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CURRENT APPOINTMENTS

Assistant Professor: Department of Physics, New York Institute of Technology (Sep 2019 –)
Research Associate: Department of Astrophysics, American Museum of Natural History (Sep 2019 –)

EDUCATION and POSTDOCTORAL APPOINTMENTS

Postdoctoral fellow (Nov 2017 – Aug 2019) **Computational Neuroscience Initiative
University of Pennsylvania (UPenn)**
Mentors: Vijay Balasubramanian, Department of Physics and Astronomy; Marc Schmidt,
Department of Biology

Postdoctoral scholar (Sep 2014 – Oct 2017) **BioCircuits Inst., U. of CA, San Diego (UCSD)**
Mentor: Henry Abarbanel, Physics Department and Scripps Institution of Oceanography

Ph.D. Physics (2013) **UCSD**
Dissertation: “Probing the Nature of Cataclysmic Variables via Photometric Studies on
Multiple Timescales”
Advisors: Richard Rothschild, Center for Astrophysics and Space Sciences, UCSD;
Joseph Patterson, Department of Astronomy, Columbia University

B.A. Astrophysics (2002) **Columbia College; Columbia University**
Mentor: David Helfand, Department of Astrophysics

INTERESTS

Scientific contexts:

- predictive models of functional biological neurons and networks that are associated with the creation and reception of auditory signals;
- the information content of acoustic communication signals;
- the neural basis of pattern generation and recognition;
- nonlinear processes in neutrino astrophysics.

Approaches:

- dynamical systems, information theory, and statistical physics;
 - optimization methods for state and parameter estimation.
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CURRENT PROJECTS

Inference frameworks to predict neutrino flavor evolution following supernova core collapse

Use inference to predict the past flavor evolution of neutrinos arriving at a detector from a supernova event. In a forward-scattering only scenario, this is a relatively straightforward initial-value problem. With back-scattering, however, the problem is nonlinear, where states at later times influence states at earlier times. Flavor evolution throughout the envelope is a problem of interest in part because it sets the abundances of roughly half of the heavy elements.

Collaborators: George Fuller (UCSD), Amol Patwardhan (U. of WI, Madison), Baha Balantekin (U. of WI, Madison), Mark Paris (Los Alamos National Labs), Shashank Shalgar* (U. of Copenhagen, Denmark), Paul Rozdeba* (U. of Potsdam, Germany), Sina Fallah Ardizi (NYIT).

Inference for retrieval of exo-planet atmospheres

Estimate parameters governing the atmospheric chemical composition of exo-planets, using as Measurements directly-imaged emission spectra. Compare the advantages – including computational efficiency and degeneracy breaking – of Monte Carlo versus optimal estimation, for tackling this problem.

Collaborators: Jacqueline Faherty (AMNH), Emily Rice (AMNH), Kelle Cruz (AMNH).

Inference for the classification of objects in large astrophysical data sets

Train a classifier to operate on data sets of time series photometry containing 10^8 - 10^9 objects, for the purposes of informing theory on the evolutionary history of galaxies.

Collaborators: Michael Shara (AMNH), Jax Apollon (NYIT).

A geometric representation of birdsong to predict female song preferences

Develop a geometric representation of a song's pressure time series, via phase space reconstruction. Here, the geometric structure (or attractor) of the underlying dynamics is unfolded in a new space constructed of time-delayed vectors of the time series. We find that this representation outperforms typical sound analysis tools (e.g. spectrograms) in terms of both the preservation of phase information within a harmonic structure and predictive power regarding observed female song preferences. The model is based on audio recordings of male brown-headed cowbirds.

Collaborators: Alicia Zeng (UPenn), Marc Schmidt (UPenn), David White* (Wilfred Laurier U., Canada), Vijay Balasubramanian (UPenn).

A statistical physics framework to link song system electrophysiology to how song shapes a society

Develop a maximum-entropy Ising model to quantify a relationship between the vocalizations within an aviary of brown-headed cowbirds and the pattern of monogamous pair bonding that emerges. Electrophysiological manipulations of the neural song circuit will be performed, and we will seek to ascertain the affects of those manipulations upon the ultimate social structure.

Collaborators: Marc Schmidt (UPenn), Clelia de Mulatier (UPenn), David White* (Wilfred Laurier U.), Andrew Gersick (Princeton U.), Vijay Balasubramanian (UPenn).

A mechanistic learning model of the zebra finch song system, with capacity for “un-learning”

Expand upon current models of the avian neural song system to explain recent observations that juvenile males, when challenged to learn a new song midway through their development, will employ a range of alternate strategies in response to that challenge. This project expands upon work in my previous postdoctoral position (at UCSD), on creating a dynamical model of zebra finch song-related nucleus HVC.

Collaborators: Ofer Tchernichovski (Hunter College, CUNY), Julia Hyland Bruno (Columbia U.), Tiberiu Tesileanu (Flatiron Institute).

* *International collaboration*

PAST POSITIONS and PROJECTS

Postdoctoral fellow (Nov 2017 – Aug 2019)

Computational Neuroscience Initiative, U. of PA

Developed a dynamical systems method to analyze the acoustic structure of songs of the male

cowbird, using time-delay embedding. Combining this method with an optimization procedure, generated synthetic songs for playback to female cowbirds, to assess song potency.

Postdoctoral scholar (Sep 2014 – Oct 2017)

BioCircuits Inst., UCSD

Created a functional dynamical model of the avian neuronal circuit associated with song generation. Use optimization to estimate parameters governing the dynamics, using whole-cell recordings of HVC neurons obtained by collaborators at the University of Chicago.

Volunteer researcher (2013 – 2014)

Weill Cornell Medical Center / NY Presbyterian Hospital

Principal Investigator: Kevin Brown, M.D., Ph.D.; Department of Otolaryngology

Co-investigator: Kaleb Yohay, M.D.; Neurofibromatosis II (NF II) Clinic

Retrospective study of Neurofibromatosis II (NF II) patients to identify predictors of vestibular schwannoma (VS) progression, for clinical use. (NFII is a degenerative disease of high morbidity, characterized by the growth of multiple tumors, particularly VS).

Graduate researcher (2011-2013)

UCSD, Columbia U.

Thesis: optical time series photometry of double-degenerate binary stars with white dwarf accretors. *Aim:* Understand post-main-sequence evolution and conditions for core electron degeneracy.

Observer (2001-2013)

Columbia U.

Time series CCD photometry of 1) binary star systems and 2) gamma-ray bursts, at Kitt Peak National Observatory (KPNO) and the Cerro Tololo Inter-American Observatory (Chile).

Training of new students. *Aims:* 1) understand late binary-star evolution; 2) interpret gamma-ray bursts as signatures of black-hole versus neutron-star formation.

Graduate researcher (2004-2006)

UCSD

Analysis of optical data from Damped Lyman Alpha systems (high-redshift hydrogen clouds that are probable progenitors to spiral galaxies). Analysis of X-ray data from black hole and neutron star binaries. *Aim:* identify systematic differences between the two classes of object.

Undergraduate researcher (1999-2002)

Columbia U.

Search for stellar radio emitters using survey data, with follow-up observations at KPNO. *Aim:* identify the physical significance of emission at this bandwidth from these objects.

MEETINGS and PRESENTATIONS

SIAM Conference on the Life Sciences (June 2020)

Garden Grove, CA

Host of mini-symposium: “Mathematical and dynamical modeling approaches to the study of birdsong”

Talk: TBA

SIAM Conference on Dynamical Systems (May 2019)

Snowbird, UT

Host of mini-symposium: “Got rhythm? - a dynamical systems survival guide for biology”

Talk: “A geometric spatial reconstruction for analyzing the information content of song”

American Physical Society annual meeting (March 2019)

Boston, MA

Talk: “Can vocalizations predict mating pairs in a society of songbirds? A maximum-entropy Ising model approach”

- International Symposium on Data Assimilation** (Jan 2019) **Kobe, Japan**
RIKEN Center for Computational Science
Invited talk: “From synaptic connections among neurons to energy-changing collisions among neutrinos: using inference to map information flow”.
- The Physics of Behavior workshop** (May – Jun 2018) **Aspen Center for Physics; Aspen, CO**
Talk: “Using nonlinear dynamics to unfold the geometry of birdsong”
- Nuclear Physics Cosmology Workshop** (July 2018) **Los Alamos National Laboratories**
Talk: “Optimization predicts neutrino flavor evolution following SNe core collapse”
- Neutrinos, Nuclear Astrophysics, and Symmetries Conference** (Jan 2018) **UCSD**
Talk: “A neural networks approach to inferring neutrino astrophysics”
- Mathematical Biology seminar** (Dec 2017) **New Jersey Institute of Technology**
Talk: “Crafting functional architectures for pattern-generating networks”
- SIAM annual meeting** (July 2017) **Pittsburgh, PA**
Talk: “Data assimilation for the testing of stochastic models in mathematical biology”
- SIAM Conference on Dynamical Systems** (May 2017) **Snowbird, UT**
Talk: “A path-integral approach to data assimilation for mapping small neuronal networks”
- MURI Winter School** (Jan 2017) **BioCircuits Institute, UCSD**
Talk: “Building models of small neuronal networks and model-testing via data assimilation”
- Dynamical systems and Data Analysis in Neuroscience Workshop** (Oct 2016) **Mathematical Biosciences Inst. Ohio State U.**
Poster: “Model of the avian nucleus HVC as a network of central pattern generators”
- SIAM Conference on the Life Sciences** (July 2016) **Boston, MA**
Host of mini-symposium: “Experiment and theory combined: an ideal vantage point upon neurodynamics”
Talk: “Model of the songbird nucleus HVC as a network of central pattern generators”
- Dynamics Days U.S.** (Jan 2016) **Durham, NC**
Talk: “From the nonlinear behavior of a single neuron to the robust pattern of a network”
- Janelia Theoretical Neuroscience Workshop** (Nov 2015) **Janelia Research Campus Howard Hughes Medical Institute; Ashburn, VA**
Talk and tutorial: “Methods of statistical nonlinear data assimilation, and what they can reveal about connectivity in small neural networks”
- Dynamics Days Europe** (Sep 2015) **Centre for Systems, Dynamics, and Control: U. of Exeter, UK**
Talk: “From the nonlinear behavior of a single neuron to the robust pattern of a network”

NEWS & MEDIA

SIAM News Blog. “Empirical model aims to predict female cowbird responses to mating calls.” Sorg, Lina. May 20, 2019. <https://sinews.siam.org/Details-Page/empirical-model-aims-to-predict-female-cowbird-responses-to-mating-calls>

Retraction Watch. “A scientist models a potential prom date.” Oransky, Ivan. Apr 1, 2017. <https://retractionwatch.com/2017/04/01/publications-questionable-scientific-value-scientist-models-potential-prom-date/>

Vice. “This is the only good April Fool’s joke so everybody else can shut up.” Pearson, Jordan. Apr 1, 2017. https://www.vice.com/en_us/article/yp9kyx/this-is-the-only-good-april-fools-joke-so-everybody-else-can-shut-up

The New Stack. “Wistful researcher applies a neural network to questions about her 1997 junior prom.” Cassel, David. Apr 9, 2017. <https://thenewstack.io/wistful-researcher-applies-neural-network-questions-1997-junior-prom/>

Retraction Watch. “Clue fans, here’s scientific proof that it was Colonel Mustard with the Candlestick.” Oransky, Ivan. Apr 1, 2018. <https://retractionwatch.com/2018/04/01/clue-fans-heres-scientific-proof-that-it-was-colonel-mustard-with-a-candlestick/>

TEACHING

Assistant Professor for physics courses (2019 -) NYIT
Adjunct Professor: physics (2010-13) Cooper Union for the Advancement of Science and Art, NY
Adjunct Professor: astronomy (2011) Lehman College, City University of NY
Adjunct Instructor: astronomy (2009) College of Staten Island, City University of NY

MEMBERSHIPS

American Physical Society (APS)
Society for Industrial and Applied Mathematics (SIAM)
National Association of Science Writers

OUTREACH and SERVICE

Volunteer (March 2014) **Weill Cornell Medical Center neurotrauma course: Tanzania, Africa**
Accompanied a neuro-trauma team to host a course at the Muhimbili Orthopedic and Neurological Institute in Dar Es Salaam, Tanzania, on modern methods of neurological surgery. Recorded surgeries; wrote report for distribution to affiliates and donors.

Volunteer (2009-2014) **Weill Cornell Medical Center: Department of Neurological Surgery, NY**
Accompanied neurological patients to surgery, with follow-up visits in recovery. Served as liaison between nursing staff and families. Shadowed a neurosurgery physician’s assistant.

Volunteer (2004-6; 2011-13) **Center for Astrophysics and Space Sciences, UCSD**
Co-hosted free outreach events throughout San Diego. Mentored students visiting from schools with little access to extracurricular activities and quality science programs.

Guest lecturer (2007-8) **American Museum of Natural History: Haydn Planetarium, NY**

Volunteer (June 2002) **African Israelites Community Orphanage: Ghana, West Africa**

Taught English and math; helped orphanage founders plan a viable future for their organization.

PUBLICATIONS

Articles in preparation

1. **Armstrong, E.**, Zeng, A., Balasubramanian, V. An attractor representation of birdsong predicts song preferences in female cowbirds.
2. **Armstrong, E.**, White, D., Schmidt, M., de Mulatier, C., Balasubramanian, V. The language of statistical physics characterizes mating preferences in a society of songbirds.

Published scientific articles

1. **Armstrong, E.** Statistical data assimilation for estimating electrophysiology simultaneously with connectivity within a biological neuronal network. *Physical Review E* 101, 012415, 2020
2. **Armstrong, E.**, Patwardhan, A.V., Johns, L., Kishimoto, C.T., Abarbanel, H.D.I., Fuller, G.M. A Path-integral-based Approach to Neutrino Flavor Evolution. *Physical Review D* 96(8): 083008, 2017
3. Abarbanel, H.D.I., Shirman, S., Breen, D., Kadakia, N., Rey, D., **Armstrong, E.**, Margoliash, D. A Unifying View of Synchronization for Data Assimilation in Complex Nonlinear Networks. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 27(12): 126802, 2017
4. Abarbanel, H.D.I., Shirman, S., **Armstrong, E.**, Dean D., Extracellular Potentials as Data Assimilation Measurement Functions for the Dynamics in Networks of Neurons. (In preparation)
5. **Armstrong, E.**, Abarbanel, H.D.I. Model of the songbird nucleus HVC as a network of central pattern generators, *J. Neurophysiol.* 116(5): 2405-2419, 2016
6. Kadakia, N., **Armstrong, E.**, Breen, D., Morone, U., Daou, A., Margoliash, D., Abarbanel, H. D.I., Nonlinear Statistical Data Assimilation for HVC_{RA} Neurons in the Avian Song System. *Biological Cybernetics* 110.6:417-434, 2016
7. Breen, D., Shirman, S., **Armstrong, E.**, Daou, A., Margoliash, D., Abarbanel, H.D.I. HVC Interneuron Properties from Statistical Data Assimilation. *arXiv preprint arXiv: 1608:04433*, 2016
8. **Armstrong, E.**, Patterson, J., Michelsen, E., Thorstensen, J., Uthas, H., Vanmunster, T., Hamsch, F.-J., Roberts, G., Dvorak, S., Orbital, Superhump, and Superorbital Periods in the Cataclysmic Variables AQ Mensae and IM Eridani. *Monthly Notices of the Royal Astronomical Society (MNRAS)* 435, 707, 2013
9. **Armstrong, E.**, Patterson, J., Kemp, J. Two Photometric Periods in the AM CVn System CP Eridani. *MNRAS* 421, 2310, 2012
10. Skinner, J., Thorstensen, J., **Armstrong, E.**, Brady, S. The New Eclipsing Cataclysmic Variable SDSS 154453+255. *Publications of the Astron. Soc. of the Pacific (PASP)* 123, 901, 2011
11. Copperwheat, C.M., Marsh, T., Dhillon, V., Littlefair, S., Woudt, A., Warner, B., Patterson, J., Steeghs, D., Kemp, J., **Armstrong, E.**, Rea, R. The Photometric Period in ES Ceti. *MNRAS* 413, 3068, 2011
12. Dai, X, Halpern, J., Morgan, N., **Armstrong, E.**, Mirabal, N., Haislip, J., Reichart, D., Stanek, K., Optical and X-Ray Observations of GRB 060526: A Complex Afterglow Consistent with an Achromatic Jet Break. *Astrophysical Journal (Ap J)* 658, 509, 2007
13. **Armstrong, E.** et. al. GRB 060102: MDM Observation, *GRB Coordinates Network, Circular Service* 4427, 1, 2006
14. Thorstensen, J., **Armstrong, E.** Is FIRST J102347.6+003841 Really a Cataclysmic Binary? *Astronomical Journal (AJ)* 130, 759, 2005
15. Patterson, J., Thorstensen, J., **Armstrong, E.** The Dwarf Nova PQ Andromedae. *PASP* 117, 922, 2005
16. Patterson, J. and 19 co-authors, Superhumps in Cataclysmic Binaries. XXV. q_{crit} , $\epsilon(q)$, and

- Mass-Radius. *PASP* 117, 1204, 2005
17. Patterson, J., Thorstensen, J., Vanmunster, T., Fried, R., Martin, B., Campbell, T., Robertson, J., Kemp, J., Messier, D., **Armstrong, E.**, Rapid Oscillations in Cataclysmic Variables. XVI. DW Cancri. *PASP* 116, 516, 2004
 18. Pretorius, M.L. Woudt, P., Warner, B., Bolt, G., Patterson, J., **Armstrong, E.**, High-speed photometry of SDSS J013701.06 - 091234.9. *MNRAS* 352, 1056, 2004
 19. Mirabal, N. Halpern, J., Chornock, R., Filippenko, A., Terndrup, D., **Armstrong, E.**, Kemp, J., Thorstensen, J., Tavares, M., Espaillat, C., GRB 021004: A Possible Shell Nebula around a Wolf-Rayet Star Gamma-Ray Burst Progenitor. *Ap J* 595, 935, 2003

Articles of questionable scientific value

1. **Armstrong, E.** Forecasting Future Murders of Mr. Boddy by Numerical Weather Prediction. <https://arxiv.org/abs/1903.12604>
2. **Armstrong, E.** Colonel Mustard in the Aviary with the Candlestick: a limit cycle attractor transitions to a stable focus via supercritical Andronov-Hopf bifurcation. <https://arxiv.org/abs/1803.11559>
3. **Armstrong, E.** A Neural Networks Approach to Predicting How Things Might Have Turned Out Had I Mustered the Nerve to Ask Barry Cottonfield to the Junior Prom Back in 1997. *arXiv preprint arXiv:1703:10449*, 2017 April 1
4. **Armstrong, E.** Pipe-cleaner Model of Neuronal Network Dynamics. *arXiv preprint arXiv:1603:09723*, 2016 April 1
5. **Armstrong, E.** Non-detection of the Tooth Fairy at Optical Wavelengths. *arXiv preprint arXiv:1204.0492* 2012 April 1; *Journal of Irreproducible Results* 52, 3: 22-25, 2014

Educational material

1. Developed a textbook for Columbia College course “Frontiers of Science” (2004), which is a core requirement for undergraduates (as of 2005). Full text: <http://ccnmtl.columbia.edu/projects/mmt/frontiers/index.html>
2. Developed an educational science-themed sketch comedy group “Spin ½”, a project by Reality Aside Theatre, Inc.. Performed in Manhattan and surrounding areas for general and student audiences (2009-2011).

REFERENCES

Henry Abarbanel

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