Ming-Chih Lai

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Education:

Ph.D. Mathematics, Courant Institute of Mathematical Sciences, New York University, 1998/09

Research Interests:

Scientific machine learning
Immersed boundary and immersed interface methods
Modeling and simulations for interfacial flow problems
Fast direct solvers for elliptic equations in non-Cartesian coordinates

Appointments:

2021/08 - present, *Dean*, College of Science, NYCU
2021/01 - present, *Chair Professor*, Department of Applied Mathematics, NYCU
2014/12 - 2020/12, *Chair Professor*, Department of Applied Mathematics, NCTU
2013/08 - present, *Jointly Appointed Research Fellow*, Institute of Mathematics, Academia Sinica
2013/01 - 2013/05, *Visiting Professor*, Hong Kong Baptist University
2012/09 - 2012/12, *Visiting Professor*, Research Institute for Mathematical Sciences (RIMS), Kyoto University
2011/06 - 2014/11, *Distinguished Professor*, Department of Applied Mathematics, NCTU
2007/08 - 2009/07, *Chair*, Department of Applied Mathematics, NCTU
2005/08 - 2011/05, *Professor*, Department of Applied Mathematics, NCTU
2002/08 - 2005/07, *Associate Professor*, Department of Applied Mathematics, NCTU
1999/08 - 2002/07, *Assistant Professor*, Department of Mathematics, National Chung Cheng University
1998/08 - 1999/07, *Research Associate*, Department of Physics, Duke University

International and Domestic Committees:

2018/05 - 2020/05, **President**, Taiwan Society for Industrial and Applied Mathematics (TWSIAM)
2015/12 - 2017/12, **President**, Mathematical Society of ROC (Taiwan)
2016/01 - 2020/12, **Deputy Director**, National Center for Theoretical Sciences (NCTS), Math Division
2014 - 2016, **SIAM** Membership committee
2013 - 2014, **President**, **SIAM** East Asia Section (EASIAM)
2012 - 2014, **Panel Chair**, National Science Council, Mathematics Division

Prizes and Awards:

TWSIAM Fellow, 2021
National Chung Hsing University, Outstanding Alumnus, 2018
Ministry of Education, National Chair Professorship, 2017
Ministry of Education, Academic Award, 2014
National Science Council, Outstanding Research Award, 2011
Mathematical Society of ROC, Academic Award, 2011
National Science Council, Outstanding Scholar Research Grant, 2009/08 - 2012/07
NCTU, Academic Research Award, 2005
National Science Council, Outstanding Research Award, 2003

Kurt O. Friedrichs Prize for an outstanding dissertation in Mathematics at Courant Institute, NYU, 1999

Editorial Boards:

Communications in Computational Physics, 2012 -
East Asian Journal on Applied Mathematics, 2010 -

Selected Talks:

1. The 7th International Conference on Scientific Computing and Partial Differential Equations (Plenary Speaker), HKPU, Hong Kong, May 22-26, 2023
2. Modeling and Simulation of Interface Dynamics in Fluids/Solids (Invited Speaker), IMS, NUS, Singapore, May 14-18, 2018
3. SIAM Conference on the Life Sciences (Mini-symposium Speaker), Boston, USA, July 11-14, 2016
4. The 7th PRCM (Section Organizer and Speaker) on "Computational Aspects of interface problems with applications", Seoul, Korea, June 27-July 1, 2016
5. JSIAM 2014 Annual Meeting (Invited Speaker), Tokyo, Japan, September 3-5, 2014
6. SIAM 2014 Annual Meeting (Membership Committee meeting and Mini-symposium Invited Speaker), Chicago, USA, July 7-11, 2014
7. KSIAM 2014 Spring Conference (Plenary Speaker), National Seoul University, Korea, May 23-24, 2014
8. Biological Complex Fluids, 2012 Cargese summer school (Invited Lecturer), Corsica Island, France, June 25-July 7, 2012.
9. Fluid dynamics, Analysis and Numerics (Invited Speaker), Duke University, USA, June 28-30, 2010
10. Workshop on Fluid Motion Driven by Immersed Structures (Tutorial Speaker), Fields Institute, Canada, August 9-13, 2010

Selected Publications:

Machine learning methods for elliptic interface problems

1. W.-F. Hu, Y.-J. Shih, T.-S. Lin, M.-C. Lai, A shallow physics-informed neural network for solving partial differential equations on static and evolving surfaces, *Comput. Methods Appl. Mech. Eng.*, in press. arXiv:2203.01581.
2. Y.-H. Tseng, T.-S. Lin, W.-F. Hu, M.-C. Lai, A cusp-capturing PINN for elliptic interface problems, *J. Comput. Phys.*, Vol 491 (2023), 112359. arXiv:2210.08424.
3. W.-F. Hu, T.-S. Lin, Y.-H. Tseng, M.-C. Lai, An efficient neural-network and finite-difference hybrid method for elliptic interface problems with applications, *Commun. Comput. Phys.*, Vol 33 (2023), pp. 1090–1105. arXiv:2210.05523.
4. W.-F. Hu, T.-S. Lin, M.-C. Lai, A discontinuity capturing shallow neural network for elliptic interface problems, *J. Comput. Phys.*, Vol 469 (2022), 111576. arXiv:2106.05587.
5. M.-C. Lai, C.-C. Chang, W.-S. Lin, W.-F. Hu, T.-S. Lin, A shallow Ritz method for elliptic problems with singular sources, *J. Comput. Phys.*, Vol 469 (2022), 111547. arXiv:2107.12013.

Immersed boundary and immersed interface methods for interfacial flows

1. K. C. Ong, Y. Seol, M.-C. Lai, An immersed boundary projection method for solving the fluid-rigid bodyinteraction problems, *J. Comput. Phys.*, Vol 466 (2022), 111367.
2. M.-C. Lai, Y. Seol, A stable and accurate immersed boundary method for simulating vesicle dynamics viaspherical harmonics, *J. Comput. Phys.*, Vol 449 (2022), 110785.

3. K.-C. Ong, M.-C. Lai, Y. Seol, An immersed boundary projection method for incompressible interface simulations in 3D flows, *J. Comput. Phys.*, Vol 430 (2021) 110090.
4. K.-C. Ong, M.-C. Lai, An immersed boundary projection method for simulating the inextensible vesicledynamics, *J. Comput. Phys.*, Vol 408 (2020) 109277.
5. Y. Seol, M.-C. Lai, Spectrally accurate algorithm for points redistribution on closed curves, *SIAM J. Sci. Comput.*, Vol 42, No 5, (2020), pp. A3030-A3054.
6. S.-H. Hsu, W.-F. Hu, M.-C. Lai, A coupled immersed interface and grid based particle method for three-dimensional electrohydrodynamic simulations, *J. Comput. Phys.*, Vol 398 (2019), 108903.
7. S.-H. Hsu, J. Chu, M.-C. Lai, R. Y.-H. Tsai, A coupled grid based particle and implicit boundary integral method for two-phase flows with insoluble surfactant, *J. Comput. Phys.*, Vol 395 (2019), pp. 747-764.
8. M.-C. Lai, K.-C. Ong, Unconditionally energy stable schemes for the inextensible interface problem withbending, *SIAM J. Sci. Comput.*, Vol 41, No 4, (2019), pp. B649-B668.
9. Y. Seol, Y.-H. Tseng, Y. Kim, M.-C. Lai, An immersed boundary method for simulating Newtonianvesicles in viscoelastic fluid, *J. Comput. Phys.*, Vol 376 (2019), pp. 1009-1027.
10. J.-J. Xu, W. Shi, and M.-C. Lai, A level-set method for two-phase flows with soluble surfactant, *J.Comput. Phys.*, Vol 353 (2018), pp. 336-355.
11. Y. Seol, S.-H. Hsu, and M.-C. Lai, An immersed boundary method for simulating interfacial flows with insoluble surfactant in three dimensions, *Commun. Comput. Phys.*, Vol 23 (2018), pp. 640-664.
12. Y. Seol, W.-F. Hu, Y. Kim and M.-C. Lai, An immersed boundary method for simulating vesicle dynamicsin three dimensions, *J. Comput. Phys.*, Vol 322 (2016), pp. 125-141.
13. W.-F. Hu, M.-C. Lai, Y. Seol and Y.-N. Young, Vesicle electrohydrodynamic simulations by coupling immersed boundary and immersed interface method, *J. Comput. Phys.*, Vol 317 (2016), pp. 66-81.
14. W.-F. Hu, M.-C. Lai, and Y.-N. Young, A hybrid immersed boundary and immersed interface method forelectrohydrodynamic simulations, *J. Comput. Phys.*, Vol 282 (2015), pp. 47-61.
15. Y. Kim, M.-C. Lai, C. S. Peskin and Y. Seol, Numerical simulations of three-dimensional foam by the immersed boundary method, *J. Comput. Phys.*, Vol 269 (2014), pp. 1-21.
16. W.-F. Hu, Y. Kim, and M.-C. Lai, An immersed boundary method for simulating the dynamics of three- dimensional axisymmetric vesicles in Navier-Stokes flows, *J. Comput. Phys.*, Vol 257 (2014), pp. 670-686.
17. K.-Y. Chen and M.-C. Lai, A conservative scheme for solving coupled surface-bulk convection-diffusion equations with an application to interfacial flows with soluble surfactant, *J. Comput. Phys.*, Vol 257 (2014), pp. 1-18.
18. M.-C. Lai, W.-F. Hu, and W.-W. Lin, A fractional step immersed boundary method for Stokes flow with an inextensible interface enclosing a solid particle, *SIAM J. Sci. Comput.*, Vol 34, No 5 (2012), pp.B692-B710.
19. K.-Y. Chen, K.-A. Feng, Y. Kim and M.-C. Lai, A note on pressure accuracy in immersed boundary method for Stokes flow, *J. Comput. Phys.*, Vol 230 (2011), 4377-4383.
20. Y. Kim and M.-C. Lai, Simulating the dynamics of inextensible vesicles by the penalty immersed boundary method, *J. Comput. Phys.*, Vol 229 (2010), 4840-4853.
21. Y. Kim, M.-C. Lai and C. S. Peskin, Numerical simulations of two-dimensional foam by the immersed boundary method, *J. Comput. Phys.*, Vol 229 (2010), 5194-5207.
22. M.-C. Lai, Y.-H. Tseng and H. Huang, Numerical simulation of moving contact lines with surfactant by immersed boundary method, *Commun. Comput. Phys.*, Vol 8 (2010), 735-757.
23. K. Ito, M.-C. Lai and Z. Li, A well-conditioned augmented system for solving Navier-Stokes equations inirregular domains, *J. Comput. Phys.*, Vol 228 (2009), 2616-2628.
24. M.-C. Lai, Y.-H. Tseng and H. Huang, An immersed boundary method for interfacial flows with insolublesurfactant, *J. Comput. Phys.*, Vol 227 (2008), 7279-7293.

25. Z. Li, W.-C. Wang, I.-L. Chern and M.-C. Lai, New formulations for interface problems in polar coordi- nates, *SIAM J. Sci. Comput.*, Vol 25, No 1 (2003), 224-245.
26. J. T. Beale and M.-C. Lai, A method for computing nearly singular integrals, *SIAM J. Numer. Anal.*,Vol 38, No 6 (2001), 1902-1925.
27. M.-C. Lai and Z. Li, A remark on jump conditions for the three-dimensional Navier-Stokes equations involving an immersed moving membrane, *Appl. Math. Lett.*, 14, Vol 2 (2001), 149-154.
28. Z. Li and M.-C. Lai, The immersed interface method for the Navier-Stokes equations with singular forces, *J. Comput. Phys.*, Vol 171 (2001), 822-842.
29. M.-C. Lai and C. S. Peskin, An immersed boundary method with formal second-order accuracy andreduced numerical viscosity, *J. Comput. Phys.*, Vol 160 (2000), 705-719.

Fluid flow simulations and applications

1. A. Farutin, H. Wu, W.-F. Hu, S. Rafai, P. Peyla, M.-C. Lai, and C. Misbah, Analytical Study for Swimmersin a Channel, *J. Fluid Mech.*, Vol 881 (2019), pp. 365-383.
2. M.-C. Lai, M.-C. Shiue, K.-C. Ong, A simple projection method for the coupled Navier-Stokes and Darcyflows, *Comput. Geosci.*, Vol 23 (2019), 21-33.
3. M.-C. Shiue, K. C. Ong, and M.-C. Lai, Convergence of the MAC scheme for the Stokes/Darcy coupling problem, *J. Sci. Comput.* , Vol 76 (2018), 1216-1251.
4. Y. Kim, M.-C. Lai, and Y. Seol, Numerical simulations of vesicle and bubble dynamics in two-dimensionalfour-roll mill flows, *Phys. Rev. E* 95 (2017), 053105.
5. K.-L. Pan, Y.-H. Tseng, J.-C. Chen, K.-L. Huang, C.-H. Wang, and M.-C. Lai, Controlling droplet bouncing and coalescence with surfactant, *J. Fluid Mech.*, Vol 799 (2016), pp. 603-636.
6. H. Nganguia, Y.-N. Young, A. T. Layton, M.-C. Lai, and W.-F. Hu, Electrohydrodynamics of a viscous drop with inertia, *Phys. Rev. E* 93 (2016), 053114.
7. J.-J. Xu, Y. Huang, M.-C. Lai and Z. Li, A coupled immersed interface and level set method for three- dimensional interfacial flows with insoluble surfactant, *Commun. Comput. Phys.*, Vol 15, No 2 (2014), pp. 451-469.
8. Y. Kim and M.-C. Lai, Numerical study for viscosity and inertial effects on tank-treading to tumbling motions of vesicle under shear flow, *Phys. Rev. E*, 86 (2012), 066321.
9. P. Constantin, M.-C. Lai, R. Sharma, Y.-H. Tseng and J. Wu, New numerical results for the surface quasi-geostrophic equation, *J. Sci. Comput.*, Vol 50, Issue 1 (2012), 1-28.
10. J. Huang, M.-C. Lai and Y. Xiang, An integral equation method for epitaxial step flow growth simulations, *J. Comput. Phys.*, Vol 216 (2006), 724-743.

Fast direct solvers for elliptic equations in non-Cartesian coordinates

1. M.-C. Lai and Y.-H. Tseng, A fast iterative solver for the variable coefficient diffusion equation on a disk, *J. Comput. Phys.*, Vol 208 (2005), 196-205.
2. M.-C. Lai, A simple compact fourth-order Poisson solver on polar geometry, *J. Comput. Phys.*, Vol 182 (2002), 337-345.
3. M.-C. Lai, W.-W. Lin and W. Wang, A fast spectral/difference method without pole conditions for Poisson-type equations in cylindrical and spherical geometries, *IMA J. Numer. Anal.*, Vol 22, No 4 (2002), 537-548.