

Anthony B. Costa, Ph.D.

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PERSONAL STATEMENT I am an interdisciplinary computational scientist. I have had the pleasure to work at the intersection of many fields through my scientific career, including fluid dynamics, machine learning, statistical and quantum mechanics, computational image analysis, and medical modeling. My current role is Assistant Professor of Neurosurgery at the Icahn School of Medicine at Mount Sinai, where I lead a group of research efforts focused on improving outcomes in medicine; These include programs in machine intelligence, computational image analysis and visualization, physics-based simulation, rapid prototyping, device design, and direct patient engagement through technology.

CURRENT APPOINTMENTS **Icahn School of Medicine at Mount Sinai**, New York, NY, USA
Assistant Professor, Neurosurgery 2015 to Present
Scientific Director, Neurosurgery Simulation Core 2015 to Present

- Perform basic science research for application of neurosurgery simulation to understanding of surgical skills and performance.
- Develop novel paradigms in neurosurgery preparation such as three-dimensional structural modeling and printing capabilities from patient-specific data sets.
- Develop novel, high-fidelity virtual-reality neurosurgery simulation through improvements in visualization, haptics, and structural modeling capabilities.
- Understand objective measures of surgical performance and their relationships to validity in surgical simulation, prediction of surgical success, and patient outcome.
- Move industry and academic simulator platforms towards production applications in clinical practice for preoperative planning and simulation.
- Develop infrastructure and methods for the analysis of multiscale, clinical neurosurgery data sets for predictive modeling of surgical success and patient outcome.

Numerical Solutions, Inc., Corvallis, OR, USA
Founder, President, and Chief Science Officer 2013 to Present

- Scientific and numerical consulting and research group with broad expertise in numerical and computational mathematics, engineering, physics, and chemistry.
- Work directly with partners to identify scientific questions and work to develop numerical methods and software implementations for their efficient solution.

PAST APPOINTMENTS **Icahn School of Medicine at Mount Sinai**, New York, NY, USA
Computational Scientist, Scientific Computing 2013 to 2015

- Application of high performance computing to computational genomics, structural and chemical biology, and basic clinical research and development efforts.
- Studied, designed, tested, and implemented massively parallel hardware and software resources in support of basic research on petascale data sets in life sciences research.
- Projects included performance optimization of next-generation-sequencing pipelines, molecular dynamics simulation for novel hardware architectures, and multiscale analysis and predictive modeling of unstructured clinical data.

EDUCATION

Northwestern University, Evanston, IL, USA

Postdoctoral Fellow

2010 to 2013

- Advised by Dr. Igal Szleifer.
- Department of Energy's Energy Frontier Research Center's Program.
- Non-Equilibrium Energy Research Center.
- Departments of Biomedical Engineering, Chemistry.

- Primary author of high-performance software for heterogeneous architectures used to study chaos in Hamiltonian dynamical systems. These tools provide an extensive toolkit for the study of deterministic chaos in the largest yet-simulated atomic and molecular systems.
- Software used to measure the importance of microscopic degrees of freedom during transient non-equilibrium processes. Demonstrated for the first time that a reduced statistical description of dissipation was possible by considering the dynamical entropy of the dissipative system only, without considering its surroundings.

Purdue University, West Lafayette, Indiana, USA

Ph.D., Magna Cum Laude, Chemistry

2010

- Advised by Dr. R. Graham Cooks.
- Thesis Topic: *Theory and Statistics of Ambient Mass Spectrometry*.
- Candidacy Exam: *Treanor Pumping Vibrational Transport on Hydrogen-Passivated Silicon Surfaces*.

- Developed general dimensionality reduction methods for imaging mass spectrometry applied to the determination of disease state in biological tissue. Real-time classification of tissue regions into an image giving the likelihood of cancer outperformed expert-analyzed histological staining. Method currently being applied *in vivo* during surgery.
- Identified, for the first time, a mechanism that explains the chiral selectivity and magic-number clustering of serine using a hierarchy of classical enhanced sampling methods and density functional theory. Serine clusters are implicated as one possible mechanism leading to the origin of biological homochirality.
- Used multi-phase and discrete particle computational fluid dynamics simulations to study droplet impact on surfaces and transport of progeny droplets. Demonstrated that momentum-transfer events explain the behavior of desorption-based ambient ionization methods in mass spectrometry. This mechanism is now widely accepted in the literature and used as the basis for the development of new ambient ionization methods.

Bowdoin College, Brunswick, Maine, USA

B.A., Music, Chemistry with Honors, Minor in Mathematics

2005

- Advised by Dr. Elizabeth A. Stemmler.
- Thesis Topic: *Fragmentation of N-Terminal Derivatives of Polyalanine Peptides by Sustained Off-Resonance Irradiation Fourier Transform Mass Spectrometry*.

PREVIOUS
WORK HISTORY

Bowdoin College, Brunswick, Maine, USA
Student Manager, Network Operations Center (NOC) 2003 to 2005

- Responsible for leadership and management of student team, including hiring, scheduling, job assignment, and general project management.
- Included all responsibilities of student staff position (described below).

Bowdoin College, Brunswick, Maine, USA
Student Network/Systems Staff, NOC 2002 to 2003

- Design, implementation, and maintenance of the core network, servers, and systems, together with a full-time professional staff.
- Included but not limited to core routing, directory services, email, database management, wired/wireless topology, and Linux/UNIX systems administration.

Bowdoin College, Brunswick, Maine, USA
Student Staff, Technology Helpdesk 2001 to 2002

- Included troubleshooting and support to students and staff for personal and professional computing, especially those related to services provided by information technology departments.

Bend Research, Bend, Oregon, USA
Intern 2002 to 2002

- Project on the characterization of polymers using size-exclusion liquid chromatography and light scattering methods.

Chemica Technologies, Inc., Bend, Oregon, USA
Intern 2001 to 2001

- Project testing the performance and properties of industrial filters for use in client-specified roles using high-performance liquid chromatography methods.

PUBLICATIONS

E. K. Oermann, J. S. Multani, J. Mascitelli, K. Nicol, J. Titano, B. Skovrlj, M. Pain, J. D. Mocco, **A. B. Costa**, R. Shrivastava, *Quantitative CT Ventriculography for Assessment and Monitoring of Hydrocephalus: a Pilot Study and Description of Method in Subarachnoid Hemorrhage (SAH)*, J. Neurosurgery, Accepted.

K. Riley, **A. B. Costa**, J. B. Bederson, R. Shrivastava, *Cranioplasty: The Role of Cranial Implants*, in *Digital Technologies in Craniomaxillofacial Surgery*, Springer, (2017) In Press.

M. Das, **A. B. Costa**, J. Green, *Extensivity and Additivity of the Kolmogorov-Sinai Entropy for Simple Fluids*, Phys. Rev. E, 92 (2017) 022102. doi:10.1103/PhysRevE.95.022102.

S. Sarkiss, S. Philemond, J. Lee, S. Sobotka, T. D. Holloway, M. Moore, **A. B. Costa**, E. Gordon, J. B. Bederson, *Neurosurgical Skill Assessment: Measuring Technical Proficiency in Neurosurgery Residents through Intraoperative Video Evaluations*, World Neurosurgery, 89 (2016) 1-8. doi:10.1016/j.wneu.2015.12.052.

S. Sultana, J. E. Blatt, Y. Lee, M. Ewend, J. S. Cetas, **A. B. Costa**, M. Audette, *Patient-Specific Cranial Nerve Identification Using a Discrete Deformable Contour Model for Skull Base Neurosurgery Planning and Simulation*, Lecture Notes in Computer Science, 4901 (2016) 36-44. doi:10.1007/978-3-319-31808-0_5.

P. Kovatch, **A. B. Costa**, Z. Giles, E. Fluder, H. M. Cho, S. Mazurkova, *Big Omics Data Experience*, SC '15 39 (2015). doi:10.1145/2807591.2807595.

T. Holloway, Z. S. Lorsch, M. A. Chary, S. Sobotka, M. M. Moore, **A. B. Costa**, R. F. Del Maestro, J. Bederson, *Operator Experience Determines Performance in a Simulated Computer-Based Brain Tumor Resection Task*, Int. J. CARS 10 (2015) 1853-1862. doi:10.1007/s11548-015-1160-y.

R. G. Brook, A. Heinecke, **A. B. Costa**, P. Peltz, Jr., M. Bader, V. C. Betro, T. Baer, R. C. Hulguin, P. Dubey, *Beacon: Exploring the Application of Intel Xeon Phi Coprocessors to Scientific Computing*, Computing in Science & Engineering 17 (2015) 65-72. doi:10.1109/MCSE.2014.113.

J. R. Green, **A. B. Costa**[‡], B. A. Grzybowski, I. Szleifer, *Relationship Between Dynamical Entropy and Energy Dissipation far from Thermodynamic Equilibrium*, PNAS 110 (2013) 16339-16343. doi:10.1073/pnas.1312165110.

A. B. Costa, J. R. Green, *Extending the Length and Time Scales of Gram-Schmidt Lyapunov Vector Computations*, J. Comput. Phys. 246 (2013) 113-122. doi:10.1016/j.jcp.2013.03.051.

A. L. Dill, L. S. Eberlin, **A. B. Costa**, D. R. Ifa, R. G. Cooks, *Data Quality in Tissue Analysis using Desorption Electrospray Ionization*, Anal. Bioanal. Chem. 401 (2011) 1949-1961. doi:10.1007/s00216-011-5249-z.

J. I. Zhang, **A. B. Costa**, W. A. Tao, R. G. Cooks, *Direct Detection of Fatty Acid Ethyl Esters using Low Temperature Plasma (LTP) Ambient Ionization Mass Spectrometry for Rapid Bacterial Differentiation*, Analyst 136 (2011) 3091-3097. doi:10.1039/C0AN00940G.

A. B. Costa, R. G. Cooks, *Origin of Chiral Selectivity in Gas-Phase Serine Tetramers*, Phys. Chem. Chem. Phys. 13 (2011) 877-885. doi:10.1039/C0CP01402H.

A. L. Dill, L. S. Eberlin, **A. B. Costa**, C. Zheng, D. R. Ifa, L. Cheng, T. A. Masterson, M. O. Koch, O. Vitek, R. G. Cooks, *Multivariate Statistical Identification of Human Bladder Carcinomas using Ambient Ionization Imaging Mass Spectrometry*, Chem. A Euro. J. 17 (2011) 2897-2902. doi:10.1002/chem.201001692.

R. G. Cooks, N. E. Manicke, A. L. Dill, D. R. Ifa, L. S. Eberlin, **A. B. Costa**, H. Wang, G. Huang, Z. Ouyang, *New Ionization Methods and Miniature Mass Spectrometers in Biomedicine: DESI Imaging for Cancer Diagnostics and Paper Spray Ionization for Therapeutic Drug Monitoring*, Faraday Discuss. 149 (2011) 247-267. doi:10.1039/c005327a.

J. I. Zhang, N. Talaty, **A. B. Costa**, Y. Xia, W. A. Tao, R. Bell, J. H. Callahan, R. G. Cooks, *Rapid Direct Lipid Profiling of Bacteria using Desorption Electrospray Ionization Mass Spectrometry*, Int. J. Mass Spectrom. 301 (2011) 37-44. doi:10.1016/j.ijms.2010.06.014.

A. L. Dill, L. S. Eberlin, C. Zheng, **A. B. Costa**, D. R. Ifa, L. Cheng, T. A. Masterson, M. O. Koch, O. Vitek, R. G. Cooks, *Multivariate Statistical Differentiation of Renal Cell Carcinomas Based on Lipidomic Analysis by Ambient Ionization Imaging Mass Spectrometry*, Anal. Bioanal. Chem., 398 (2010) 2969-2978. doi:10.1007/s00216-010-4259-6.

[‡]Indicates equal contribution to first author

L. S. Eberlin, A. L. Dill, **A. B. Costa**, D. R. Ifa, L. Cheng, T. Masterson, M. Koch, T. L. Ratliff, R. G. Cooks, *Cholesterol Sulfate Imaging in Human Prostate Cancer Tissue by Desorption Electrospray Ionization Mass Spectrometry*, *Anal. Chem.* 82 (2010) 3430-3434. doi:10.1021/ac9029482.

A. L. Dill, D. R. Ifa, N. E. Manicke, **A. B. Costa**, D. W. Knapp, R. G. Cooks, *Lipid Profiles of Canine Transitional Cell Carcinoma and Adjacent Benign Tissue by Desorption Electrospray Ionization Imaging Mass Spectrometry*, *Anal. Chem.* 81 (2009) 8758-8764. doi:10.1021/ac901028b.

M. Fico, J. D. Maas, S. A. Smith, **A. B. Costa**, W. J. Chappell, R. G. Cooks, *Circular Arrays of Polymer-Based Miniature Rectilinear Ion Traps*, *Analyst* 134 (2009) 1338-1347. doi:10.1039/b822140e.

A. B. Costa, R. G. Cooks, *Simulated Splashes: Elucidating the Mechanism of Desorption Electrospray Ionization*, *Chem. Phys. Lett.* 464 (2008) 1-8. doi:10.1016/j.cplett.2008.08.020.

A. B. Costa, R. G. Cooks, *Simulation of Atmospheric Transport and Droplet-Thin Film Collisions in Desorption Electrospray Ionization*, *Chem. Commun.* (2007) 3915-3917. doi:10.1039/b710511h.

NOTABLE
EVENTS

Workshop Chair, *2nd Annual SC Workshop on Medical Image Analysis and Visualization Workshop (MIAV)*, SC '17, Denver, CO (2017).

Course Director, *Advanced Use of Digital Technologies for Intracranial Surgery*, American Association of Neurological Surgeons, Los Angeles, CA (2017).

Workshop Chair, *Taking Supercoming to the Clinic: Medical Image Analysis and Visualization*, SC '16, Salt Lake City, UT (2016).

Invited Talk, *Big Omics Data Experience*, SC '15, Austin, TX (2015).

Invited Talk, *High Field MRI for Modeling of Cranial Nerves and Small Caliber Vessels in Neurosimulation*, World Federation of Neurosurgical Societies, Rome, Italy (2015).

Invited Talk, *What's Next for Haptic Neurosurgery Simulators?*, European Congress of Neurosurgery, Prague, Czech Republic (2014).

Invited Talk, *Characterization and Benchmarking of NGS Workflow Methods on Various Platform Architectures*, Bio-IT World Conference & Expo, Boston, MA (2014).

Invited Talk, *Measuring Dissipation in Very-Far-From-Equilibrium Processes*, Chemistry Department Seminar Series, Bowdoin College, Brunswick, ME (2012).

Invited Talk, *Recent Theoretical and Experimental Results on Droplet Production and Transport in Desorption Electrospray Ionization*, Ambient Surface Analysis, Bio-Surface Interaction and Nano-Biotechnology Conference, National Physical Laboratory, Teddington, UK (2008).

CURRENT
TEACHING

Instructor, *Community Research Education and Engagement for Data Science Summer School for Computational Genomics*, Icahn School of Medicine at Mount Sinai. Begun 2016.

Course Director, *Introduction to Scientific Computing*, Icahn School of Medicine at Mount Sinai. Begun 2015.

PAST
TEACHING

Instructor, *Introduction to Scientific Computing*, Icahn School of Medicine at Mount Sinai. 2013 to 2015.

Teaching Assistant, *Introductory Chemistry for Engineers I, II*, Purdue University. 2005 to 2006.