

# Christopher M. Boyce

Columbia University

The Fu Foundation School of Engineering and Applied Science

Department of Chemical Engineering

## A. Field of Specialization

Academic Specialization: Chemical Engineering

Research Specialization: Multiphase Flows, Granular Flows

## B. Education

- B.S., Massachusetts Institute of Technology, Chemical Engineering and Physics, 2011
  - Ph.D., University of Cambridge, Chemical Engineering, 2015
- Dissertation: “Fundamental Studies of the Physics of Gas-Solid Fluidization”  
Sponsor: Dr. John Dennis

## C. Positions Held Since Bachelor’s Degree was Conferred

- Associate Professor of Chemical Engineering, Columbia University (Jan. 2023-Present)
- Assistant Professor of Chemical Engineering, Columbia University (Jan. 2018-Dec. 2022)
- Postdoctoral Researcher, ETH Zurich (Jan. 2017-Dec. 2017)
- Postdoctoral Researcher, Princeton University (Jan. 2015-Dec. 2016)
- Graduate Research Assistant, University of Cambridge (Sept. 2011-Dec. 2014)

## D. Honors, Prizes and Fellowships

- Invited Visiting Professorship, Federal University of Rio de Janeiro, Brazil, January 2024
- ONR Young Investigator Award, 2023
- NSF CAREER Award, 2022
- Published an Invited Paper in the “Futures” Issue of AIChE Journal for Future Leaders in Chemical Engineering, 2022
- Article Selected as Cover Article for Industrial and Engineering Chemistry Research, 2021
- Article Selected as Cover Article for Chemical Engineering Science, 2021
- Sabic Young Professional Award from the AIChE Particle Technology Forum for Outstanding Contributions to Particle Technology from an Individual Under 40, 2019
- Article Selected as Cover Article for Chemical Engineering Science, 2019
- Forbes 30 Under 30 in Science, 2019
- Published an Invited Paper in the “Futures” Issue of AIChE Journal for Future Leaders in Chemical Engineering, 2018
- Published an Invited Paper for the Best Presentation in Session at the World Congress on Particle Technology 8, 2018

- Danckwerts-Pergamon Prize for the Best PhD Thesis Related to Chemical Engineering, University of Cambridge, 2015
- Gates Cambridge Scholar, 2011-2014
- 2<sup>nd</sup> Prize, Third Year Presentation, Department of Chemical Engineering and Biotechnology, University of Cambridge, 2014
- 1<sup>st</sup> Prize, Second Year Poster Presentation, Department of Chemical Engineering and Biotechnology, University of Cambridge, 2013
- Phi Beta Kappa Academic Honor Society, MIT, 2011
- Sigma Pi Sigma Physics Honor Society, MIT, 2011
- Tau Beta Pi Engineering Honor Society, MIT, 2010

## **E. Grants and Contracts**

### *Young Investigator Awards:*

Title: CAREER: Magnetic Resonance Imaging of Periodically Structured Bubbling Phenomena in Dense Suspensions and Fluidized Granular Materials (NSF CAREER Award)

Lead PI: Chris Boyce

Source: National Science Foundation

Period of Performance: 7/2022-6/2027

Title: Controllable Segregation of Granular Particles for Powering Undersea Vehicles (ONR Young Investigator Program (YIP) Award)

Lead PI: Chris Boyce

Source: Office of Naval Research

Period of Performance: 11/2022-10-2025

### *National Science Foundation (NSF) Grants:*

Title: Magnetic Resonance Imaging and Modeling of Gas and Particle Flow in Fluidized Beds

Lead PI: Chris Boyce

Source: National Science Foundation

Period of Performance: 11/2020-10/2023

Title: REU Site: ChemE-NYC: Climate and Health Solutions

Lead PI: Chris Boyce

Source: National Science Foundation

Period of Performance: 4/2022-3/2025

### *Department of Defense (DoD) Grants:*

Title: Designing and Characterizing Hydrogen-Producing Reactors for Naval Purposes

Lead PI: Chris Boyce

Co-PI: Dan Esposito

Source: Office of Naval Research

Period of Performance: 02/01/2024-01/31/2025

Title: Particle segregation and forces on internal pipes in model particle-liquid-gas multiphase reactors

Lead PI: Chris Boyce

Source: Office of Naval Research

Period of Performance: 1/2022-12/2024

Title: Magnetic Resonance Imaging of Flow within Model Gas-Turbines

Lead PI: Chris Boyce

Source: US Army

Prime Applicant: Chris Boyce; no subawards

Period of Performance: 8/2022-11/2022

*National Institutes of Health (NIH) Grants:*

Title: Microfluidic Preparation of Specimens to Enable Submillisecond Time-Resolved Cryo-EM

Lead PI: Qiao Lin

Co-PIs: Chris Boyce, Oliver Clarke, Joachim Frank, Andrew Marks

Source: National Institutes of Health

Period of Performance: 9/22/2023-8/31/2027

*Industrial Grants:*

Title: Magnetic Resonance Imaging of Filtration

Lead PI: Chris Boyce

Co-PI: Jia Guo

Source: Pall Corporation

Period of Performance: 04/2022-04/2024

Title: Magnetic Resonance Imaging of Filtration

Lead PI: Chris Boyce

Co-PI: Jia Guo

Source: Pall Corporation

Period of Performance: 01/2020-12/2021

*Private Foundations:*

Title: Collaboration between Tuskegee University and Columbia University

Lead PIs: Chris Boyce, Mandar Kathe

Source: Sloan Foundation

Period of Performance: 12/2021-11/2023

Title: Assessment of a Collaboration between Tuskegee University and Columbia University

Lead PIs: Chris Boyce and Shahryar Jafarinejad

Source: Genentech Giving

Period of Performance: 5/1/2023-4/30/2024

Title: Summer Research Experience in Chemical Engineering at Columbia University for Underrepresented Minority Undergraduates from Tuskegee University: Multiphase Flows  
Lead PI: Chris Boyce  
Source: Columbia University  
Period of Performance: 05/2021-08/2021

*Internal Columbia Grants:*

Title: Removal of Contaminants from Mining Waters using Electrochemically Generated pH Gradients and Controlled Bubble Dynamics  
Lead PIs: Chris Boyce and D.R. Nagaraj  
Co-PIs: Dan Esposito and Ray Farinato  
Source: Columbia SEAS  
Period of Performance: 07/01/2024-06/31/2025

Title: Sustainable Mining via Novel Separation of Granular Particles  
Lead PIs: Chris Boyce, D.R. Nagaraj, Ray Farinato  
Source: Columbia University  
Period of Performance: 09/2021-08/2023

Title: Take a look inside – Magnetic Resonance Imaging of magma analogues to study volcanic eruptions  
Lead PIs: Chris Boyce and Einat Lev  
Source: Columbia University  
Period of Performance: 09/2020-08/2022

**F. Publications**

**Publication Statistics (Retrieved from Chris Boyce's [Google Scholar](#) Page 01/29/2029):**

Publications: 60 total, 45 corresponding author, 24 last author  
Total citations: 1822  
h-index: 24  
i10-index: 43

**Peer-Reviewed Journal Publications:**

Note on Authorship Convention in the Field: The first author is typically a student or postdoctoral researcher who conducted the most experimental, theoretical or numerical work for the paper. The last author is typically the senior researcher primarily advising the research.

Note: Names of students and postdoctoral researchers from the candidate's group are underlined. The candidate's name is **bolded**. Corresponding author is marked with \*.

- | #   | Title   |
|-----|---|
| 60) | <u>Punch, O. J.</u> ; <u>Guo, Q.</u> ; <u>Gueye, M.</u> ; <u>Omidi, J.</u> ; <u>Jordan, M. W.</u> ; <u>Sanghishetty, J. M.</u> ; <b>Boyce, C. M.*</b> Anomalous Descent of Intruders in Vibrated Gas-Fluidized Granular Materials, <i>Physical Review E (Letter/Rapid Communication)</i> <b>2025</b> , 111, L013403. <a href="#">Link</a> |
| 59) | <u>Punch, O. J.</u> ; <u>Spitler, C.</u> ; <u>Cabrera, B. N.</u> ; <u>Jordan, M. W.</u> ; <u>Khan, A.</u> ; <b>Boyce, C. M.*</b> Mitigation of Spouted Bed Instabilities Using Vibration. <i>Ind. Eng. Chem. Res.</i> <b>2024</b> , 64, 2433-2445. <a href="#">Link</a>   |
| 58) | <u>Guo, Q.*</u> ; <u>Tian, J.</u> ; <u>Huang, R.</u> ; <b>Boyce, C. M.*</b> Towards accurate modeling of vibration in CFD-DEM simulations of vibrated gas-fluidized beds without using a moving mesh. <i>Chem. Eng. Sci.</i> <b>2024</b> , 298, 120445. <a href="#">Link</a>  |
| 57) | <u>Punch, O. J.*</u> ; <u>Cabrera, B. N.</u> ; <u>Spitler, C.</u> ; <b>Boyce, C. M.</b> Control of spout deflection in dry and wet spouted beds using vibration. <i>Chem. Eng. J.</i> <b>2024</b> , 153459. <a href="#">Link</a>  |
| 56) | <u>Sanghishetty, J. M.</u> ; <u>Spitler, C.</u> ; <u>Guo, Q.</u> ; <u>Nagaraj, D. R.</u> ; <u>Farinato, R. S.</u> ; <b>Boyce, C. M.*</b> Structured Bubbling in Vibrated Gas-Fluidized Beds of Binary Granular Particles: Experiments and Simulations. <i>Soft Matter</i> <b>2024</b> , 20, 5221-5236. (Invited) <a href="#">Link</a>     |
| 55) | <u>Bordbar, A.</u> ; <u>Zia, W.</u> ; <u>Omidi, J.</u> ; <u>Birnbaum, J.</u> ; <u>Lee, R. F.</u> ; <u>Lev, E.</u> ; <b>Boyce, C. M.*</b> Magnetic Resonance Imaging of a Stream Bubbles Injected into Liquid Suspensions. <i>Chem. Eng. J.</i> <b>2024</b> , 494, 153282. <a href="#">Link</a>  |
| 54) | <u>Omidi, J.</u> ; <u>Punch, O. J.</u> ; <u>Guo, Q.</u> ; <b>Boyce, C. M.*</b> Faraday waves in gas-fluidized beds subject to combined vertical and horizontal vibration. <i>Powder Technol.</i> <b>2024</b> , 438, 119648. <a href="#">Link</a>  |
| 52) | <u>Bordbar, A.</u> ; <u>Benders, S.</u> ; <u>Zia, W.</u> ; <u>Penn, A.</u> ; <b>Boyce, C. M.*</b> Computer Simulation of Magnetic Resonance Imaging of the Flow of Fluidized Particles. <i>Ind. Eng. Chem. Res.</i> <b>2023</b> , 62, 11677–11688. <a href="#">Link</a>   |
| 51) | <u>Guo, Q.</u> ; <u>Wu, R.</u> ; <u>Da, W.</u> ; <u>Y. Zhang</u> ; <u>J. Wei</u> ; <b>Boyce, C. M.*</b> Faraday Wave Instability Analog in Vibrated Gas-Fluidized Granular Particles. <i>Phys. Rev. E</i> <b>2023</b> , 107, 034603. <a href="#">Link</a>   |
| 50) | <u>Birnbaum, J.</u> ; <u>Zia, W.</u> ; <u>Bordbar, A.</u> ; <u>Lee, R. F.</u> ; <b>Boyce, C. M.*</b> ; <u>Lev, E.*</u> Magnetic Resonance Imaging of Multi-Phase Lava Flow Analogs: Velocity and Rheology. <i>Journal of Geophysical Research: Solid Earth</i> <b>2023</b> , 128, e2023JB026464. <a href="#">Link</a>                     |
| 49) | <u>Guo, Q.</u> ; <u>Chiu, S.</u> ; <u>Da, W.</u> ; <b>Boyce, C. M.*</b> Heat transfer within dynamically structured bubbling fluidized beds subject to vibration: A two-fluid modeling study. <i>AIChE J.</i> <b>2023</b> , e17970. <a href="#">Link</a>  |
| 48) | <u>Guo, Q.</u> ; <u>Zhang, Y.</u> ; <u>Kovar, T. M.</u> ; <u>Xi, K.</u> ; <b>Boyce, C. M.*</b> A Rayleigh-Bénard Convection Instability Analog in Vibrated Gas-Fluidized Granular Particles. <i>Soft Matter</i> <b>2022</b> , 18, 3323-3327. <a href="#">Link</a>   |
| 47) | <u>Guo, Q.</u> ; <u>Zhang, Y.</u> ; <u>Vazquez, C.</u> ; <u>Xi, K.</u> ; <b>Boyce, C. M.*</b> Multi-Fluid Model Simulations of Gravitational Instabilities in Fluidized Binary Granular Materials. <i>AIChE J.</i> <b>2022</b> , e17714. <a href="#">Link</a>   |
| 46) | <u>Guo, Q.</u> ; <b>Boyce, C. M.*</b> Structured Bubbling in Layered Gas-Fluidized Beds Subject to Vibration: A CFD-DEM Study. <i>AIChE J.</i> <b>2022</b> , e17709. <a href="#">Link</a>   |

- 45) Metzger, J. P.; McLaren, C. P.; Pinzello, S.; Conzelmann, N. A.; **Boyce, C. M.**; Müller, C. R.\* Sinking Dynamics and Splitting of a Granular Droplet. *Phys. Rev. Fluids* **2022**, 7 (1), 014309. [Link](#)
- 44) Padash, A.; Chen, B.; **Boyce, C. M.**\* Characterizing Alternating Bubbles Emerging from Two Interacting Vertical Gas Jets in a Liquid. *Chem. Eng. Sci.* **2022**, 117199. [Link](#)
- 43) Guo, Q.; Zhang, Y.; Padash, A.; Xi, K.; Kovar, T. M.; **Boyce, C. M.**\* Dynamically Structured Bubbling in Vibrated Gas-Fluidized Granular Materials. *Proc. Natl. Acad. Sci.* **2021**, 118 (35). [Link](#) (Featured in *Scientific American*)
- 42) Guo, Q.; Bordbar, A.; Ma, L.; Yu, Y.; Xu, S.; **Boyce, C. M.**\*; Ye, M.\* A CFD-DEM Study of the Solid-like and Fluid-like States in the Homogeneous Fluidization Regime of Geldart A Particles. *AIChE J.* **2021**, e17420. [Link](#)
- 41) Xi, K.; Guo, Q.; **Boyce, C. M.**; Lu, Y.\* Contact-Based Method to Evaluate Mixing in Multicomponent Experiments and Simulations. *Ind. Eng. Chem. Res.* **2021**, 60 (44), 16126–16142. [Link](#)
- 40) Xi, K.; Guo, Q.; **Boyce, C. M.**\* Comparison of CFD-DEM and TFM Simulations of Single Bubble Injection in 3D Gas-Fluidized Beds with MRI Results. *Chem. Eng. Sci.* **2021**, 243, 116738. [Link](#)
- 39) Xi, K.; Kovar, T.; Fullmer, W. D.; Penn, A.; Musser, J.; **Boyce, C. M.**\* CFD-DEM Study of Bubble Properties in a Cylindrical Fluidized Bed of Geldart Group D Particles and Comparison with Prior MRI Data. *Powder Technol.* **2021**, 389, 75–84. [Link](#)
- 38) Xi, K.; Guo, Q.; **Boyce, C. M.**\* Comparison of Two-Fluid Model Simulations of Freely Bubbling Three-Dimensional Gas-Fluidized Beds with Magnetic Resonance Imaging Results. *Ind. Eng. Chem. Res.* **2021**, 60 (19), 7429–7442. [Link](#) ([Journal Cover Image](#))
- 37) McLaren, C. P.; Metzger, J. P.; **Boyce, C. M.**\*; Müller, C. R.\* Reduction in Minimum Fluidization Velocity and Minimum Bubbling Velocity in Gas-Solid Fluidized Beds Due to Vibration. *Powder Technol.* **2021**, 382, 566–572. [Link](#)
- 36) Guo, Q.; Padash, A.; **Boyce, C. M.**\* A Two Fluid Modeling Study of Bubble Collapse Due to Bubble Interaction in a Fluidized Bed. *Chem. Eng. Sci.* **2021**, 232, 116377. [Link](#) ([Journal Cover Image](#))
- 35) Lev, E.\*; **Boyce, C. M.**\* Opportunities for Characterizing Geological Flows Using Magnetic Resonance Imaging. *iScience* **2020**, 23 (9). [Link](#)
- 34) Penn, A.; Padash, A.; Lehnert, M.; Pruessmann, K. P.; Müller, C. R.\*; **Boyce, C. M.**\* Asynchronous Bubble Pinch-off Pattern Arising in Fluidized Beds Due to Jet Interaction: A Magnetic Resonance Imaging and Computational Modeling Study. *Phys. Rev. Fluids* **2020**, 5 (9), 094303. [Link](#)
- 33) Padash, A.; **Boyce, C. M.**\* Collapse of a Bubble Injected Side-by-Side with Another Bubble into an Incipiently Fluidized Bed: A CFD-DEM Study. *Phys. Rev. Fluids* **2020**, 5 (3), 034304. [Link](#)
- 32) Penn, A.\*; **Boyce, C. M.**; Pruessmann, K. P.; Müller, C. R. Regimes of Jetting and Bubbling in a Fluidized Bed Studied Using Real-Time Magnetic Resonance Imaging. *Chem. Eng. J.* **2020**, 123185. [Link](#)

- 31) McLaren, C. P.; Kovar, T. M.; Penn, A.; Müller, C. R.\*; **Boyce, C. M.\*** Gravitational Instabilities in Binary Granular Materials. *Proc. Natl. Acad. Sci.* **2019**, 201820820. [Link](#) (Featured in [Gizmodo](#) and [Popular Mechanics](#))
- 30) **Boyce, C. M.\***; Penn, A.; Lehnert, M.; Pruessmann, K. P.; Müller, C. R. Characteristics of a Single Jet Injected into an Incipiently Fluidized Bed: A Magnetic Resonance Imaging Study. *Adv. Powder Technol.* **2019**. [Link](#)
- 29) **Boyce, C.M.\***; Penn, A.; Lehnert, M.; Pruessmann, K.P.; Müller, C. R. Magnetic Resonance Imaging of Interaction and Coalescence of Two Bubbles Injected Consecutively into an Incipiently Fluidized Bed. *Chem. Eng. Sci.* **2019**, 115152. [Link](#)
- 28) **Boyce, C. M.\***; Penn, A.; Padash, A.; Lehnert, M.; Pruessmann, K. P.; Müller, C. R. Anomalous Collapse of Interacting Bubbles in a Fluidized Bed: A Magnetic Resonance Imaging Study. *Phys. Rev. Fluids* **2019**, 4, 034303. [Link](#)
- 27) **Boyce, C. M.\***; Penn, A.; Lehnert, M.; Pruessmann, K. P.; Müller, C. R. Magnetic Resonance Imaging of Single Bubbles Injected into Incipiently Fluidized Beds. *Chem. Eng. Sci.* **2019**, 200, 147–166. [Link](#)
- 26) **Boyce, C. M.\***; Penn, A.; Lehnert, M.; Pruessmann, K. P.; Müller, C. R. Wake Volume of Injected Bubbles in Fluidized Beds: A Magnetic Resonance Imaging Velocimetry Study. *Powder Technol.* **2019**. (Invited). [Link](#)
- 25) Penn, A.\*; **Boyce, C. M.**; Conzelmann, N.; Bezing, G.; Pruessmann, K. P.; Müller, C. R.\* Real-Time Magnetic Resonance Imaging of Fluidized Beds with Internals. *Chem. Eng. Sci.* **2019**, 198, 117–123. [Link](#) (Journal Cover Image)
- 24) **Boyce, C. M.\***; Penn, A.; Lehnert, M.; Pruessmann, K. P.; Müller, C. R. Effect of Liquid Bridging on Bubbles Injected into a Fluidized Bed: A Magnetic Resonance Imaging Study. *Powder Technol.* **2019**, 343, 813–820. [Link](#)
- 23) **Boyce, C. M.\*** Gas-Solid Fluidization with Liquid Bridging: A Review from a Modeling Perspective. *Powder Technol.* **2018**, 336, 12–29. [Link](#)
- 22) Penn, A.\*; **Boyce, C. M.\***; Kovar, T.; Tsuji, T.; Pruessmann, K. P.; Müller, C. R. \* Real-Time Magnetic Resonance Imaging of Bubble Behavior and Particle Velocity in Fluidized Beds. *Ind. Eng. Chem. Res.* **2018**, 57 (29), 9674–9682 (Invited). [Link](#)
- 21) **Boyce, C. M.\***; Penn, A.; Pruessmann, K. P.; Müller, C. R. Magnetic Resonance Imaging of Gas–Solid Fluidization with Liquid Bridging. *AIChE J.* **2018**, 64 (8), 2958–2971 (Invited). [Link](#)
- 20) Penn, A.; Tsuji, T.; Brunner, D. O.; **Boyce, C. M.**; Pruessmann, K. P.; Müller, C. R. \* Real-Time Probing of Granular Dynamics with Magnetic Resonance. *Science Advances* **2017**, 3 (9), e1701879. [Link](#)
- 19) Kolehmainen, J.\*; Sippola, P.; Raitanen, O.; Ozel, A.; **Boyce, C. M.**; Saarenrinne, P.; Sundaresan, S. Effect of Humidity on Triboelectric Charging in a Vertically Vibrated Granular Bed: Experiments and Modeling. *Chem. Eng. Sci.* **2017**, 173, 363–373. [Link](#)
- 18) **Boyce, C. M.\***; Ozel, A.; Kolehmainen, J.; Sundaresan, S.; McKnight, C. A.; Wormsbecker, M. Growth and Breakup of a Wet Agglomerate in a Dry Gas–solid Fluidized Bed. *AIChE J.* **2017**, 63 (7), 2520–2527. [Link](#)

- 17) **Boyce, C. M.\***; Ozel, A.; Kolehmainen, J.; Sundaresan, S. Analysis of the Effect of Small Amounts of Liquid on Gas–Solid Fluidization Using CFD-DEM Simulations. *AIChE J.* **2017**, *63* (12), 5290–5302. [Link](#)
- 16) **Boyce, C. M.\***; Ozel, A.; Rice, N. P.; Rubinstein, G. J.; Holland, D. J.; Sundaresan, S. Effective Particle Diameters for Simulating Fluidization of Non-Spherical Particles: CFD-DEM Models vs. MRI Measurements. *AIChE J.* **2017**, *63* (7), 2555–2568. [Link](#)
- 15) Kolehmainen, J.\*; Ozel, A.; **Boyce, C. M.**; Sundaresan, S. Triboelectric Charging of Monodisperse Particles in Fluidized Beds. *AIChE J.* **2017**, *63* (6), 1872–1891. [Link](#)
- 14) **Boyce, C. M.\***; Rice, N. P.; Ozel, A.; Davidson, J. F.; Sederman, A. J.; Gladden, L. F.; Sundaresan, S.; Dennis, J. S.; Holland, D. J. Magnetic Resonance Characterization of Coupled Gas and Particle Dynamics in a Bubbling Fluidized Bed. *Phys. Rev. Fluids* **2016**, *1* (7), 74201. [Link](#)
- 13) **Boyce, C. M.\***; Ozel, A.; Sundaresan, S. Intrusion of a Liquid Droplet into a Powder under Gravity. *Langmuir* **2016**, *32* (34), 8631. [Link](#)
- 12) Kolehmainen, J.\*; Ozel, A.; **Boyce, C. M.**; Sundaresan, S. A Hybrid Approach to Computing Electrostatic Forces in Fluidized Beds of Charged Particles. *AIChE J.* **2016**, *62* (7), 2282. [Link](#)
- 11) **Boyce, C. M.\***; Rice, N. P.; Davidson, J. F.; Sederman, A. J.; Dennis, J. S.; Holland, D. J. Magnetic Resonance Imaging of Gas Dynamics in the Freeboard of Fixed Beds and Bubbling Fluidized Beds. *Chem. Eng. Sci.* **2016**, *147*, 13. [Link](#)
- 10) **Boyce, C. M.\***; Rice, N. P.; Sederman, A. J.; Dennis, J. S.; Holland, D. J. 11-Interval PFG Pulse Sequence for Improved Measurement of Fast Velocities of Fluids with High Diffusivity in Systems with Short T2\*. *J. Magn. Reson.* **2016**, *265*, 67. [Link](#)
- 9) Lu, X.; **Boyce, C. M.**; Scott, S. A.; Dennis, J. S.; Holland, D. J.\* Investigation of Two-Fluid Models of Fluidisation Using Magnetic Resonance and Discrete Element Simulations. *Procedia Eng.* **2015**, *102*, 1436. [Link](#)
- 8) **Boyce, C. M.\***; Holland, D. J.; Scott, S. A.; Dennis, J. S. Limitations on Fluid Grid Sizing for Using Volume-Averaged Fluid Equations in Discrete Element Models of Fluidized Beds. *Ind. Eng. Chem. Res.* **2015**, *54* (43), 10684. [Link](#)
- 7) Pore, M.; Ong, G. H.; **Boyce, C. M.**; Materazzi, M.; Gargiuli, J.; Leadbeater, T.; Sederman, A. J.; Dennis, J. S.\*; Holland, D. J.; Ingram, A.; et al. A Comparison of Magnetic Resonance, X-Ray and Positron Emission Particle Tracking Measurements of a Single Jet of Gas Entering a Bed of Particles. *Chem. Eng. Sci.* **2015**, *122*, 210. [Link](#)
- 6) **Boyce, C. M.\***; Davidson, J. F.; Holland, D. J.; Scott, S. A.; Dennis, J. S. The Origin of Pressure Oscillations in Slugging Fluidized Beds: Comparison of Experimental Results from Magnetic Resonance Imaging with a Discrete Element Model. *Chem. Eng. Sci.* **2014**, *116*, 611. [Link](#)
- 5) **Boyce, C. M.\***; Holland, D. J.; Scott, S. A.; Dennis, J. S. Novel Fluid Grid and Voidage Calculation Techniques for a Discrete Element Model of a 3D Cylindrical Fluidized Bed. *Comput. Chem. Eng.* **2014**, *65*, 18. [Link](#)



- 4) Harper, R. N.; **Boyce, C. M.**; Scott, S. A.\* Oxygen Carrier Dispersion in Inert Packed Beds to Improve Performance in Chemical Looping Combustion. *Chem. Eng. J.* **2013**, 234, 464. [Link](#)
- 3) **Boyce, C. M.\***; Holland, D. J.; Scott, S. A.; Dennis, J. S. Adapting Data Processing To Compare Model and Experiment Accurately: A Discrete Element Model and Magnetic Resonance Measurements of a 3D Cylindrical Fluidized Bed. *Ind. Eng. Chem. Res.* **2013**, 52 (50), 18085. [Link](#)
- 2) Taylor, R. E.; **Boyce, C. M.**; Boyce, M. C.; Pruitt, B. L.\* Planar Patterned Stretchable Electrode Arrays Based on Flexible Printed Circuits. *J. Micromechanics Microengineering* **2013**, 23 (10), 105004. [Link](#)
- 1) Barr, M. C.; Rowehl, J. A.; Lunt, R. R.; Xu, J.; Wang, A.; **Boyce, C. M.**; Im, S. G.; Bulović, V.\*; Gleason, K. K.\* Direct Monolithic Integration of Organic Photovoltaic Circuits on Unmodified Paper. *Adv. Mater.* **2011**, 23 (31), 3500. [Link](#)

## G. Patents

| #  | Title   |
|----|---|
| 3) | <b>Boyce, C.M.</b> , Socrate, S., Greviskes, B.P., Boyce, M.C. “Structured materials with tailored isotropic and anisotropic poisson’s ratios including zero and negative poisson’s ratios” (Application 2011, full patent not pursued) |
| 2) | Taylor, R.E., Pruitt, B.L., Boyce, M.C., <b>Boyce, C.M.</b> , “In-plane-strain-actuated out-of-plane actuator”, U.S. Utility Patent 10150665 (Application 2014, Granted 2018).  |
| 1) | Boyce, M.C., Socrate, S., <b>Boyce, C.M.</b> and Greviskes, B., “Structured material substrates for flexible, stretchable electronics”, U.S. Utility Patent 8,883,287 (Application 2010, Granted 2014).                                 |

## H. Teaching Experience

### Courses Taught

CHEN E3110, Transport Phenomena I (Undergraduate Core) (2018-2021)

CHEN E3110, Principles of Transport Phenomena (Undergraduate Core) (2022-Present)

CHEN E4150, Computational Fluid Dynamics in Chemical Engineering (Graduate Elective) (2018-Present)

CHEN E9000, Chemical Engineering Colloquium (PhD Core) (2020-2021)

CHEN E9500, Doctoral Research (PhD Core) (2018-Present)

CHEN E9400, Master’s Research (Master’s Elective) (2018-Present)

CHEN E3900, Undergraduate Research Project (Undergraduate Elective) (2018-Present)

### Course Development:

- Developed CHEN E4150, Computational Fluid Dynamics in Chemical Engineering from scratch, 2018.

- Incorporated in-class, collaborative problem solving sessions for full class periods into the curriculum of CHEN E3110, Transport Phenomena I, 2020.
- Developed a new CHEN E3110, Principles of Transport Phenomena, incorporating fluid mechanics, heat and mass transport into one course, 2022.

### **Experience as a Thesis Sponsor and Committee Member for Student Research**

#### **Doctoral Students (Sponsored):**

1. **Azin Padash** (Sept. 2018-Nov. 2021; Current Position: Healthcare Consultant at Guidehouse)  
Thesis Title: *Bubble Rise Dynamics in Complex Fluids*  
Publications: 6 total; 3 first-author
2. **Jagan Mohan Sanghishetty** (Sept. 2019-Sept. 2024)  
Thesis Title: *Granular Mixing and Rheology under Shear, Vibration and Gas Flow*  
Publications: 1 total; 1 first-author; 2 first-author in preparation
3. **Alireza Bordbar** (Jan. 2020-Dec. 2024)  
Thesis Title: *Magnetic Resonance Imaging of the Flow of Granular Suspensions*  
Publications: 4 total; 2 first-author
4. **Christopher Spittler** (Jan. 2022-Present)  
Thesis Area: *Controlling Wetted Granular Flows for Aluminum-Water Reactors*  
Publications: 3 total
5. **Javad Omid** (Jan. 2022-Present)  
Thesis Area: *Characterizing Periodically Repeating Flow Patterns in Complex Fluids*  
Publications: 2 total; 1 first-author; 1 more in revision

#### **Doctoral Students (Reader and Committee Member):**

1. **Chen Yong**, ETH Zurich, Mechanical and Process Engineering, 2017
2. **Jonathan Davis**, Columbia University, Chemical Engineering, 2019
3. **Richa Batra**, Columbia University, Mechanical Engineering, 2019
4. **Christopher McLaren**, ETH Zurich, Mechanical and Process Engineering, 2022
5. **Jamie Robinson**, University of Canterbury (NZ), Chemical Engineering, 2022
6. **Philipp Riechmann**, EPFL, Chemical Engineering, 2022
7. **Kiran Dhatt-Gauthier**, Columbia University, Chemical Engineering, 2022
8. **Xueqi Pang**, Columbia University, Chemical Engineering, 2022
9. **Zhengyan Zhang**, Columbia University, Chemical Engineering, 2023
10. **Daniela Fraga**, Columbia University, Chemical Engineering, 2023
11. **Youssef Badran**, Polytechnique Montreal and National Polytechnic Institute of Toulouse, Chemical Engineering, 2024

#### **Master's Students (Sponsored Thesis):**

1. **Sophia Ihrfelt**, KTH Royal Institute of Technology, Sweden, Chemical Engineering, 2024  
Thesis Area: *Effects of Horizontal Vibration on Spout-Fluidized Beds*  
Publications: First author on one publication in preparation

#### **Undergraduate Students (Sponsored Senior Thesis):**

1. **Carolina Vazquez** (2021, Pursuing a Master's at University of Michigan)  
Co-author on 1 publication

2. **Yuxuan Zhang** (2022, Pursuing a Master's at EPFL)  
Co-author on 4 publications
3. **Shawn Chiu** (2022, Pursuing a PhD at UCLA)  
Co-author on 1 publication
4. **Lisa Tian** (2023, Pursuing a PhD at UCLA)  
Co-author on 1 publication
5. **Boyuan Chen** (2023, Pursuing a PhD at Caltech)  
Co-author on 1 publication
6. **Charlotte Fels** (2024, undergraduate at ETH Zurich)  
First author on a paper in preparation

**Postdoctoral Researchers Advised:**

1. **Qiang Guo** (Dec. 2019-Aug. 2023, Now an Assistant Professor at Chinese Academy of Sciences)  
Publications: 15 total, 9 first author
2. **Wasif Zia** (Jul. 2020-Dec. 2022, Now an MRI Engineer at Nathan Kline Institute)  
Publications: 3 total
3. **Oscar Punch** (Jul. 2023-Present)  
Publications: 4 total; 3 first-author

**Postbaccalaureate Researchers Advised:**

1. **Michael Jordan** (Sep. 2023-Aug. 2024, recent alumnus from Tuskegee University, started an MS degree at Columbia in Fall 2024)

**I. Invited Talks**

- 26) **Boyce, C.M.** (2024) “Computational Modeling and Energy Applications of Vibrated Gas-Fluidized Beds” *Invited Seminar at the MIT Conference on Computation, Combustion, and Energy: A Meeting in Honor of Professor Ahmed Ghoniem.*
- 25) **Boyce, C.M.** (2024) “Structured Flow Instabilities in Granular Materials Subject to Combined Gas Flow and Vibration” *Invited Seminar at the Federal University of Rio de Janeiro.*
- 24) **Boyce, C.M.** (2023) “Structured Flow Instabilities in Excited Granular Materials and Applications to Powering Undersea Vehicles” *Invited Seminar for the Department of Defense Basic Research Forum.*
- 23) **Boyce, C.M.** (2023) “Structured Flow Instabilities in Vibrated Gas-Fluidized Beds” *Invited Keynote Presentation at the Fluidization XVII Conference.*
- 22) **Boyce, C.M.** (2023) “Structured Flow Instabilities in Granular Materials Subject to Combined Gas Flow and Vibration” *Invited Seminar at Caltech.*
- 21) **Boyce, C.M.** (2022) “Structured Flow Instabilities in Granular Materials Subject to Combined Gas Flow and Vibration” *Invited Seminar at the Chinese Academy of Sciences.*
- 20) **Boyce, C.M.** (2022) “Structured Flow Instabilities in Granular Materials Subject to Combined Gas Flow and Vibration” *Invited Seminar at Granular Matter Gordon Research Conference.*

- 19) **Boyce, C.M.** (2022) “Structured Flow Instabilities in Granular Materials Subject to Combined Gas Flow and Vibration” *Invited Seminar at the Federal University of Rio de Janeiro.*
- 18) **Boyce, C.M.** (2022) “Fluid or Not? Structured Instabilities in Excited Granular Flows” *Invited Seminar at the City College of New York.*
- 17) **Boyce, C.M.** (2021) “Structured Bubbly Flows in Particle-Laden Complex Fluids” *Invited Seminar at Rutgers University.*
- 16) **Boyce, C.M.** (2021) “Characterizing and Structuring Multiphase Granular Flows” *Invited Seminar at the University of Cambridge.*
- 15) **Boyce, C.M.** (2021) “Characterizing and Structuring Multiphase Granular Flows” *Invited Seminar at The Ohio State University.*
- 14) **Boyce, C.M.** (2021) “Characterizing and Structuring Multiphase Granular Flows” *Invited Seminar at New York University.*
- 13) **Boyce, C.M.** (2021) “Characterizing and Structuring Multiphase Granular Flows” *Invited Seminar at UC Davis.*
- 12) **Boyce, C.M.** (2020) “Characterizing and Structuring Multiphase Granular Flows” *Invited Seminar at Stevens Institute of Technology.*
- 11) **Boyce, C.M.** (2020) “Characterizing and Structuring Multiphase Granular Flows” *Invited Seminar at Columbia University.*
- 10) **Boyce, C.M.** (2020) “Magnetic Resonance Imaging and Optical Imaging of Multiphase Granular Flows” *Invited Seminar at Lamont-Doherty Earth Observatory.*
- 9) **Boyce, C.M.** (2020) “Gaseous Bubbles and Granular Bubbles in Fluidized Granular Particles” *Invited Seminar at Stony Brook University.*
- 8) **Boyce, C.M.** (2020) “Phenomena in Fluidized Granular Flows” *Invited Plenary Lecture at the 12<sup>th</sup> Northeast Complex Fluids and Soft Matter Conference.*
- 7) **Boyce, C.M.** (2019) “MRI, Optical Imaging and Computational Modeling of Fluidization Phenomena” *Invited Sabic Young Professional Award Lecture at the AIChE Annual Meeting.*
- 6) **Boyce, C.M.** (2019) “MRI and Computational Modeling of Multiphase Granular Flows” *Invited Seminar at the City College of New York.*
- 5) **Boyce, C.M.** (2019) “MRI and Computational Modeling of Multiphase Granular Flows” *Invited Seminar at the U.S. Naval Undersea Warfare Center.*
- 4) **Boyce, C.M.** (2019) “Magnetic Resonance Imaging of Multiphase Granular Flows” *Invited Seminar at TU Hamburg.*
- 3) **Boyce, C.M.** (2019) “Structures and Instabilities in Multiphase Granular Flows” *Invited Seminar at the Chinese Academy of Sciences.*
- 2) **Boyce, C.M.** (2018) “MRI and Computational Modeling of Multiphase Chemical Reactors” *Invited Seminar at ExxonMobil Chemical.*
- 1) **Boyce, C.M.** (2018) “MRI and Computational Modeling of Multiphase Flows” *Invited Seminar at Pall Corporation.*

## **J. Service**

### **Service to the School of Engineering and Applied Sciences**

- Columbia-Amazon Summer Undergraduate Research Experience (SURE) Program Committee Member, SEAS, 2020-2022

- Co-organized program, recruited students and evaluated applications
- Undergraduate Education Reform Committee Member, SEAS, 2019
  - Worked on ways to expose first year undergraduates to more forms of engineering

### **Service to the Department of Chemical Engineering**

- Undergraduate Committee Member, Department of Chemical Engineering, 2018-Present
  - Conducted biannual advising sessions, streamlined student course selection, evaluated senior theses, participated in various recruitment events
- Designed a new course from scratch “CHEN 4150: Computational Fluid Dynamics in Chemical Engineering”, 2018.
- Undergraduate Transport Committee Member, Department of Chemical Engineering, 2021-Present
  - Personally combined fundamentals of transport phenomena from two semester-long courses into a single semester-long course to provide more flexibility and choice to undergraduates in their education
- Chemical Engineering Department Representative, Committee of Instruction (COI), SEAS, 2021
  - Passed changes to the undergraduate chemical engineering curriculum
- Search Committee Member for a New Faculty Hire, Department of Chemical Engineering, 2024-2025

### **Service to the Discipline**

- **Peer Reviewer for Journals** (10-20 papers per year): *PNAS*, *PRL*, *Science Advances*, *PLoS ONE*, *Scientific Reports*, *AIChE Journal*, *Chemical Engineering Science*, *Industrial and Engineering Chemistry Research*, *Chemical Engineering Research and Design*, *Journal of Fluid Mechanics*, *Physical Review Fluids*, *Physics of Fluids*, *International Journal of Multiphase Flow*, *Powder Technology*
- **Grant Proposal Reviewer**: National Science Foundation (3 times), Army Research Office (1 time)
- **External Reviewer**: Department of Energy, National Energy Technology Laboratory (1 time)
- Editorial Board, *Powder Technology*, 2024-Present
- Young Professional Editorial Board, *Particuology*, 2021-Present
- Editorial Advisory Board, *ACS Engineering Au*, 2021-Present
- Session Chair, APS March Meeting, 2024-Present
- Session Chair, APS DFD Meeting, 2022-Present
- Session Chair, AIChE Annual Meeting, Powder Technology Forum, 2021-Present
- Session Chair, AIChE Annual Meeting, Powder Technology Forum, 2022-Present

### **Conferences and Workshops Organized**

- Organized a new seminar series, “Fluids@Columbia”, for fluid mechanics research across schools and departments, 2021-2023
- Organized and chaired the 18<sup>th</sup> Northeast Complex Fluids and Soft Matter Workshop, 2023

## **Outreach**

- Hosted lab tours for NYC middle school students through Columbia’s Inside Engineering Program, 2019-Present
- Hosted 6 total high school students for summer laboratory research through Columbia’s Engineering the Next Generation Program, 2019-Present
- Created research videos published online with thousands of views and conducted subsequent interviews for media outlets, including features in [\*Scientific American\*](#), [\*Gizmodo\*](#) and [\*Popular Mechanics\*](#), 2019-Present

## **K. Media Coverage**

Research findings have been written about in popular scientific media outlet articles:

1. “These Bubbles are Made of Sand” by Ryan Mandelbaum, [\*Gizmodo\*](#), 2019.
2. “Scientists Made Bubbles of Sand, and That’s a Big Deal” by Avery Thompson, [\*Popular Mechanics\*](#), 2019.
3. “Tiny Vibrating Bubbles Could Make Mining More Sustainable” by Tesse Joose, [\*Scientific American\*](#), 2021.