

May 16, 2019

JULIO M. OTTINO
CURRICULUM VITAE

Personal

US citizen¹, born in La Plata, Argentina.
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Education

Ph.D. in Chemical Engineering, University of Minnesota, 1979.
Chemical Engineering Diploma, National University of La Plata, Argentina, 1974.
Executive Program, Kellogg School of Management, 1995.

Current Position

Dean, R.R. McCormick School of Engineering and Applied Science, 2005-
R.R. McCormick Institute Professor, Northwestern University, 2000-
Walter P. Murphy Professor, Chemical Engineering, Northwestern University, 1991-
Professor (by courtesy), Mechanical Engineering, Northwestern University, 2000-

Teaching and Research Positions

Co-Director, the Northwestern Institute on Complex Systems, 2004-2005.
Chair, Department of Chemical Engineering, Northwestern University, 1992-2000.
Professor of Chemical Engineering, Northwestern University, 1991-
George T. Piercy Distinguished Professor, Department of Chemical Engineering and Materials
Sciences, University of Minnesota, 1998.
Senior Research Fellow, Center for Turbulence Research, Stanford University, 1990.
Professor, Department of Chemical Engineering, University of Massachusetts, Amherst, 1986-1991.
Chevron Visiting Associate Professor of Chemical Engineering, California Institute of Technology,
1986.
Associate Professor, Department of Chemical Engineering, University of Massachusetts, Amherst,
1983-1986.
Adjunct Professor, Department of Polymer Science and Engineering, University of Massachusetts,
Amherst, 1979-1991.
Assistant Professor, Department of Chemical Engineering, University of Massachusetts, Amherst,
1979-1983.
Instructor, Department of Chemical Engineering, University of Minnesota, Minneapolis, 1978-1979.

Honors and Significant Lectureships

2109 Covestro Distinguished Lectureships, Dept. of Chemical and Petroleum Engineering,
University of Pittsburgh
2018 Founders Award for Outstanding Contributions to the Field of Chemical Engineering,
American Institute of Chemical Engineers
2018 William M.W. Mong Distinguished Lecture, University of Hong Kong

¹Naturalized March 21, 1991, Northampton, Massachusetts.

2018 John C. Chen Distinguished Lecture, Department of Chemical and Biomolecular Engineering, Lehigh University

2017 Bernard M. Gordon Prize for Innovation in Engineering and Technology Education, National Academy of Engineering

2016 Schlinger Symposium opening plenary address, Chemical Heritage Foundation

2015 SABIC Lectureship Award, Polymer Engineering, University of Akron

2015 Institute of Molecular Engineering Distinguished Lectures, University of Chicago

2014 4th KAIST CBE Global Distinguished Lectureship, Korea

2014 2nd Thomas H. Chilton Lecture, du Pont Central Research and Development

2013 Creativity in Science and Society, Symposium Celebrating Niels Bohr, Royal Danish Academy of Sciences and Letters, Copenhagen

2013 Alumni Endowed Lectures in Chemical Engineering, UMass-Amherst

2013 Fellow, American Institute of Chemical Engineers

2013 Distinguished Lecture, Chemical Engineering, Syracuse University

2012 Distinguished Research Lecture in Chemical Engineering, Carnegie Mellon University

2012 Eminent Lecturer, National Technical University Singapore

2012 TechniGraphicS Foundation Lecture, IIT Bombay, India

2012 Keynote ASME Design Automation Conference, Chicago

2011 Keynote ASME Dynamics Systems and Control Conference, Washington DC

2010 62nd Institute Lecture, American Institute of Chemical Engineers

2008 Fluid Dynamics Prize, American Physical Society

2008 Otto Laporte Lecture, American Physical Society

2008 AIChE 100th Anniversary “One Hundred Engineers of the Modern Era”, American Institute of Chemical Engineers.

2008 μ TAS (12th International Conference on Miniaturized Systems for Chemistry and Life Sciences, San Diego).

2007 Pirkey Lecture, University of Texas, Austin

2006 Dean’s Distinguished Lecture, College of Engineering and Mathematical Sciences, University of Vermont

2006 Reilly Lectures University of Notre Dame

2003 Member, American Academy of Arts and Sciences

2002 Ernest W. Thiele Award (AIChE, Chicago section)

2002 Robb Distinguished Lecture in Chemical Engineering Science, Penn State University

2001 William H. Walker Award, American Institute of Chemical Engineers

2001 John S. Guggenheim Fellowship

2001 Paul J. Flory Lecturer, Stanford University

1999 Danckwerts Memorial Lecture, London, England

1997 Member, National Academy of Engineering

1996 Fellow, American Association for the Advancement of Science

1996 Sigma Xi Distinguished Lecturer (1997-1999)

1996 SON Lecture (Foundation for Chemical Research, The Netherlands)

1995 Faculty Honor Roll, Associated Student Government, Northwestern University

1994 Alpha Chi Sigma Award, American Institute of Chemical Engineers

1994 William N. Lacey Lectureship in Chemical Engineering, California Institute of Technology

1994 College of Engineering Centennial Speaker, University of Maryland
1993 Fellow, American Physical Society, Division of Fluid Mechanics
1991 Fifth Stanley Corrsin Lectureship in Fluid Mechanics, The Johns Hopkins University
1989 Finalist Scientific Prize, Art for Science, LV-MH, Paris, France
1989 Merck Sharp & Dohme Lecturer, University of Puerto Rico
1988 University Fellow, University of Massachusetts
1987 Allan P. Colburn Memorial Lectureship, Chemical Engineering, University of Delaware
1984 Presidential Young Investigator Award (NSF)
1982 Outstanding Junior Faculty Scholar Award (University of Massachusetts)

Selected professional activities

- Chair, Draper Prize Committee, National Academy of Engineering; Member 2014- vice chair 2017, chair 2019.
- Co-Chair (with John Guckenheimer, Mathematics, Cornell University) “*Foundations for Complex Systems: Research in the Physical Sciences and Engineering*” (report from an NSF Workshop, September 2008).
- Member of several NRC committees, Benchmarking Committee, US Chemical Engineering (2007), Committee on the Challenges for the Chemical Sciences (2002-3) Draper Prize Committee (2014-).
- AIChE Chemical Engineering Operating Council, 2002-Benchmarking Committee, US
- Member International Review of Engineering in the UK –EPSRC/Royal Academy of Engineering (2004).
- Member NAE Committee on Membership (2003-2006)
- Founding Editor, *AIChE Journal*, Perspectives (1999-2006); Associate Editor (1994-2006)

Selected boards and advising activities

- Takata Quality Assurance Panel, 2015; www.takatapanel.com
- Scientific Board, AkzoNobel, 2010-2013
- Noribachi LLC, Albuquerque, New Mexico, 2008-2010
- Member, International Advisory Board, UC Santa Barbara (2005-2010)
- Unilever, Senior Advisor (1997-2008)
- Dow Chemical (Engineering Sciences Technical Advisory Board, 2000-2004).
- Member program reviews at Cornell, Houston, U.C. Santa Barbara, etc.

CURRENT AREAS OF RESEARCH

Granular Dynamics, Mixing – Fluid Dynamics, Segregation and Coarsening, Complex Systems.

Publications in Refereed Journals: Over 230 publications in refereed journals; ISI *h*-index: 58, Google Scholar *h*-index: 71; book “*The Kinematics of Mixing*” has been cited over 3,000 times. Publications have appeared in the following journals:

1. *Advances in Chemical Engineering*
2. *Advances in Complex Systems*
3. *American Institute of Chemical Engineers Journal*
4. *American Journal of Physics*
5. *Annals of Biomedical Engineering*
6. *Annual Review of Fluid Mechanics*
7. *Annual Review of Chemical and Biomolecular Engineering*

8. *Archives for Rational Mechanics and Analysis*
9. *Biotechnology Progress*
10. *Cardiovascular Engineering and Technology*
11. *Chaos*
12. *Chaos, Solitons and Fractals*
13. *Chemical Engineering Communications*
14. *Chemical Engineering Education*
15. *Chemical Engineering Science*
16. *European Journal of Physics*
17. *European Phys. Letters*
18. *Exp. Thermal Fluid Sci.*
19. *Geophysical Research Letters*
20. *Granular Matter*
21. *Industrial Engineering Chemistry Fundamentals*
22. *Industrial Engineering Chemistry Research*
23. *International Journal of Multiphase Flow*
24. *Int. J. Bifurcations and Chaos*
25. *Journal of Chemical Physics*
26. *Journal of Colloid and Interface Science*
27. *Journal of Fluid Mechanics*
28. *Journal of Non-Newtonian Fluid Mechanics*
29. *Lectures in Applied Mathematics*
30. *Macromolecules*
31. *Nature*
32. *Nature Communications*
33. *Nature Physics*
34. *New Journal of Physics*
35. *Philosophical Transactions of the Royal Society of London*
36. *Physics Reports*
37. *Physical Review*
38. *Physical Review Applied*
39. *Physical Review E*
40. *Physical Review Letters*
41. *Physical Review Fluids*
42. *Physics of Fluids and Physics of Fluids A*
43. *Polymer*
44. *Polymer Engineering Science*
45. *Powder Technology*
46. *Proceedings of the National Academy of Sciences of the US*
47. *Proceedings of the Royal Society of London*
48. *SIAM Journal on Applied Dynamical Systems*
49. *Soft Matter*
50. *Science*
51. *Tribology Letters*

Publications in Magazines

52. *CHEMTECH*
53. *INGENIA*
54. *Scientific American*
55. *The Chronicle of Higher Education*

PUBLICATIONS

Books

J.M. Ottino, *The Kinematics of Mixing: Stretching, Chaos, and Transport*, Cambridge University Press, Cambridge, England 1989 (xiv, 364 pp., illus., + plates), reprinted 1990, 1997; 2004.

R. Sturman, J.M. Ottino, and S. Wiggins, *Mathematical Foundations of Mixing: The Linked Twist Map as a Paradigm in Applications – Micro to Macro, Fluids to Solids*, Cambridge University Press, Cambridge, England, 2006

Publications in Refereed Journals, Technical Papers

J.M. Ottino, W.E. Ranz, and C.W. Macosko, A lamellar model for analysis of liquid-liquid mixing, *Chem. Eng. Sci.*, **34**, 877-890 (1979).

J.M. Ottino and C.W. Macosko, An efficiency parameter for batch mixing of viscous liquids, *Chem. Eng. Sci.*, **35**, 1454-1457 (1980).

J.M. Ottino, Lamellar mixing models for structured chemical reactions and their relationship to statistical models; Macro- and micro-mixing and the problem of averages, *Chem. Eng. Sci.*, **35**, 1377-1391 (1980).

L.J. Lee, J.M. Ottino, W.E. Ranz, and C.W. Macosko, Impingement mixing in reaction injection molding, *Polym. Eng. Sci.*, **20**, 868-874 (1980).

J.M. Ottino, Efficiency of mixing from data on fast reactions in multi-jet reactors and stirred tanks, *AIChE Journal*, **27**, 184-192 (1981).

J.M. Ottino, C.W. Macosko, and W.E. Ranz, Framework for the description of mechanical mixing of fluids, *AIChE Journal*, **27**, 565-577 (1981).

J.M. Ottino and H.T. Davis, Pressure tensor in lamellarly structured fluids, *J. Chem. Phys.*, **74**, 6388-6393 (1981).

J.M. Ottino, Description of mixing with diffusion and reaction in terms of the concept of material interfaces, *J. Fluid Mech.*, **114**, 83-103 (1982).

K.K. Mohanty, J.M. Ottino, and H.T. Davis, Reaction and transport in disordered composite media: Introduction of percolation concepts, *Chem. Eng. Sci.*, **37**, 905-924 (1982).

R. Chella and J.M. Ottino, Simplified model for mechanical mixing, diffusion, and reaction in a single screw extruder, *ACS Symp. Ser.*, **196**, 567-578 (1982).

J.M. Ottino, A mechanical mixing parameter for continuous mixing systems, *AIChE Journal*, **29**, 159-161 (1983).

- R. Chella and J.M. Ottino, Modeling of rapidly-mixed fast-crosslinking exothermic polymerizations I: Adiabatic temperature rise, *AIChE Journal*, **29**, 373-382 (1983).
- J.E. Sax and J.M. Ottino, Transport of small molecules in polymer blends: Application of effective medium theory, *Polym. Eng. Sci.*, **23**, 165-176 (1983).
- J.M. Ottino and R. Chella, Mixing of polymeric liquids: A brief review and recent theoretical developments, *Polym. Eng. Sci.*, **23**, 357-379 (1983).
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- R. Chella and J.M. Ottino, The fluid mechanics of mixing in a single screw extruder, *Ind. Eng. Chem. Fundam.*, **24**, 170-180 (1985).
- R. Chella and J.M. Ottino, Conversion and selectivity modifications due to mixing in unpremixed Reactors, *Chem. Eng. Sci.*, **39**, 551-567 (1984).
- J.E. Sax and J.M. Ottino, Influence of morphology on the transport properties of polystyrene/polybutadiene blends: Experimental results, *Polymer*, **26**, 1073-1080 (1985).
- N. Shah, J.E. Sax, and J.M. Ottino, Influence of morphology on the transport properties of polystyrene/polybutadiene blends: Modeling results, *Polymer*, **26**, 1229-1246 (1985).
- R. Chella and J.M. Ottino, Stretching in some classes of fluids motions and asymptotic mixing efficiencies as a measure of flow classification, *Arch. Rat. Mech. Anal.*, **90**, 15-45 (1985).
- D.J. Lin, J.M. Ottino, and E.L. Thomas, A kinetic study of the activated anionic polymerization of ϵ -Caprolactam, *Polym. Eng. Sci.*, **25**, 1155-1163 (1985).
- N. Shah and J.M. Ottino, Effective transport properties of random multi-phase composites: Application of renormalization Theory, *Chem. Eng. Sci.*, **41**, 283-296 (1986).
- D.V. Khakhar and J.M. Ottino, A note on the linear vector model of Olbricht, Rallison, and Leal as applied to the breakup of slender axisymmetric drops, *J. Non-Newtonian Fluid Mech.*, **21**, 127-131 (1986).
- D.V. Khakhar and J.M. Ottino, Deformation and breakup of slender drops in linear flows, *J. Fluid Mech.*, **166**, 265-285 (1986).
- W.L. Chien, H. Rising, and J.M. Ottino, Laminar and chaotic mixing in several cavity flows, *J. Fluid Mech.*, **170**, 355-377 (1986).
- D.V. Khakhar, H. Rising, and J.M. Ottino, An analysis of chaotic mixing in two model systems, *J. Fluid Mech.*, **172**, 419-451 (1986).
- D.V. Khakhar and J.M. Ottino, Fluid mixing (stretching) by periodic sequences for weak flows, *Phys. Fluids*, **29**, 3503-3505 (1986).
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- S.D. Fields and J.M. Ottino, Mixing effects during polymerizations by the adiabatic temperature rise technique, *AIChE Journal*, **33**, 157-160 (1987).
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- S.D. Fields and J.M. Ottino, Effect of striation thickness distribution on the course of an unpremixed polymerization, *Chem. Eng. Sci.*, **42**, 459-465 (1987).
- S.D. Fields and J.M. Ottino, Effect of stretching path on the course of polymerizations: applications to idealized unpremixed reactors, *Chem. Eng. Sci.*, **42**, 467-477 (1987).
- D.J. Kinning, E.L. Thomas, and J.M. Ottino, Effect of morphology on the transport of small molecule gases in block copolymers, *Macromolecules*, **20**, 1129-1133 (1987).
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- M. Serrano, W.J. MacKnight, E.L. Thomas and J.M. Ottino, Transport-morphology in polybutadiene polyurethanes. 1: Experimental results, *Polymer*, **28**, 1667-1673 (1987).
- M. Serrano, W.J. MacKnight, E.L. Thomas, and J.M. Ottino, Transport-morphology in polybutadiene polyurethanes. 2: Analysis, *Polymer*, **28**, 1674-1679 (1987).
- D.V. Khakhar, J.G. Franjione, and J.M. Ottino, A case study of chaotic mixing in deterministic flows: The partitioned pipe mixer, *Chem. Eng. Sci.*, **42**, 2909-2926 (1987).
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- E.M. Sevick, P.A. Monson, and J.M. Ottino, Monte Carlo calculations of cluster statistics in continuum models of composite morphology, *J. Chem. Phys.*, **88**, 1198-1206 (1988).
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[reprinted in "*Chaos and Nonlinear Dynamics*" edited by R.C. Hilborn and N.B. Tufillaro, American Association of Physics Teachers, College Park, Maryland, 1999.]
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E.M. Sevick, P.A. Monson, and J.M. Ottino, Clustering and percolation in assemblies of anisotropic particles: Perturbation theory and Monte Carlo simulation, *Phys. Rev. A.*, **38**, 5376-5383 (1988).

J.M. Ottino, The mixing of fluids, *Scientific American*, **260**, 56-67 (1989) (cover article). [translations appeared in *Pour la Science*, Le mélange des fluides, mensuel **137**, 32-42, Mars 1989, and *Investigacion y Ciencia*, Mezcla de Fluidos, Número **150**, 44-55, Marzo (1989); *Le Scienze*, Il Mescolamento dei Fluidi, n° **247**, 152-161 (1989); *Mischen zäher Flüssigkeiten*, Spektrum der Wissenschaft, März (1989), S66 - 77].

E.M. Sevick, P.A. Monson, and J.M. Ottino, Morphology and transport using the Ising lattice as a morphology description, *Chem. Eng. Sci.*, **44**, 21-32 (1989).

H.A. Kusch, J.M. Ottino, and D.M. Shannon, Analysis of impingement mixing-reaction data: Use of a lamellar model to generate fluid mixing information, *Ind. Eng. Chem. Res.*, **28**, 302-315 (1989).

F. J. Muzzio and J.M. Ottino, Evolution of a lamellar system with diffusion and reaction: A scaling approach, *Phys. Rev. Lett.*, **63**, 47-50 (1989).

C.-W. Leong and J.M. Ottino, Experiments on mixing due to chaotic advection in a cavity, *J. Fluid Mech.*, **209**, 463-499 (1989).

J.G. Franjione, C.W. Leong, and J.M. Ottino, Symmetries within chaos: a route to effective mixing, *Phys. Fluids A.*, **1**, 1772-1783 (1989).

F. J. Muzzio and J.M. Ottino, Dynamics of a lamellar system with diffusion and reaction: Scaling analysis and global kinetics, *Phys. Rev. A.*, **40**, 7182-7192 (1989).

J.M. Ottino, Mixing, Chaotic advection, and turbulence, *Ann. Revs Fluid Mech.*, **22**, 207-54 (1990).

C.-W. Leong and J.M. Ottino, Increase in regularity by polymer addition during chaotic mixing in two-dimensional flows, *Phys. Rev. Lett.*, **64**, 874-877 (1990).

P.D. Swanson and J.M. Ottino, A comparative computational and experimental study of chaotic mixing of viscous fluids, *J. Fluid Mech.*, **213**, 227-249 (1990).

T.J. Danielson and J.M. Ottino, Structural stability in two-dimensional model flows: Lagrangian and Eulerian turbulence, *Phys. Fluids A*, **2**, 2024-2035 (1990).

F.J. Muzzio and J.M. Ottino. Diffusion and reaction in a lamellar system: Self-similarity with finite rates of reaction, *Phys. Rev. A*, **42**, 5873-5884 (1990).

J.M. Ottino, Unity and Diversity in Mixing: Stretching, diffusion, breakup, and aggregation in chaotic flows, *Phys. Fluids A*, **5**, 1417-1430 (1991).

F.J. Muzzio, P.D. Swanson, and J.M. Ottino, The statistics of stretching and stirring in chaotic flows, *Phys. Fluids A*, **5**, 822-834 (1991).

- T.J. Danielson, F.J. Muzzio, and J.M. Ottino, Aggregation and structure formation in chaotic and regular flows, *Phys. Rev. Lett.*, **66**, 3128-3131 (1991).
- K. Shariff, T.H. Pulliam, and J.M. Ottino, A dynamical systems analysis of kinematics in the time-periodic wake of a circular cylinder, *Lectures in Applied Mathematics*, **28**, 613-646 (1991).
- J.G. Franjione and J.M. Ottino, Stretching in duct flows, *Phys. Fluids A.*, **3**, 2819-2821 (1991); *erratum*, *Phys. Fluids*, **6**, 3501 (1991).
- M. Tjahjadi and J.M. Ottino, Stretching and breakup of droplets in chaotic flows, *J. Fluid Mech.*, **232**, 191-219 (1991).
- F.J. Muzzio, M. Tjahjadi, and J.M. Ottino, Self-similar drop size distributions produced by breakup in chaotic flows, *Phys. Rev. Lett.*, **67**, 54-57 (1991).
- H.A. Kusch and J.M. Ottino, Experiments on mixing in continuous chaotic flows, *J. Fluid Mech.*, **236**, 319-348 (1992).
- S.C. Jana and J.M. Ottino, Chaos-enhanced transport in cellular flows, *Proc. Roy. Soc. London A.*, **338**, 519-532 (1992). Also published in *Nonlinear Dynamics of Engineering Systems*, edited by J.M.T. Thompson and W. Schliehler, London: The Royal Society (1992).
- F.J. Muzzio, P.D. Swanson, and J.M. Ottino, Mixing distributions produced by multiplicative stretching in chaotic flows, *Int. J. Chaos and Bifurcations*, **2**, 37-50 (1992) (*cover article*).
- J.G. Franjione and J.M. Ottino, Symmetry concepts for the geometric analysis of mixing flows, *Phil. Trans. Roy. Soc. Lond.*, **338**, 301-323 (1992).
- F.J. Muzzio, C. Meneveau, P.D. Swanson, and J.M. Ottino, Scaling and multifractal properties of mixing in chaotic flows, *Phys. Fluids A*, **4**, 1439-1456 (1992).
- J. M. Ottino, F. J. Muzzio, M. Tjahjadi, J. G. Franjione, S. C. Jana, H. A. Kusch, Chaos, Symmetry, and self-similarity: Exploiting order and disorder in mixing processes, *Science*, **257**, 754-760 (1992).
- M. Tjahjadi, H.A. Stone, and J.M. Ottino, Satellite and sub-satellite formation in capillary breakup, *J. Fluid Mech.*, **243**, 297-317 (1992).
- T. Shinbrot and J.M. Ottino, Geometric method to create coherent structures in chaotic flows, *Phys. Rev. Lett.*, **71**, 843-846 (1993).
- T.C. Niederkorn and J.M. Ottino, Mixing of viscoelastic fluids in time-periodic flows, *J. Fluid Mech.* **256**, 243-268 (1993).
- J.M. Ottino, S.C. Jana, and V.J. Chakravarthy, From Reynolds's stretching and folding to mixing studies using horseshoe maps, *Phys. Fluids A.*, **6**, 685-699 (1994).
- M. Tjahjadi, H.A. Stone, and J.M. Ottino, Estimating interfacial tension via relaxation of drops shapes and filament breakup, *AIChE Journal*, **40**, 385-394 (1994).

- G. Metcalfe and J.M. Ottino, Autocatalytic processes in chaotic flows, *Phys. Rev. Lett.*, **72**, 2875-2878 (1994); erratum, *Phys. Rev. Lett.*, **73**, 21 (1994).
- S.C. Jana, G. Metcalfe, and J.M. Ottino, Experimental and computational studies of mixing in complex Stokes flows: The vortex mixing flow and multicellular cavity flows, *J. Fluid Mech.* **256**, 199-246 (1994).
- S.C. Jana, M. Tjahjadi, and J.M. Ottino, Chaotic mixing of viscous fluids by periodic changes of geometry: The baffle-cavity system, *AIChE Journal*, **40**, 1769-1781 (1994).
- T.C. Niederkorn and J.M. Ottino, Mixing of shear thinning fluids in time-periodic flows, *AIChE Journal*, **40**, 1782-1793 (1994).
- J.M. Ottino, Mixing and chemical reactions: A tutorial, *Chem. Eng. Sci.* **49** (24A), 4005-4027 (1994).
- T. Shinbrot and J.M. Ottino, Maps, PDE's and solitary waves, *Int. J. Bifur. Chaos*, **5**, 955-970 (1995).
- G. Metcalfe, J.M. Ottino, C.R. Bina, Kinematical considerations for mantle mixing, *Geophys. Rev. Lett.*, **22**, 743-746 (1995).
- A. Souvaliotis, S.C. Jana, and J.M. Ottino, Potentialities and limitations of mixing simulations, *AIChE Journal*, **41**, 1605-1621 (1995).
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- V.J. Chakravarthy and J.M. Ottino, Mixing studies using horseshoes, *Int. J. Bifurcation and Chaos*, **5**, 519-530 (1995).
- J. M. Ottino, A. Souvaliotis, and G. Metcalfe, Chaotic mixing processes: New problems and computational issues, *Chaos, Solitons, and Fractals*, **6**, 425-438 (1995).
- S. Hansen and J.M. Ottino, Agglomerate Erosion: A non-scaling solution to the fragmentation equation, *Phys. Rev. E*, **53**, 4209-4212 (1996).
- S. Hansen and J.M. Ottino, Aggregation and cluster size evolution in non-homogenous flows, *J. Colloid and Int. Sci.*, **179**, 89-103 (1996).
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- L. Bresler, T. Shinbrot, and J.M. Ottino, Control of transport in chaotic lattice, *Physica D*, **93**, 191-209 (1996).
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L. Bresler, T. Shinbrot, G. Metcalfe, and J.M. Ottino, Isolated mixing regions: Origin, robustness, and control, *Chem. Eng. Sci.* **52**, 1623-1639 (1997).

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S. Hansen and J.M. Ottino, Fragmentation with abrasion and cleavage: Analytical results, *Powder Tech.* **93**, 177-184 (1997).

D.V. Khakhar, J.J. McCarthy, T. Shinbrot, and J.M. Ottino, Transverse flow and mixing of granular materials in a rotating cylinder, *Phys. Fluids*, **9**, 31-43 (1997).

D.V. Khakhar, J.J. McCarthy, and J.M. Ottino, Radial segregation of granular mixtures in rotating cylinders, *Phys. Fluids*, **9**, 3600-3614 (1997).

J.M. Ottino, Kinematical views of mixing of fluids and granular materials: A brief review and open questions, *Rev. Mex. Fis.* **44**: (3) 215-221 (1998).

T. Shinbrot, L. Bresler, and J.M. Ottino, Manipulation of isolated structures in experimental chaotic fluid flows, *Exp. Therm. Fluid Sci.* **16**: (1-2) 76-83 (1998).

J.J. McCarthy and J.M. Ottino, Particle dynamics simulations: A hybrid technique applied to granular mixing, *Powder Technol.* **91**, 91-99 (1998).

S. Hansen, D.V. Khakhar, and J.M. Ottino, Dispersion of solids in nonhomogeneous viscous flows, *Chem. Eng. Sci.* **53**, 1803-1817 (1998).

G.O. Fountain, D.V. Khakhar, and J.M. Ottino, Visualization of three-dimensional chaos, *Science*, **281**, 683-686 (1998) (cover article).

M. Horner, W.M. Miller, J.M. Ottino, and E.T. Papoutsakis, Transport in grooved perfusion flat-bed bioreactor for cell therapy applications, *Biotechnology Progress*, **14**, 689-698 (1998).

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20th International Symposium of Theoretical and Applied Mechanics (*plenary presentation*)

2nd Experimental Chaos Conference, Washington, DC (*plenary presentation*)

3M Center, Process Research and Technology, Division Engineering, St. Paul, Minnesota

3M Technical Forum, 3M Technical Center, Corporate Research Laboratory, St. Paul, MN

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ANTEC/SPE - New Technology Forum, San Francisco, California
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 National Bureau of Standards, Fluid Mechanics Division, Gaithersburg, Maryland
 National Bureau of Standards, Polymer Science and Standards Group, Gaithersburg
 NATO Workshop in Mixing, Cargèse, Corsica, France
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 Symposium on Contemporary Applications of Mathematics, The Five College Applied Mathematics
 Program, Mount Holyoke College, South Hadley, Massachusetts
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 University of California, Berkeley, Mechanical Engineering
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 University of Cambridge, Applied Mathematics and Theoretical Physics
 University of Cambridge, Chemical Engineering
 University of Chicago (James Frank Institute)
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University of Notre Dame, Reilly Lectures
University of Pennsylvania, Department of Chemical Engineering
University of Pittsburgh, Chemical and Petroleum Engineering
University of South Carolina, “Images in Nanotechnology” Conferences
University of South Carolina, Chemical Engineering
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World Congress of Chemical Engineering (*plenary*), Glasgow, Scotland
XL National Congress of Physics; Monterrey, Mexico (*plenary talk*)
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3M (1994-2000), DSM, Netherlands (1992-1998), Rohm & Haas (1993), Gardner, Carton & Douglas (1994), B.F. Goodrich (1996-97), Unilever (1997-2008), Helene Curtis (1997), Intellicoat (1998), Dow Chemical (2000-2004), Merck (2000), Abbott (2001), Baxter (2002-3), Resodyn Corp. (2004-), SC Johnson (2004), Brookwood Pharmaceuticals (2006), Swagelok (2008), AkzoNobel (2010-2014).

Funding and Advising

Supervised over 50 Ph.D. students – from chemical engineering, mechanical engineering, polymer science, physics, and applied mathematics – currently working in industry and academia (of these 30 have been singly advised by JMO). Federal funding sources have included NSF, DOE, AFOSR, and the U.S. Army. Industrial sources have included ALCOA, 3M, Exxon, Xerox, Dow Chemical, Owens Corning, Union Carbide, Rohm & Haas, du Pont, and others. Other sources have included The Petroleum Research Fund and the Dreyfus Foundation. Current PI in one NSF grant.