraded Toda hierarchy (with A. Yadavalli), *J. Phys. A: Math. Theor.* **53** (2020), 065202, 24 pp.

6. An operadic approach to vertex algebra and Poisson vertex algebra cohomology (with A. De Sole, R. Heluani and V.G. Kac), *Japanese J. Math.* **14** (2019), no. 2, 249–342.

7. Twisted logarithmic modules of lattice vertex algebras (with M. Sullivan), *Trans. Amer. Math. Soc.* **371** (2019), no. 11, 7995–8027.

8. Twisted logarithmic modules of free field algebras (with M. Sullivan), *J. Math. Phys.* **57** (2016), 061701, 19 pp.

9. Twisted logarithmic modules of vertex algebras, *Comm. Math. Phys.* **345** (2016), no. 1, 355–383.

10. Additional symmetries of the extended bigraded Toda hierarchy (with W. Wheeless), *J. Phys. A: Math. Theor.* **49** (2016) 055201, 25 pp.

11. Orbifolds of lattice vertex algebras under an isometry of order two (with J. Elsinger), *J. Algebra* **441** (2015), 57–83.

12. Bosonizations of $\widehat{\mathfrak{sl}}_2$ and integrable hierarchies (with D. Fleisher), *SIGMA* **11** (2015) 005, 19 pp.

13. $\mathcal{W}$-constraints for the total descendant potential of a simple singularity (with T. Milanov), *Compositio Math.* **149** (2013), no. 5, 840–888.

14. Irreducible modules over finite simple Lie pseudoalgebras, II. Primitive pseudoalgebras of type $K$ (with A. D'Andrea and V.G. Kac), *Adv. Math.* **232** (2013), no. 1, 188–237.

15. Non-linear Lie conformal algebras with three generators (with A. De Sole), *Selecta Math. (NS)* **14** (2009), no. 2, 163–198.

16. Constructing models of vertex algebras in higher dimensions (with N.M. Nikolov), *Bulg. J. Phys.* **35** (2008), no. s1, 36–42.

17. Infinite-dimensional Lie algebras in 4D conformal quantum field theory (with N.M. Nikolov, K.-H. Rehren and I. Todorov), *J. Phys. A: Math. Theor.* **41** (2008), 194002, 12 pp.

18. Unitary positive-energy representations of scalar bilocal quantum fields (with N.M. Nikolov, K.-H. Rehren and I. Todorov), *Comm. Math. Phys.* **271** (2007), no. 1, 223–246.

19. Jacobi identity for vertex algebras in higher dimensions (with N.M. Nikolov), *J. Math. Phys.* **47** (2006), no. 5, 053505, 30 pp.

20. Irreducible modules over finite simple Lie pseudoalgebras, I. Primitive pseudoalgebras of type $W$ and $S$ (with A. D'Andrea and V.G. Kac), *Adv. Math.* **204** (2006), no. 1, 278–346.

21. Field algebras (with V.G. Kac), *Int. Math. Res. Not.* **2003**, no. 3, 123–159.

22. Theory of finite pseudoalgebras (with A. D'Andrea and V.G. Kac), *Adv. Math.* **162** (2001), no. 1, 1–140.

23. On the lego–Teichmüller game (with A. Kirillov Jr.), *Transform. Groups* **5** (2000), no. 3, 207–244.

24. Cohomology of conformal algebras (with V.G. Kac and A.A. Voronov), *Comm. Math. Phys.* **200** (1999), no. 3, 561–598.

25. Highest weight modules over $W_{1+\infty}$ algebra and the bispectral problem (with E. Horozov and M. Yakimov), *Duke Math. J.* **93** (1998), no. 1, 41–72.

26. Highest weight modules of $W_{1+\infty}$, Darboux transformations and the bispectral problem (with E. Horozov and M. Yakimov), *Serdica Math. J.* **23**

(1997), no. 2, 95–112.

27. Bispectral algebras of commuting ordinary differential operators (with E. Horozov and M. Yakimov), *Comm. Math. Phys.* **190** (1997), no. 2, 331–373.

28. General methods for constructing bispectral operators (with E. Horozov and M. Yakimov), *Phys. Lett. A* **222** (1996), no. 1-2, 59–66.

29. Bäcklund–Darboux transformations in Sato's Grassmannian (with E. Horozov and M. Yakimov), *Serdica Math. J.* **22** (1996), no. 4, 571–586.

30. Tau-functions as highest weight vectors for $W_{1+\infty}$ algebra (with E. Horozov and M. Yakimov), *J. Phys. A* **29** (1996), no. 17, 5565–5573.

### Research Monograph

*Lectures on tensor categories and modular functors* (with A. Kirillov Jr.), University Lecture Series, vol. 21, American Mathematical Society, Providence, RI, 2001, x+221 pp.

### Publications in Conference Proceedings

1. Poisson vertex algebra cohomology and differential Harrison cohomology (with A. De Sole, V.G. Kac, and V. Vignoli), to appear in *Progress in Mathematics*, 2020, 23 pp.; arXiv:1907.06934.

2. Inhomogeneous supersymmetric bilinear forms (with M. Sullivan), in Proc. AMS Special Session on Representations of Lie Algebras, Quantum Groups and Related Topics, *Contemporary Math.* **713** (2018), 35–45.

3. Vertex (Lie) algebras in higher dimensions, Hermann Weyl prize lecture, in *Proc. XXVI Internat. Coll. on Group Theoretical Methods in Physics*, ed. J.L. Birman, S. Catto and B. Nicolescu, Canopus Pub. Ltd., Exeter, UK, 2009, pp. 15–20.

4. Generalized vertex algebras (with V.G. Kac), in *Lie theory and its applications in physics VI*, ed. V.K. Dobrev et al., Heron Press, Sofia, 2006, pp. 3–25.

5. Twisted modules over lattice vertex algebras (with V.G. Kac), in *Lie theory and its applications in physics V*, ed. H.-D. Doebner and V.K. Dobrev, World Scientific Publishing, River Edge, NJ, 2004, pp. 3–26.

6. Automorphisms of the Weyl algebra and bispectral operators (with E. Horozov and M. Yakimov), in *The bispectral problem*, ed. J. Harnad and A. Kasman, CRM Proceedings and Lecture Notes, vol. 14, American Mathematical Society, Providence, RI, 1998, pp. 3–10.

7. A QFT approach to $W_{1+\infty}$ (with L.S. Georgiev and I.T. Todorov), in *New trends in quantum field theory*, ed. A. Ganchev et al., Heron Press, Sofia, 1996, pp. 147–158.

## Teaching and Mentoring

• Courses taught at NCSU include: Abstract Algebra; Applications of Algebra; Calculus III; Calculus for Life and Management Sciences; Introduction to Manifold Theory; Introduction to Modern Algebra for Mathematics Majors; Introduction to Probability; Introduction to Riemannian Geometry; Lie Algebras; Linear Algebra; Quantum Computation; Representations of Infinite-Dimensional Lie Algebras; Soliton Equations; Vertex Algebras.

• Coaching undergraduate math students for the Putnam Competition, since 2004.

• Directed an REU project during Summer 2010 with 4 undergraduate students.

• Directed REG projects during the Summers of 2011, 2012, and 2013.

• Supervised 5 M.S. students and 20 undergraduate math students.

• Teaching Assistantships at MIT (1997–1998) and Sofia University (1995–1996).

## Postdoctoral Advisees

1. Maria Vega, 2012–2015, United States Military Academy.

## Ph.D. Students

1. Katie Liszewski, Ph.D. 2011 (co-advised with N. Jing). Employed at the Federal Bureau of Investigation. Dissertation title: *The charged free boson integrable hierarchy.*

2. Daniel Fleisher, Ph.D. 2013. Postdoctoral fellow at the Weizmann Institute, Israel. Dissertation title: *Wakimoto modules, FMS bosonization and integrable hierarchies.*

3. Jason Elsinger, Ph.D. 2014. Tenure-track Assistant Professor at Spring Hill College, Mobile, AL. Dissertation title: *Classification of orbifold modules under an automorphism of order two.*

4. William Wheeless, Ph.D. 2015. Employed at the Department of Defense. Dissertation title: *Additional symmetries of the extended Toda hierarchy.*

5. McKay Sullivan, Ph.D. 2017. Tenure-track Assistant Professor at Dixie State University. Dissertation title: *Twisted logarithmic modules of free field and lattice vertex algebras*.

6. Anila Yadavalli, Ph.D. 2019. MathCEP Postdoc at the University of Minnesota. Dissertation title: *Darboux transformations and Fay identities of the extended bigraded Toda hierarchy*.

7. Samantha Kirk, expected graduation: 2020.

8. Noufe Aloudah, expected graduation: 2021.

9. Ju Wang, expected graduation: 2021.

10. Hassan Hatam, expected graduation: 2022.

11. Chris Portwood, expected graduation: 2022.

### Conferences Organized

1. Special session *Algebraic Structures in Mathematical Physics: Lie Algebras, Vertex Algebras, Quantum Algebra*, AMS meeting, Athens, GA, March 5–6, 2016.

2. Eight Southeastern Lie Theory workshop, NC State University, October 9–11, 2015.

3. International conference *Symmetries in Mathematics and Physics II*, IMPA, Rio de Janeiro, Brazil, June 24–28, 2013.

4. Special session *Completely Integrable Systems, Random Matrices, and the Bispectral Problem*, Joint Mathematics Meetings, New Orleans, January 8, 2011.

5. International conference *Bifurcation Theory, Integrable Systems, and the Bispectral Problem*, Sofia University, Bulgaria, May 15–19, 2010.

6. International workshop *Algebraic Groups, Quantum Groups and Related Topics*, Peking University, Beijing, China, July 18–22, 2009.

7. Special session *Kac–Moody Algebras, Vertex Algebras, Quantum Groups, and Applications*, AMS meeting, Raleigh, NC, April 4–5, 2009.

### Editorial and Review Service

• Served on the editorial board of the journal ISRN Algebra, 2011–2014.

• Refereed NSF proposals in 2003, 2011, NSA proposals in 2009, 2011, 2015, 2016, an NSERC (Canada) proposal in 2009, and an NWO (Netherlands) proposal in 2016.

• Served on NSF proposal review panels in 2011 and 2014.

• Refereed articles for: Acta Mathematica; Advances in Mathematics; Communications in Algebra; Communications in Mathematical Physics; Contemporary Mathematics; Duke Mathematical Journal; International Journal of Mathematics; Israel Journal of Mathematics; Journal of Algebra; Journal of Algebra and Its Applications; Journal of the European Mathematical Society; Journal of Lie Theory; Journal of Mathematical Physics; Journal of Physics A; Journal of Generalized Lie Theory and Applications; Letters in Mathematical Physics; Mathematical Control and Related Fields; Mathematica Scandinavica; SIGMA; Transformation Groups.

### Outreach Activities

• Gave presentations for middle and high school students: Math Circle in the Triangle, 2012; Enloe High School, Raleigh, NC, 2009.

### Department Service

• Co-organizer of the Algebra and Combinatorics Seminar at NCSU, 2008–present.

• Co-organizer of the SUM Series at NCSU, 2015–present.

• Co-organizer of the Algebra Seminar at NCSU, 2004–2008.

• Member of the following NCSU Mathematics Department committees: Faculty Advisory Committee (2012–2014, 2016–2018), Graduate Program for Majors (2015–2017), Graduate Recruitment (2004–2006, 2008–2011), High School Math Competitions (2004–2010), Hiring Committee (2012, 2015, 2019), Personnel Evaluation Committee (2019–2020), Ph.D. Preliminary Exam (2005, 2011, 2012, 2014, 2015, 2017, 2018), Postdoc Hiring Committee (2011), Putnam Competition (2004–present, co-chair since 2017), Undergraduate Honors Program (2006–present).

### University Service

• Member of the Research and Education Advisory Committee of the IBM Q Hub at NC State, since 2019.