Dervis C. Vural, Associate Professor

Department of Physics, **University of Notre Dame**
Email: dvural@nd.edu

Research Interests Evolutionary biology, ecology, biophysics

Personal Statement I specialize in the theoretical analysis of complex systems, from biological materials to ecosystems. I was trained in theoretical physics (University of Illinois at Urbana-Champaign), applied mathematics (Harvard University), and biology (Yale University). Currently, my main research thrust is to describe, predict and control the evolution of within and between species interactions, and in particular, to understand the role of physical properties of complex materials in shaping these interactions.

Employment

University of Notre Dame, Associate Professor of Physics 2020-

University of Notre Dame, Assistant Professor of Physics 2014-2020

Training

Yale University, Postdoctoral Researcher 2013-2014
Department of Molecular Cellular and Developmental Biology
Advisor: Thierry Emonet

Harvard University, Postdoctoral Researcher 2011-2013
School of Engineering and Applied Sciences
Advisor: L. Mahadevan

University of Illinois at Urbana-Champaign, Ph.D. 2002-2011
Department of Physics
Advisor: Anthony J. Leggett (Nobel Lauriate, 2003)

Middle East Technical University, Ankara, Turkey. B.S. 1998-2002
Department of Physics, Honors Program, *Magna cum Laude*

PUBLICATIONS # Vural Group Graduate Student, @ Vural Group Postdoc, + Vural Group Undergraduate, ∗ Corresponding Author.

1. M. Heidelman[#], **D.C. Vural**[*], Geomorphodynamics, evolution and ecology of vertical roots, Frontiers in Plant Science, 14:1047 (2023)

2. S. Ghonge[#], **D.C. Vural**[*], Counterfactual Thermodynamics: Extracting work from a lack of change, Physica A: Statistical Mechanics and Applications, 11:126893 (2022)

3. B. Morsky[#], **D.C. Vural**[*], Suppressing evolution through environmental switching, Jan 1, Journal of Theoretical Ecology, (2022)

4. V. Nguyen[#], **D.C. Vural**[*], Extinction in complex communities as driven by adaptive dynamics. Journal of Evolutionary Biology, doi:10.1111/jeb.13796 (2021)

5. V. Nguyen[#], **D.C. Vural**[*], Theoretical guidelines for editing ecological communities. Journal of Theoretical Biology, 534, 110945 (2021)

6. S. Ghonge[#], **D.C. Vural**[*], Disruption of equilibrium due to lack of change, arXiv:2010.00640 (2021)

7. G. Uppal[#], **D.C. Vural**[*], Circulatory systems and mortality rates, biorxiv doi.org/10.1101/2021.05.27.446029 (2021)

8. G. Uppal[#], G. Bahcecioglu, P. Zorlutuna, **D.C. Vural**[*], Tissue failure propagation as mediated by circulatory flow. Biophysical Journal, doi: 10.1016/j.bpj.2020.11.004 (2020)

   [**Featured Article**]

9. N. Rupprecht[#], **D.C. Vural**[*], Predictive Maxwell's demons, Physical Review E, 102.6 (2020): 062145.

10. G. Uppal[#], W. Hu[+], **D.C. Vural**[*]. Evolution of chemotactic hitchhiking. Journal of Evolutionary Biology. https://doi.org/10.1111/jeb.13695 (2020).

11. N. Rupprecht[#], **D.C. Vural**[*], Depletion force between disordered linear macromolecules, Physical Review E, 101.2, 022607 (2020).

12. G. Uppal[#], **D.C. Vural**[*]. Evolution of specialized microbial cooperation in dynamic fluids. Journal of Evolutionary Biology. doi:10.1111/jeb.13593 (2020).

    [**Cover Article**]

13. N. Rupprecht[#], **D.C. Vural**[*], Enhancing the predictability and retrodictability of stochastic processes. Communications Physics, Nature Publishing Group, 2.1 (2019): 57

14. N. Rupprecht[#], **D.C. Vural**[*], Maxwell's demons with finite size and response time, Physical Review Letters, 123, 080603 (2019).

15. Ghonge S.[#], **D.C. Vural**[*], Temperature as a quantum observable. Journal of Statistical Mechanics, 073102 (2018).

16. N. Rupprecht[#], **D.C. Vural**[*], Limits on Inferring the Past, Physical Review E, 97.6 (2018): 062155

17. Morsky B.[@], **D.C. Vural**[*], Cheater-altruist synergy in immunopathogenic ecological public goods games, Journal of Theoretical Biology, 454, 7: 231-239 (2018)

18. X. Fu, S. Kato, J. Long, **D.C. Vural**, S.W. Zucker and T. Emonet[*], Spatial Self-Organization Resolves Conflicts Between Individuality and Collective Migration, Nature Communications, 9.1 (2018): 2177

19. G. Uppal[#], **D.C. Vural**[*], Shearing in flow environment promotes evolution of social behavior in microbial populations. eLife. (2018) May 22;7:e34862

    [**Featured Article**]

20. D. Suma[#], A. Acun, P. Zorlutuna, **D.C. Vural**[*], Interdependence Theory of Tissue Failure: Bulk and Boundary Effects, Proceedings of the Royal Society, Open Science, 5.2 (2018):171395

21. N. Rupprecht[#], **D.C. Vural**[*], Collective Motion of Predictive Swarms, PLoS ONE, 12(10) (2017), e0186785

22. V. Nguyen[#], **D.C. Vural**[*], Morphological Inversion of Complex Diffusion, Physical Review E, 96.3 (2017): 032314

23. G. Forte[@], **D.C. Vural**[*], Iterative Control Strategies for Nonlinear Systems, Physical Review E, 96.1 (2017): 012102

24. S. Ghonge[+], **D.C. Vural**[*], Inferring Network Structure from Cascades, Physical Review E, 96.1 (2017): 012319

25. A. Acun, **D.C. Vural**, P. Zorlutuna[*], A Tissue Engineered Model of Aging: Interdependence and Cooperative Effects in Failing Tissues, Scientific Reports, 7.1 (2017): 5051

26. I.U. Can, N. Nagarajan, **D.C. Vural**, P. Zorlutuna[*]. "Muscle-Cell-Based Living Diodes", Advanced Biosystems, 1600035 (2017) [IF: 7.5-10 (estimated)].

    [**Cover Article**]

27. **D.C. Vural***, A. Isaakov, L. Mahadevan*. "Organization and Control of Evolving Interdependent Populations", Proceedings of the Royal Society Interface, 12: 20150044 (2015)

28. **D.C. Vural***, G. Morrison, Mahadevan*. "Aging in complex interdependency networks." Physical Review E 89.2 : 022811 (2014)

29. A.J. Leggett*, **D.C. Vural***, The "Tunnelling Two-Level Systems" Model of the Low-Temperature Properties of Glasses: Are "Smoking-Gun" Tests Possible?, The Journal of Physical Chemistry B, (2013).

30. **D.C. Vural**, A.J. Leggett*, Universal sound absorption in amorphous solids: A Theory of Elastically Coupled Generic Blocks, Journal of Non-Crystaline Solids, 357(11), 3528-3537 (2011)

31. **D.C. Vural***, When Models Interact with their Subjects: The Dynamics of Model-Aware Systems. PLoS ONE, 6(6): e20721 (2011)

32. T. Achler, **D.C. Vural**, E. Amir*. Counting Objects with Biologically Inspired Regulatory-Feedback Networks, Neural Networks IJCNN, IEEE, 5178976, pp. 36-40 (2009)

33. S. Erkoc*, **D.C. Vural**, Molecular-Dynamics Simulations of Carbon Nano-Cage Structures: Nanoballs and Nanotoroids. International Journal of Modern Physics C. 12(5) 685-690 (2001)

Patents

Vural DC, Ghonge S, inventors; University of Notre Dame, assignee. Methods and systems for inferring network structure from cascades. United States patent US 10,652,096. 2020 May 12.

Awarded Funding

1. NSF CBET-1805157, 6/1/2018 - 5/31/2022
Engineering of Biomedical Systems. "Tissue Engineered Model of Aging to Study the Role of Cellular Interdependence in Failing Tissues", **Role:** PI (Theoretical modeling in experimental collaboration). **Budget:** $400,000. **Award Allocation Effort**: 50%

2. Department of Defense / BioFabUSA, 8/1/2018 - 7/31/2021
Advanced Regenerative Manufacturing Institute. "A Modular Bioreactor for Large-Scale Culture of Anchorage-Dependent Cells".
Role: PI (Theoretical modeling in experimental collaboration).
Budget: $1,589,199. **Award Allocation Effort**: 25%

3. Santa Fe Institute, "Adaptation, Aging, Arrow of Time",
Grant #220020491 funded by James McDonnel Foundation, 07/01/2017 - 06/30/2022. Workshop: Irreversible Processes in Ecological Evolution. **Role:** Lead PI. **Budget:** $30,041 **Award Allocation Effort**: 100%

4. DARPA HR0011-16-C-0062, 01/01/2016 - 12/31/2018
   Biological Technology Office. "Ecological & Biosocial Control: Directing Coevolving Networks", **Budget:** $338,682. **Role:** Sole PI. **Award Allocation Effort**: 100%

5. NSF PHY-1607643, 6/15/2016 - 5/31/2017
   Physics of Living Systems. "Workshop on Aging and Failure in Biological, Physical and Engineered Systems", **Role:** Lead PI. **Budget:** $31,442. **Award Allocation Effort**: 50%

Pending Funding

- IMPETUS "Human demography on chip for aging research"
  Role: Co-PI, **Budget:** $434,912. **Award Allocation Effort**: 50%

- NSF-CBET Biomechanics and mechanobiology, "Evolution of chemotactic hitchhiking in collectively migrating cancer cells"
  Role: Lead PI, **Budget:** $572,692. **Award Allocation Effort**: 50%

- NSF-RECODE, "Addressing cardiomyocyte heterogeneity and maturity with controlled local mechanical stress and extracellular vesicle-derived signaling molecules"
  Role: Co-PI, **Budget:** $1,500,000. **Award Allocation Effort**: 25%

- NIH National Cancer Institute, "Personalized Approach to Screening and Surveillance for Esophageal Cancer."
  Role: Co-PI, **Budget:** $512,858. **Award Allocation Effort**: 25%

Invited Talks

- Oakland University Colloquium, Department of Physics, "Evolution of specialization and social cooperation in dynamic fluids", October 31, 2019
- MIT Colloquium, Department of Physics, "Concurrent evolution of specialist and generalists in dynamic fluids.", Jun 18, 2019.
- University of Chicago, Colloquium, Department of Evolution and Ecology "Evolution of Cooperation and Specialization in Dynamic Fluids", May 6, 2019.
- Northwestern University Colloquium, Institute of Complex Systems, "Evolution of Cooperation and Specialization in Dynamic Fluids", April 17, 2019.
- Harvard University Colloquium, Department of Systems Biology, "Rise and fall of evolutionary sand castles", March 8, 2019.
- Santa Fe Institute, Invited Speaker, Workshop on Irreversible Processes in Ecological Evolution, January 29-31, 2019.

- Santa Fe Institute, Invited Speaker, Workshop on Dynamic Multi-System Resilience in Human Aging, November 12-13, 2018.
- "Cooperation, specialization, and cheating in dynamic fluids", Colloquium: Wayne State University, October 25, 2018.
- Colloquium at Santa Fe Institute. "Rise and Fall of Evolutionary Sand Castles." February 19, 2018.
- "Evolutionary Control Theory", DARPA, Biological Technology Office, Biological Control Program Kickoff, December 1, 2016, Booz Allen Hamilton One Preserve facility, Rockville, MD.
- "Filling the Gap Between Cell Damage and Tissue Failure', NSF Workshop: Aging and Failure in Biological, Physical and Engineered Systems, May 15-18, 2016.
- "Beyond Cellular Aging: How Complex Structures Fail", NSF Workshop: Physics of Wear, Tear, Aging and Failure in Living and Non-May, 6-8, 2015, Living Systems, Tysons Corner, VA.
- "Statistical Mechanics of Aging and Death", Colloquium: Western Michigan University, December 7, 2015, Kalamazoo, MI.
- "How things Fall Apart", Colloquium: Indiana University-Purdue University at Indianapolis, November 5, 2015, Indianapolis, IN.
- "Predicting Aging", Colloquium: Middle East Technical University, January 20, 2015, Ankara, Turkey.
- "Evolution of Interdependence and Aging", NSF Workshop: Biological and Physical Principles of Mammalian Aging, May 14-16, 2014, Arlington, VA.
- "Universal Properties of Disordered Materials", Workshop on Large Fluctuations and Collective Phenomena in Disordered Materials, May 16-19, 2011, University of Illinois at Urbana Champaign, IL.

Conference Presentations

- G. Uppal[#], **D.C. Vural**, Evolutionary game theory of sticky motile bacteria. American Physical Society March Meeting, March 2-6, 2020, Denver CO.
- N. Rupprecht[#], **D.C. Vural**, Maxwell's demons with finite size and response time, American Physical Society March Meeting, March 2-6, 2020, Denver CO.
- G. Uppal[#], G. Bahcecioglu, P. Zorlutuna, **D.C. Vural**, Failure propagation in multicellular tissues as mediated by advective flow, March 2-6, 2020; Denver CO.
- G. Uppal[#], **D.C. Vural**. Evolution of multicellular specialization in dynamic fluids. American Physical Society March Meeting, March 4-8, 2019; Boston, MA.
- N. Rupprecht[#], **D.C. Vural**. Enhancing the predictability and retrodictability of stochastic processes. American Physical Society March Meeting, March 4-8, 2019; Boston, MA.

- **D.C. Vural**, P. Zorlutuna, Failure Propagation in Cooperating Multicellular Systems. American Physical Society March Meeting, March 4-8, 2019; Boston, MA.
- S. Ghonge[#], **D.C. Vural**, Is Temperature a Local Realistic Variable? American Physical Society March Meeting. March 5-9, 2018; Los Angeles, CA.
- N. Rupprecht[#], **D.C. Vural**, Limits on Inferring the Past. American Physical Society March Meeting. March 5-9, 2018; Los Angeles, CA.
- V.A.T. Nguyen[#], **D.C. Vural**, Forecasting Extinction in Ecosystems with Coevolving Species. American Physical Society March Meeting. March 5-9, 2018; Los Angeles, CA.
- G. Uppal[#], **D.C. Vural**, Controlling social evolution of microbial populations. American Physical Society March Meeting. March 5-9, 2018; Los Angeles, CA.
- G. Uppal[#], **D.C. Vural**, Fluid dynamics and evolution. BMES Annual Meeting. 2017
- G. Uppal[#], **D.C. Vural**, Fluid dynamics and evolution. The Beg Rohu Summer School on Statistical Physics and Condensed Matter: Out of Equilibrium Dynamics, Evolution and Genetics. July 24, 2017
- G. Forte[#], **D.C. Vural**, Controlling stochastic nonlinear systems: "universal" strategies. American Physical Society March Meeting. March 13-17, 2017; New Orleans, LA.
- G. Uppal[#], **D.C. Vural**, Fluid dynamics and evolution. 5th Midwest Q-Bio Symposium. April 8, 2017
- BMES 2017 Annual Meeting, U.I. Can, **D.C. Vural**, P. Zorlutuna "Muscle Cell-Based 'Living' Diodes", October 11-14, 2017, Phoenix, AZ
- **D.C. Vural**, V.A.T. Nguyen[#], An Upper Bound to Catastrophe Size in Ecosystems. American Physical Society March Meeting. March 13-17, 2017; New Orleans, LA.
- V.A.T. Nguyen[#], **D.C. Vural**, Diffusion, Backward In Time: A Universal Inversion Scheme. American Physical Society March Meeting. March 14-18, 2016; Baltimore, MD.
- BMES Annual Meeting, A. Acun, **D.C. Vural**, P. Zorlutuna. A Tissue Engineered Model of Aging, October 7-10, 2016, Minneapollis, MN.
- BMES Annual Meeting, D. Suma[#], P. Zorlutuna, **D.C. Vural**. How failure propogates in aging tissues: Accelerated implosion hypothesis. October 7-10, 2016, Minneapolis, MN.
- **D.C. Vural**, G. Morrison G., L. Mahadevan, Why Do Complex Systems Age? American Physical Society March Meeting. February 27-March 2, 2012; Boston, MA.
- **D.C. Vural**, Universal Sound Attenuation in Amorphous Solids. American Physical Society March Meeting. March 21-25, 2011; Dallas, TX.
- **D.C. Vural**, Dynamics of Model Aware Systems. Complex Driven Systems – From Statistical Physics to Life Sciences Conference, October

1-3, 2010, Virginia Tech, Blacksburg.

Service

- Lead organizer, "Irreversible Processes in Ecological Evolution", Santa Fe Institute, January 29-31, 2019. Funded by James McDonnel foundation.
- Organizer and Chair in Annual Midwest Quantitative Biology Symposium at Notre Dame, April 8, 2017.
- Lead organizer, "Aging and Failure in Biological, Physical and Engineered Systems", May 15-18, 2016. Funded by NSF, Physics of Living Systems.
- Chair, APS Prairie Section. "Biological and Complex Systems", November 20, 2015.
- Reviewer for Nature Communications, Physical Review Letters, Physical Review B, Physical Review E, PLoS One, New Journal of Physics, Proceedings of the Royal Society Interface.
- Proposal Reviewer for Cariplo Foundation
- Proposal Reviewer/Panelist for NSF, Department of Energy
- Departmental service: Colloquium committee, undergraduate research committee, graduate curriculum committee, faculty hiring committee.

Teaching

Courses taught:

- PHYS10320: General Physics II
- PHYS20452: Mathematical Methods for Physicists II
- PHYS60410: Patterns of Life (**Course designed by D. Vural**)
- PHYS10062: Science Literacy
- PHYS10033: Earth Focus

Teaching Award: Received Sigma Pi Sigma, Physics Honor Society award for excellence in teaching in 2018.
Ph.D.'s graduated: Nathaniel Rupprecht, Vu Nguyen, Gurdip Uppal.
Postdocs advised: Giuseppe Forte, Bryce Morsky, Francesco Pancaldi