

JULIO M. OTTINO

BIOGRAPHY

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Dr. Julio M. Ottino is the dean of the Robert R. McCormick School of Engineering and Applied Sciences at Northwestern University where he holds the titles of Distinguished Robert R. McCormick Institute Professor and Walter P. Murphy Professor of Chemical and Biological Engineering. Born in Argentina he had a career as an artist before he moved to the U.S. for his PhD in Chemical Engineering at the University of Minnesota. He then held a faculty position at UMass/Amherst and held chaired and senior appointments at Caltech, Stanford, and the University of Minnesota. He joined Northwestern in 1991 and was chairman of the Department of Chemical and Biological Engineering from 1992 to 2000. He was the founder and co-director of the Northwestern Institute on Complex Systems. As dean he led to a 22 percent renewal of the faculty in three years, launched the Segal Design Institute in 2007, the Farley Center for Entrepreneurship and Innovation in 2008, and was instrumental in the creation of the Initiative in Sustainability and Energy at Northwestern, launched also in 2008.

Ottino's research has been featured in articles and on the covers of *Nature*, *Science*, *Scientific American*, the *Proceedings of the National Academy of Sciences of the USA* and other publications, and has impacted fields as diverse as complex systems, fluid dynamics, granular dynamics, microfluidics, geophysical sciences. One of his books, "*The Kinematics of Mixing: Stretching, Transport and Chaos*," Cambridge (published in 1989, and reprinted in 1997), has become a classic in the field. His most recent book, with R. Sturman and S. Wiggins, is the *Mathematical Foundations of Mixing: The Linked Twist Map as a Paradigm in Applications – Micro to Macro, Fluids to Solids*, and was published by Cambridge University Press in 2006

Ottino served on committees of the National Research Council and the National Academy of Engineering and was a member of the International Review of Engineering in the United Kingdom. He was a senior advisor to Unilever, a member of the Technical Advisory Board of Dow Chemical, and served on advisory and visiting boards for startups, non-profit organizations and educational institutions in the United States. He has lectured to a range of diverse audiences in topics ranging from the purely technical to creativity and art. Ottino received many national awards including the Alpha Chi Sigma Award and the William H. Walker from the American Institute of Chemical Engineers (AIChE), and the Fluid Dynamics Prize from the American Physical Society. He has been a Guggenheim Fellow and a Sigma Xi Lecturer. In 2008 he was selected by the AIChE as one of the "One Hundred Engineers of the Modern Era." Ottino has given numerous named lectureships, including the Lacey Lectures at Caltech, the Corrsin Lecture in Johns Hopkins, the Centennial Lecture in Maryland, the Pirkey Lecture at Texas/Austin, and the Danckwerts Lecture in England. He is a fellow of the American Physical Society and the American Association for the Advancement of Science and is a member of both the National Academy of Engineering and the American Academy of Arts and Sciences.

Dr. Ottino's interests are at the intersection of art, science and technology. He is currently working on a book about the creative processes connecting these domains.

Dr. Ottino lives in Winnetka, Illinois, with his wife, Dr. Alicia Löffler who works in the biotechnology sector. They have two sons.

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 Lectureships

2008 Fluid Dynamics Prize and Otto Laporte Lecture, American Physical Society
2008 "One Hundred Engineers of the Modern Era", American Institute of Chemical Engineers.
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 Robb Distinguished Lecture in Chemical Engineering Science, Penn State University
2002 Ernest W. Thiele Award (AIChE, Chicago section)
2001 William H. Walker Award, American Institute of Chemical Engineers

¹Naturalized March 21, 1991, Northampton, Massachusetts.

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)
 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 Merck Sharp & Dohme Lecturer, University of Puerto Rico
 1989 Finalist Scientific Prize, Art for Science, LV-MH, Paris, France
 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)

Main professional activities last five years

- 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, International Advisory Board, UC Santa Barbara (2005-)
- Member NRC Benchmarking Committee, US Chemical Engineering (2007).
- Member International review of Engineering in the UK –EPSRC/Royal Academy of Engineering (2004).
- Chair NAE Peer Committee Chemical Engineering, 2002
- Member NAE Committee on Membership (2003-2006)
- Member program reviews at Cornell, Houston, etc., U of Ill, Chicago,
- Founding Editor, *AICHE Journal*, Perspectives (1999-2006); Associate Editor (1994-2006)

Boards and advising activities last five years

- Noribachi LLC, Albuquerque, New Mexico, 2008-
- School of Engineering, University of California, Santa Barbara, 2005-
- Unilever, Technical Advisor (1997-2008)
- Dow Chemical (Engineering Sciences Technical Advisory Board, 2000-2004).
- Council for Chemical Research (1998-2001)
- Chemical Engineering Technology Operating Council, AIChE (2001-2002).

Significant University Committees at Northwestern

- *Co-Chair*, Reorganization of Basic Industrial Research Laboratory (BIRL), Northwestern's Research Park (1995-1996)
- *Member*, Provost Search Committee (1995)
- *Chair*, Long-Range Planning Committee for the Geology Department, Northwestern University (1996-1997)
- *Member*, Honorary Degree Committee (1997-2001)
- *Member*, *Ad Hoc* Planning Committee (Chaired by Provost) (1997-1998)
- *Member* “*Highest Order of Excellence*” (*HOE I* 1998, *HOE II* 2003)
- *Member* Subcommittee – ad hoc group on Reducing Administrative Complexity at Northwestern
- *Member*, Great Debates Committee, 2000-2001

- Task Force on Cross School Hiring (reports to Provost), 2000
- Member, Dean of Weinberg College Search Committee, 2001

CURRENT AREAS OF RESEARCH

Complex Systems, Granular Dynamics, Mixing, Segregation and Coarsening, Fluid Mechanics of Mixing.

Publications in Refereed Journals: About 170 publications in refereed journals; *h*-index: 46; book “*The Kinematics of Mixing*” has been cited well over 1,000 times. Publications have appeared or are in press in the following journals:

1. *Advances in Chemical Engineering*
2. *Advances in Complex Systems*
3. *American Institute of Chemical Engineers Journal*
4. *Annuals Reviews of Fluid Mechanics*
5. *Archives for Rational Mechanics and Analysis*
6. *Biotechnology Progress*
7. *Chaos, Solitons and Fractals*
8. *Chemical Engineering Communications*
9. *Chemical Engineering Education*
10. *Chemical Engineering Science*
11. *European Journal of Physics*
12. *Exp. Thermal Fluid Sci.*
13. *Geophysical Research Letters*
14. *Granular Matter*
15. *Industrial Engineering Chemistry Fundamentals*
16. *Industrial Engineering Chemistry Research*
17. *International Journal of Multiphase Flow*
18. *Int. J. Bifurcations and Chaos*
19. *Journal of Chemical Physics*
20. *Journal of Colloid and Interface Science*
21. *Journal of Fluid Mechanics*
22. *Journal of Non-Newtonian Fluid Mechanics*
23. *Lectures in Applied Mathematics*
24. *Macromolecules*
25. *Nature*
26. *Nature Physics*
27. *Philosophical Transactions of the Royal Society of London*
28. *Physica D*
29. *Physical Review A*
30. *Physical Review E*
31. *Physical Review Letters*
32. *Physics of Fluids and Physics of Fluids A*
33. *Polymer*
34. *Polymer Engineering Science*
35. *Powder Technology*
36. *Proceedings of the National Academy of Sciences of the US*
37. *Proceedings of the Royal Society of London*
38. *Soft Matter*
39. *Science*
40. *Tribology Letters*

Publications in Magazines

41. CHEMTECH
42. INGENIA
43. *Scientific American*

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).
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- J.M. Ottino and N. Shah, Analysis of transient sorption and permeation of small molecules in multiphase polymer systems, *Polym. Eng. Sci.*, **24**, 153-162 (1984).
- R. Chella and J.M. Ottino, Conversion and selectivity modifications due to mixing in unpremixed Reactors, *Chem. Eng. Sci.*, **39**, 551-567 (1984).
- R. Chella and J.M. Ottino, The fluid mechanics of mixing in a single screw extruder, *Ind. Eng. Chem. Fundam.*, **24**, 170-180 (1985).
- 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 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).
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S.D. Fields, E.L. Thomas, and J.M. Ottino, Visualization of interfacial urethane polymerizations by means of a new microstage reactor, *Polymer*, **27**, 1423-1432 (1986).

N. Shah and J.M. Ottino, Transport and reaction in evolving, disordered composites: I. Gasification of porous solids, *Chem. Eng. Sci.*, **42**, 63-72 (1987).

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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).

D.V. Khakhar and J.M. Ottino, Breakup of liquid threads in linear flows, *Int. J. Multiphase Flow*, **13**, 71-86 (1987).

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).

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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).

J.G. Franjione and J.M. Ottino, Feasibility of numerical tracking of material lines and surfaces in chaotic flows, *Phys. Fluids*, **30**, 3641-3643 (1987).

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J. M. Ottino, C.W. Leong, H. Rising, and P.D. Swanson, Morphological structures produced by mixing in chaotic flows, *Nature*, **333**, 419-425 (1988) (*cover article*).
[reprinted in "*Chaos and Nonlinear Dynamics*" edited by R.C. Hilborn and N.B. Tufillaro, American Association of Physics Teachers, College Park, Maryland, 1999.]

F. Muzzio and J.M. Ottino, Coagulation in chaotic flows, *Phys. Rev. A*, **38**, 2516-2524 (1988).

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).
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- 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).
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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).
- V.J. Chakravarthy and J.M. Ottino, Mixing of two viscous fluids in a rectangular cavity, *Chem. Eng. Sci.*, **51**, 3613-3622 (1996).
- L. Bresler, T. Shinbrot, and J.M. Ottino, Control of transport in chaotic lattice, *Physica D*, **93**, 191-209 (1996).
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- S. Hansen and J.M. Ottino, Fragmentation with abrasion and cleavage: Analytical results, *Powder Tech.* **93**, 177-184 (1997).
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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
University of Southern California, Department of Chemical Engineering

University of Tennessee, Department of Chemical Engineering
University of Texas, Austin, Department of Chemical Engineering
University of Texas, Austin, Nonlinear Dynamics
University of Vermont, Dean's Distinguished Lecture
University of Virginia, Chemical Engineering
University of Washington, Seattle, Department of Chemical Engineering
University of Wisconsin, Madison, Department of Chemical Engineering
Washington University, Department of Chemical Engineering
World Congress of Chemical Engineering (*plenary*), Glasgow, Scotland
XL National Congress of Physics; Monterrey, Mexico (*plenary talk*)
Yale University, Department of Mechanical Engineering

Consulting

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).

Funding and Advising

Advised 35 Ph.D. students – from chemical engineering, polymer science, physics, and mathematics -- currently working in industry and academia (25 of the 35 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.