

# Anastasia Bizyaeva

**Nonlinear dynamics · Multi-agent systems · Collective decision-making · Distributed control & AI · Complex networks**

Postdoctoral Scholar · NSF AI Institute in Dynamic Systems, University of Washington · Seattle, WA 98195

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## Education & Research Appointments

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### University of Washington

Seattle, WA, USA

POSTDOCTORAL SCHOLAR, NSF AI INSTITUTE IN DYNAMIC SYSTEMS & DEPARTMENT OF MECHANICAL ENGINEERING

Oct. 2022 — Present

- Applying ideas from control theory and nonlinear dynamical systems to analyze learning and forecasting capacity in recurrent neural networks trained with a reservoir computing approach.
- Developing new methods for nonlinear system identification for stochastic and partially observed processes, motivated by the study of self-organization in biological swarms.
- Supervised by Steven L. Brunton (Mechanical Engineering) and J. Nathan Kutz (Applied Math, Electrical and Computer Engineering)

### Princeton University

Princeton, NJ, USA

DOCTOR OF PHILOSOPHY IN MECHANICAL AND AEROSPACE ENGINEERING

Sep. 2017 — Sep. 2022

- Dissertation: *Nonlinear dynamics of multi-agent multi-option belief and opinion formation*
- Developed theory of fast and flexible biologically inspired decision-making; proposed and analyzed a new mathematical model of social decision-making for multi-agent systems; applied new modeling framework to interdisciplinary research questions, e.g. new approaches for decentralized coordination of autonomous teams and the study of political polarization.
- Advisor: Naomi Ehrich Leonard

### University of California, Berkeley

Berkeley, CA, USA

BACHELOR OF ARTS IN PHYSICS, MINOR IN MECHANICAL ENGINEERING

Sep. 2012 — Dec. 2016

## Awards

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- 2022 **Distinguished Postdoctoral Fellowship**  
NSF AI Institute in Dynamic Systems, University of Washington
- 2022 **Simons Postdoctoral Fellowship Award (offered, declined)**  
NSF-Simons Center, Harvard University
- 2021 **Princeton School of Engineering and Applied Science Award for Excellence**  
Awarded to 15 graduate students who performed at the highest level as scholars and researchers
- 2019 **Larisse Rosentweig Klein Memorial Prize, Princeton University**  
Awarded for outstanding research achievements by the third year of enrollment
- 2019 **National Science Foundation Graduate Research Fellowship**  
Award in mechanical engineering; five-year graduate research fellowship with three years of funding
- 2019 **Ford Foundation Predoctoral Fellowship Competition Honorable Mention**  
Fellowship for scholars who combine academic excellence with strong commitment to diversity
- 2018 **Howard Crathorne Phillips Fellowship in Mechanical Engineering, Princeton University**  
Award recognizing a second-year student who demonstrates excellence in coursework and research
- 2017 **Gordon Y.S. Wu Fellowship in Engineering, Princeton University**  
Fellowship awarded to the most outstanding incoming doctoral students in engineering
- 2017 **Student Service Award, UC Berkeley Physics**  
Award recognizing two undergraduate students for their service contributions to the department

# Publications

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## JOURNAL PAPERS

- [J7] N.E. Leonard, **A. Bizyaeva**, A. Franci. “Fast and flexible multi-agent decision-making”, *To appear in Annual Review of Control, Robotics, and Autonomous Systems*.
- [J6] **A. Bizyaeva**, A. Franci, and N.E. Leonard, “Nonlinear opinion dynamics with tunable sensitivity”, *IEEE Transactions on Automatic Control*, vol. 68, no. 3, pp. 1415-1430, March 2023
- [J5] A. Franci, M. Golubitsky, I. Stewart, **A. Bizyaeva**, and N.E. Leonard, “Breaking indecision in multi-agent multi-option dynamics”, *SIAM Journal on Applied Dynamical Systems*, vol. 22, no. 3, pp. 1780-1817, August 2023.
- [J4] **A. Bizyaeva**, G. Amorim, M. Santos, A. Franci and N. E. Leonard, “Switching transformations for decentralized control of opinion patterns in signed networks: application to dynamic task allocation”, *IEEE Control Systems Letters*, June 2022.
- [J3] S. Park, **A. Bizyaeva**, M. Kawakatsu, A. Franci, N.E. Leonard, “Tuning cooperative behavior in games with nonlinear opinion dynamics”, *IEEE Control Systems Letters*, vol. 6, pp. 2030-2035, December 2021.
- [J2] N.E. Leonard\*, K. Lipsitz\*, **A. Bizyaeva\*\***, A. Franci\*\*, and Y. Lelkes\*\*. “The nonlinear feedback dynamics of asymmetric political polarization”, *Proceedings of the National Academy of Sciences*, vol. 118, no. 50, pp. 1-9, December 2021.
- [J1] A. Franci, **A. Bizyaeva**, S. Park, and N.E. Leonard. “Analysis and control of agreement and disagreement opinion cascades”, *Swarm Intelligence*, vol. 15, pp. 47–82, May 2021

## PEER-REVIEWED CONFERENCE PAPERS

- [C5] **A. Bizyaeva**, A. Franci, N.E. Leonard. “Sustained oscillations in multi-topic belief dynamics over signed networks”, American Control Conference, May 2023.
- [C4] **A. Bizyaeva**, T. Sorochnikov, A. Franci, N.E. Leonard, “Control of agreement and disagreement cascades with distributed inputs”, IEEE Conference on Decision and Control, December 2021.
- [C3] **A. Bizyaeva**, A. Matthews, A. Franci, N.E. Leonard, “Patterns of nonlinear opinion formation on networks”, American Control Conference, May 2021
- [C2] L. Rosendahl, **A. Bizyaeva**, J.D. Cohen, “A novel quantum approach to the dynamics of decision making”, 42nd Annual Meeting of the Cognitive Science Society, July 2020
- [C1] S. Musslick, **A. Bizyaeva**, S. Agaron, N.E. Leonard, and J.D. Cohen. “Stability-flexibility dilemma in cognitive control: a dynamical system perspective”, 41nd Annual Meeting of the Cognitive Science Society, July 2019

## PEER-REVIEWED EXTENDED CONFERENCE ABSTRACTS

- [A1] C. Cathcart, S. Park, **A. Bizyaeva**, N.E. Leonard, “Robot navigation around oncoming movers using bio-inspired opinion dynamics”, *International Conference on Intelligent Robots and Systems (IROS), workshop on robotics-inspired biology*, 2020.

## UNDER REVIEW AND IN PREPARATION

- [1] **A. Bizyaeva**, A. Franci, and N.E. Leonard. “Multi-topic belief formation through bifurcations over signed social networks”, **Preprint (August 2023): [arXiv:2308.02755]**, *under review in IEEE Trans. on Aut. Control*.
- [2] **A. Bizyaeva\***, M. Ordorica\*, Y. Zhou, S. Levin, N.E. Leonard. “Active risk aversion in SIS epidemics on networks”, *Under review for American Control Conference*
- [3] S. Musslick, **A. Bizyaeva**. “Examining cognitive flexibility through the lens of dynamical systems”. *In prep, invited review for Current Opinion in Behavioral Sciences*

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\* or \*\* indicates equal contribution by the authors

- [4] **A. Bizyaeva**, J. N. Kutz, S. L. Brunton. “Model reduction of Lur’e systems by data-informed balancing, with application to RNNs”, *in prep.*
- [5] S. Musslick, **A. Bizyaeva**, B. Jongkees, N.E. Leonard, J.D. Cohen. “On the rational boundedness of cognitive control: cognitive stability versus cognitive flexibility”, *in prep.*

## Presentations & Tutorials

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- 2024 **Upcoming invited talk:** “Nonlinear dynamics of belief formation in social networks”  
*American Physical Society March Meeting, Focus Session on Physics of Human Social Systems*
- 2024 **Upcoming invited seminar talk:** “Nonlinear dynamics of belief formation in social networks”  
*Santa Fe Institute, Santa Fe, New Mexico*
- 2024 **Upcoming invited talk:** “Design of flexible decisions in multi-agent systems, leveraging bifurcations”  
*Workshop on Geometrically Guided Analysis and Design in Optimization and Control, Nanyang Technological University, Singapore*
- 2023 **Upcoming invited seminar talk (virtual):** “Nonlinear dynamics of collective belief formation”  
*Virginia Commonwealth University BioMath Seminar*
- 2023 **Upcoming tutorial:** “Forecasting dynamical systems with echo state neural networks”  
*Montana State University AI seminar*
- 2023 **Upcoming invited seminar talk:** “Model reduction of nonlinear feedback systems with applications to networked systems and reservoir computing”  
*Montana State University applied math seminar*
- 2023 **Invited seminar talk:** “Active risk aversion in SIS epidemics on networks”  
*Network Dynamics and Control Focus Period Seminar Series, Linköping University, Sweden*
- 2023 **Invited seminar talk:** “Nonlinear dynamics of collective belief formation”  
*KTH Royal Institute of Technology, Stockholm, Sweden*
- 2023 **Invited seminar talk:** “Nonlinear dynamics of collective belief formation”  
*Uppsala University, Uppsala, Sweden*
- 2023 **Invited seminar talk:** “Nonlinear dynamics of collective belief formation”  
*Network Dynamics and Control Focus Period Seminar Series, Linköping University, Sweden*
- 2023 **Invited seminar talk (virtual):** “Nonlinear dynamics of collective belief formation”  
*University of Iowa MathBio Seminar*
- 2023 **Invited talk:** “Nonlinear dynamics of collective belief formation”  
*Dynamical Systems in the Life Sciences Satellite Workshop, Columbus, Ohio*
- 2023 **Contributed poster:** “Nonlinear dynamics of collective decision-making on multiple options”  
*Santa Fe Institute Collective Intelligence Symposium, Santa Fe, New Mexico*

- 2023 **Paper presentation:** “Sustained oscillations in multi-topic belief dynamics over signed networks”  
*American Control Conference, San Diego, California*
- 2023 **Invited minisymposium talk:** “Nonlinear dynamics of collective belief formation”  
*SIAM Conference on Applications of Dynamical Systems, Portland, Oregon*
- 2023 **Invited poster and short talk:** “Collective belief formation on multiple interdependent options”  
“From individual to group decision making: experiments and theory” workshop at the Weizmann Institute of Science, Israel
- 2023 **Invited talk:** “Nonlinear dynamics of opinions and beliefs”  
*ControlX Seminar, University of Washington*
- 2023 **Invited talk:** “Nonlinear dynamics of collective belief formation”  
*Invited virtual talk in the research group of Francesco Bullo, Department of Mechanical Engineering, UC Santa Barbara*
- 2022 **Paper presentation:** “Switching transformations for decentralized control of opinion patterns in signed networks: application to dynamic task allocation”  
*2022 IEEE Conference on Decision and Control, Cancun, Mexico*
- 2022 **Invited tutorial:** “Network dynamic modeling of cognitive control”  
*3rd Workshop on Mental Effort, Carney Institute for Brain Science, Brown University*
- 2022 **Invited talk:** “Decision-making in multi-agent systems: a tale of symmetries and deadlocks”  
*Talk in the research group of Lakshminarayanan Mahadevan, Department of Physics, Harvard University*
- 2021 **Invited talk:** “Sensitive transitions in collective behavior: perspectives from neuronal dynamics and bifurcation theory”  
*Virtual talk in the research group of Iain Couzin, Department of Collective Behaviour, Max Planck Institute of Animal Behaviour*
- 2021 **Invited paper presentation:** “Control of agreement and disagreement cascades with distributed inputs”  
*2021 IEEE Conference on Decision and Control, virtual*
- 2021 **Invited tutorial:** “Network dynamic modeling of cognitive control”  
*2nd Workshop on Mental Effort, virtual*
- 2021 **Contributed talk & poster:** “Patterns of nonlinear opinion formation on networks”  
*2021 American Control Conference, virtual*
- 2021 **Invited minisymposium talk:** “Nonlinear dynamics of opinion cascades on networks”  
*SIAM Conference on Applications of Dynamical Systems, virtual*
- 2020 **Contributed poster:** “A general model of opinion dynamics with tunable sensitivity”  
*UCLA Institute for Pure & Applied Mathematics, Mathematical Challenges and Opportunities for Autonomous Vehicles Program, Workshop IV: Social Dynamics beyond Vehicle Autonomy, virtual*
- 2020 **Invited minisymposium talk:** “Nonlinear dynamics of agreement and disagreement decision making”  
*SIAM Conference on the Life Sciences, virtual*
- 2019 **Contributed poster:** “Stability-flexibility dilemma in cognitive control: a dynamical system perspective”  
*52nd Annual Meeting of the Society for Mathematical Psychology, Montreal, Canada*
- 2019 **Invited minisymposium talk:** “Symmetry and synthesis of agreement and disagreement dynamics”  
*SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah*

## Research Mentorship

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- 2023 - pres. Dima Tretiak (University of Washington ME Ph.D. student)  
*Physics-informed approaches to reservoir computing; mentoring with Steven Brunton.*
- 2022 - pres. Alessandra Brondetta (University of Turin physics master student)  
*Benefits of heterogeneous group attention in collaborative task-switching; mentoring with Sebastian Musslick and Giovanni Petri*
- 2022 - pres. Marcela Ordorica (Princeton MAE Ph.D. student)  
*Active control of network epidemics. Mentoring with Naomi Ehrich Leonard.*
- 2021 - 2022 Ritika Ramprasad (Princeton ECE '22), senior thesis  
*Designing and implementing strategies for human-robot interaction using a nonlinear model of opinion dynamics; mentored with María Santos, Naomi Ehrich Leonard, and Jaime Fisac*
- 2021 - 2022 Christine Ohenzuwa (Princeton MAE '23), junior independent work  
*Spatial decision-making via opinion dynamics; mentored with María Santos and Naomi Ehrich Leonard*
- 2020 - 2021 Timothy Sorochkin (University of Waterloo Physics '22), independent work  
*Numerical investigations of opinion cascades in networks of agents with dynamic attention; co-author of paper in 2021 IEEE Conference on Decision and Control; mentored with Naomi Ehrich Leonard*
- 2019 - 2020 Ayanna Matthews (Princeton Physics '20), senior thesis  
*The role of network structure and heterogeneity in nonlinear multi-agent opinion formation; co-author of paper in 2021 American Control Conference; mentored with Naomi Ehrich Leonard*

## Teaching

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### Instructor

University of Washington

#### MECHANICAL ENGINEERING

2023

- S23: ME565 Mechanical Engineering Analysis, co-instructor with Steven Brunton

### Assistant in Instruction

Princeton University

#### MECHANICAL AND AEROSPACE ENGINEERING

2019 - 2022

- F19: MAE501 Mathematical Methods of Engineering Analysis; Instructor: Luc Deike
- S20: MAE434 Modern Control; Instructor: Naomi Ehrich Leonard
- F20: MAE501 Mathematical Methods of Engineering Analysis; Instructor: Luc Deike
- S22: MAE541/APC571 Applied Dynamical Systems; Instructor: Clarence Rowley

### Instructor — Princeton Prison Teaching Initiative

Princeton Prison Teaching Initiative

#### TAUGHT MATH COURSES ACCREDITED BY RARITON VALLEY COMMUNITY COLLEGE IN THE NEW JERSEY STATE PRISON SYSTEM

2018-2021

- F18: MATH015 Basic Mathematics (East Jersey State Prison)
- S19: MATH030 Intermediate Algebra (Edna Mahan Correctional Facility for Women)
- F19: MATH020 Basic Algebra (Mountainview Youth Correctional Facility) — **Lead instructor**
- S20: MATH015 Basic Mathematics (Edna Mahan Correctional Facility for Women)
- F21: MATH015 Basic Mathematics (East Jersey State Prison)

### Math & Physics Peer Tutor

UC Berkeley

#### ATHLETIC STUDY CENTER

2013-2017

Held part-time job providing one-on-one and small-group tutoring support in math and physics for student-athletes at UC Berkeley; received weekly training on equitable teaching practices

## **Undergraduate Instructor**

*UC Berkeley*

### **WOMEN IN TECH DeCAL (STUDENT-RUN COURSE)**

*Fall 2016*

Co-designed course curriculum, led lectures and group activities in student-run course on professional development for women interested in STEM careers in industry and academia

## **Professional Service**

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### **Reviewer**

#### **JOURNALS**

IEEE Transactions on Automatic Control, IEEE Transactions on Control of Network Systems, IEEE Control Systems Letters, Automatica, SIAM Journal on Applied Dynamical Systems, Proceedings of the National Academy of Sciences of the USA, IEEE Transactions on Signal Processing, Journal of the Royal Society Interface, Systems and Control Letters

#### **CONFERENCE PROCEEDINGS**

IEEE Conference on Decision and Control, American Control Conference, IEEE International Symposium on Multi-Robot and Multi-Agent Systems, IEEE International Conference on Robotics and Automation

### **Institutional committee service**

#### **PRINCETON UNIVERSITY**

Graduate student member of Climate and Inclusion Committee, Department of Mechanical and Aerospace Engineering (2019-2021); Princeton School of Engineering and Applied Science Diversity and Inclusion Advisory Committee Member (2021-2022)

#### **UC BERKELEY**

Physics department: undergraduate member of Reading Room Planning Committee (2014-2015); undergraduate member of Major Course Committee, Service Course Committee, and Physics Chair Advisory Committee Against Sexual Harassment (2015-2016)

### **Organizer**

#### **ORGANIZING COMMITTEE MEMBER**

- 2023. Workshop on “Creative Convergence: At the Crossroads of Dance, Ecology, Neuroscience, and Control Engineering” at Princeton University, Princeton, NJ
- 2015. Zone 18 Meeting for the Society of Physics Students at UC Berkeley — Annual regional conference for physics undergraduates across California, Nevada, and Hawaii hosted in Berkeley, CA

#### **INVITED CONFERENCE SESSION ORGANIZATION**

- 2023. Minisymposium on “Collective decisions and entropy in data-driven optimization landscapes” at SIAM Conference on Optimization, Seattle, WA
- 2021. Invited session on “Dynamics of social networks” at IEEE Conference on Decision and Control, virtual
- 2021. Minisymposium on “Collective behaviour in biological and biologically inspired systems” at SIAM Conference on Applications of Dynamical Systems, virtual

## Selected Leadership, Professional Development & Outreach \_\_\_\_\_

- 2023 **“Network Dynamics and Control” Focus Period Participant, Linköping, Sweden**  
I took part in an invited 5-week residency at Linköping University followed by a 3-day workshop with leading senior scholars, with the goal of stimulating interdisciplinary interaction between scientists working on network dynamics and control from different perspectives
- 2023 **Invited Workshop Participant, Monterey, CA**  
Air Force Office of Scientific Research Workshop on “Topics at the Intersection of Deep Learning and Computational Nonlinear Control”
- 2021 **NextProf Nexus Workshop Participant, Ann Arbor, Michigan**  
Three-day workshop that prepares selected participants for a faculty position in engineering academia
- 2019 **Future Digileaders Workshop Participant, Stockholm, Sweden**  
Three day event for selected early career female researchers interested in the broad area of digitalization technology
- 2018 - 2021 **Officer, Princeton Graduate Society of Women Engineers**  
Organized various social and professional development events for women engineers at Princeton
- 2019 **Near-peer mentor, Princeton Biophysics REU**  
Mentored a community college student who was participating in a summer research program in the Biophysics department at Princeton
- 2019 **Panelist, Pathways to Graduate School, Princeton School of Engineering and Applied Science**  
Served on a panel about demystifying graduate school admissions at an event for high-achieving, rising college seniors majoring in STEM disciplines with strong potential to contribute to the diversity and excellence of our academic community
- 2018,2019 **Volunteer, Princeton MAE Harlem Prep Elementary School visit**  
Led control engineering demos at an annual Princeton visit for elementary school children from Harlem
- 2018 **Volunteer, Princeton Center for Complex Materials Frankenstein Day**  
Science experiments with elementary school-aged children
- 2015 - 2017 **Student Program Coordinator, Cal NERDS (New Experience for Research and Diversity in Sciences)**  
Held part-time job helping organize programs for a center at UC Berkeley that provides mentorship, funding, and professional development opportunities for high achieving STEM undergraduates and graduate students from diverse backgrounds
- 2013 - 2016 **Officer, UC Berkeley Society of Physics Students**  
Served as Activities Officer, Vice President, and President of the physics student club at UC Berkeley