The Historical Development and Transformation of Applied Mathematics at Caltech

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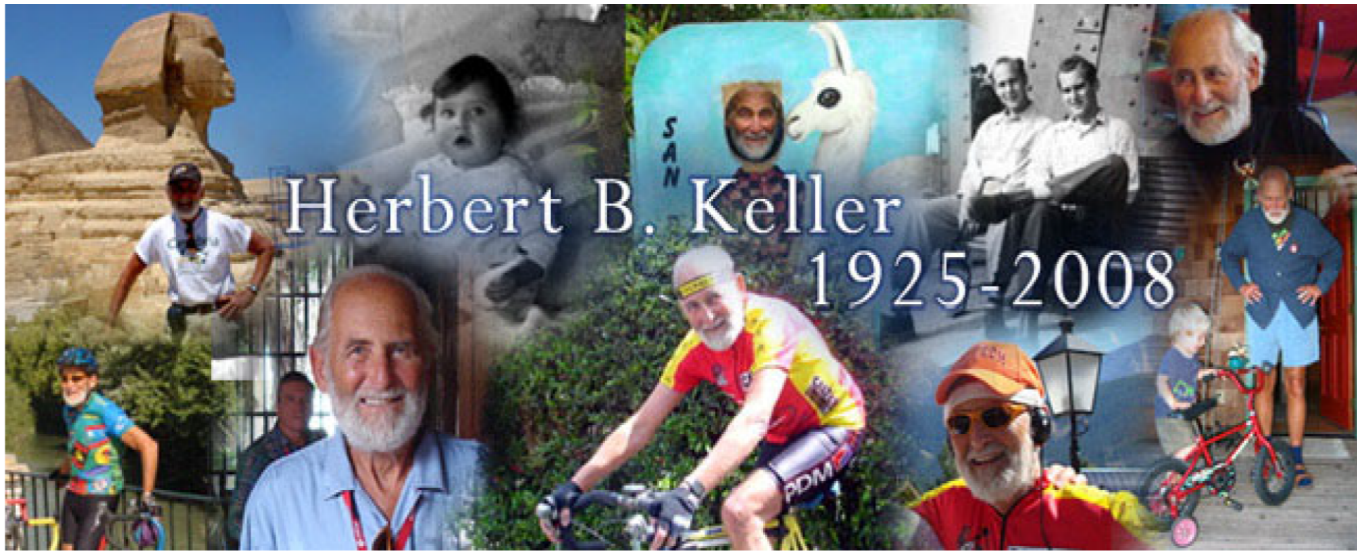
Early history of Applied Mathematics (AMa) at Caltech

- The Applied Math Option (AMa) was established in 1967 by Gerald Whitham, who served as the first chair (EO) from 1971 to 1980, and was named the Powell Professor from 1983 to 1998.
- The earlier faculty members include Philip Saffman, Donald Cohen, Herbert Keller, and Joel Franklin. Heinz-Otto Kreiss joined AMa from 1978 to 1987 and Dan Meiron joined in 1985.
- Heinz Kreiss left Caltech and joined UCLA in 1988. Micth Luskin Joined Caltech for one year between 1989 and 1990.
- Sheila Shull joined AMa on 10/25/1978 and retired in 2021. She has played a crucial role in keeping everything run so smoothly.

AMa faculty: Don Cohen, Herb Keller, Dan Meiron, Jerry Whitham, Joel Franklin, and Philip Saffman

The legend of Herb B. Keller

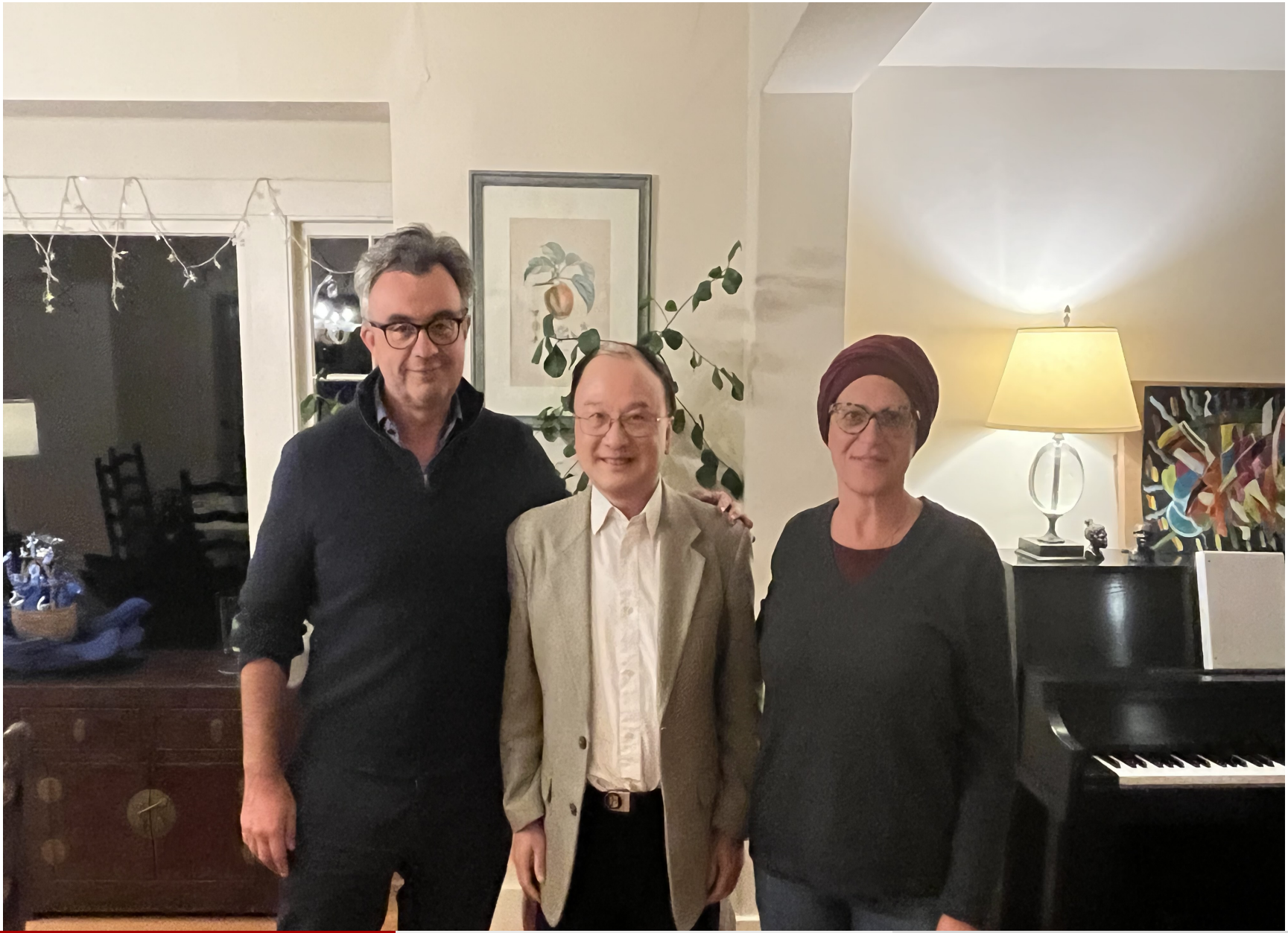


Transformation from AMa to ACM in last 30 years

- I received a tenure offer from Caltech in June of 1992 and joined Caltech in June of 1993.
- Oscar Bruno joined Caltech in 1995, Niles Pierce joined in 1999, and Emmanuel Candes joined in 2000.
- In 2001, we renamed AMa to ACM and hired Houman Owhadi in 2003, Joel Tropp in 2006, Venkat Chandrasekaran in 2012, Andrew Stuart in 2016, and Franca Hoffmann in 2020 (joined in 2022).
- Sydney Garstang joined ACM on 2/22/2005, and Diana Bohler joined ACM on 2018. They keep everything running smoothly.
- In 2010, ACM was merged with CS and CDS to form the Computing and Mathematical Sciences Department (CMS) with a strong focus on mathematics of information and data science.

Joel Tropp, Hannes Helgason, Emmanuel Candes, 5/08

Emmanuel Candes and Chiara Sabatti, 11/11/22



P. Isett, A. Stuart, J. Chen, and H. Owhadi, 5/12/2022

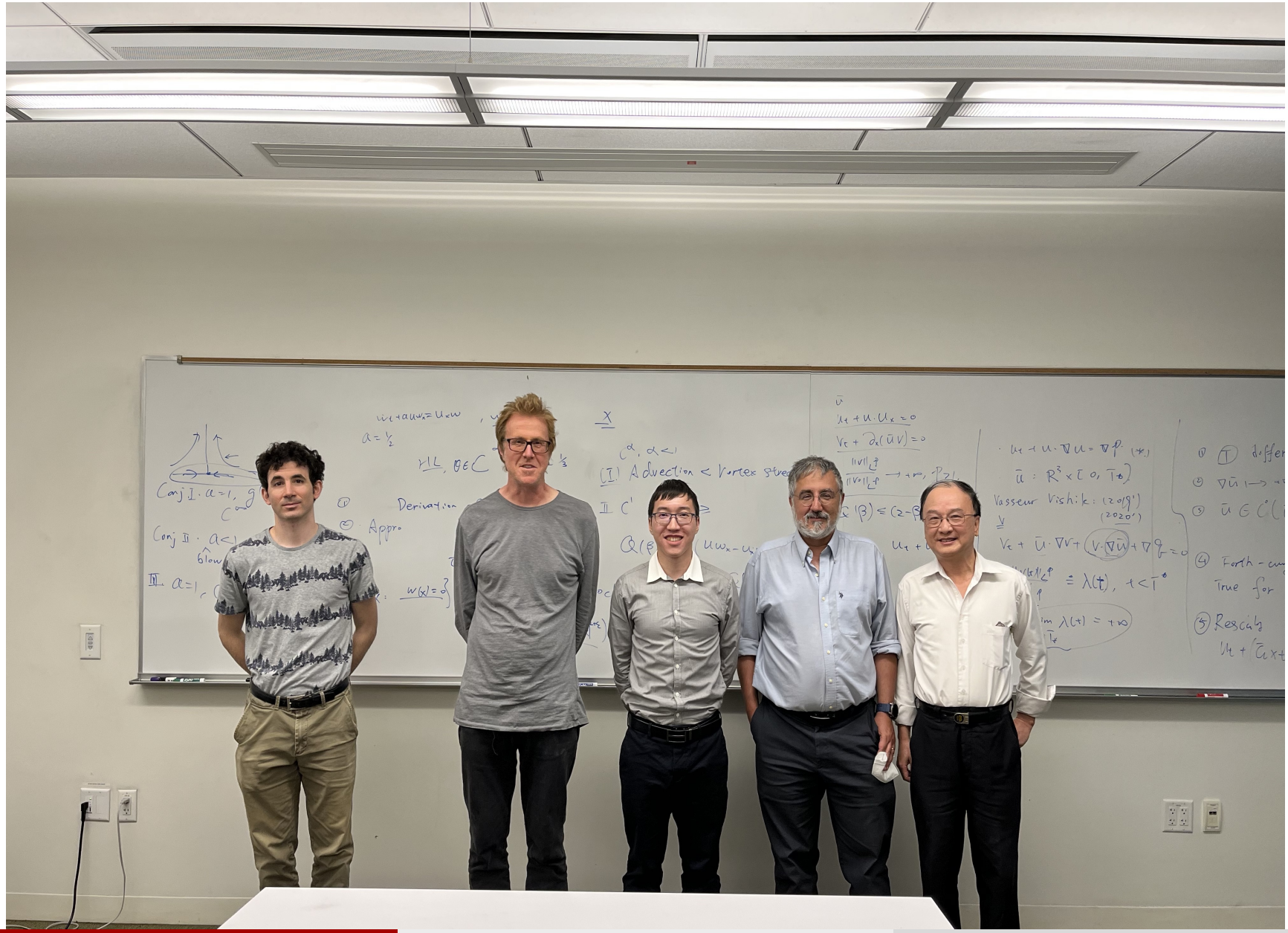


Photo with Mathieu Desbrun (CMS EO), Ares Rosakis (EAS Chair), 6/1/2012 before dinner with EAS VC

Some of the students from AMa/ACM

Earlier students include

Javier Jimenez (Ph.D. 1973, Whitham, Madrid),

Ruben Rosales (Ph.D. 1977, Whitham, MIT),

John Neu (Ph.D. 1978, Berkeley, Cohen),

A. S. Fokas (Ph.D. 1979, Cambridge, Paco Lagerstrom),

Greg Baker (Ph.D. 1977, Saffman, OSU),

Bill Kath (Ph.D. 1981, Cohen, Northwestern),

Thomas Hagstrom (Ph.D 1983, Keller, Univ. New Mexico),

Saleh Tanveer (PhD 1984, OSU), and

Bill Henshaw (Ph.D. 1985, Kreiss, RPI).

Some of the students from AMa/ACM

From late 80s to 2000, we have

Michael Ward (Ph.D. 1988, Cohen, UBC),

Thomas Wiltelski (Ph.D. 1995, Cohen, Duke),

Darren Crowdy (Ph.D. 1998, Saffman, Imperial College),

Yalchin Efendiev (Ph.D. 1999, Hou, TAMU),

Peter Park (Ph.D. 1999, Hou, Harvard),

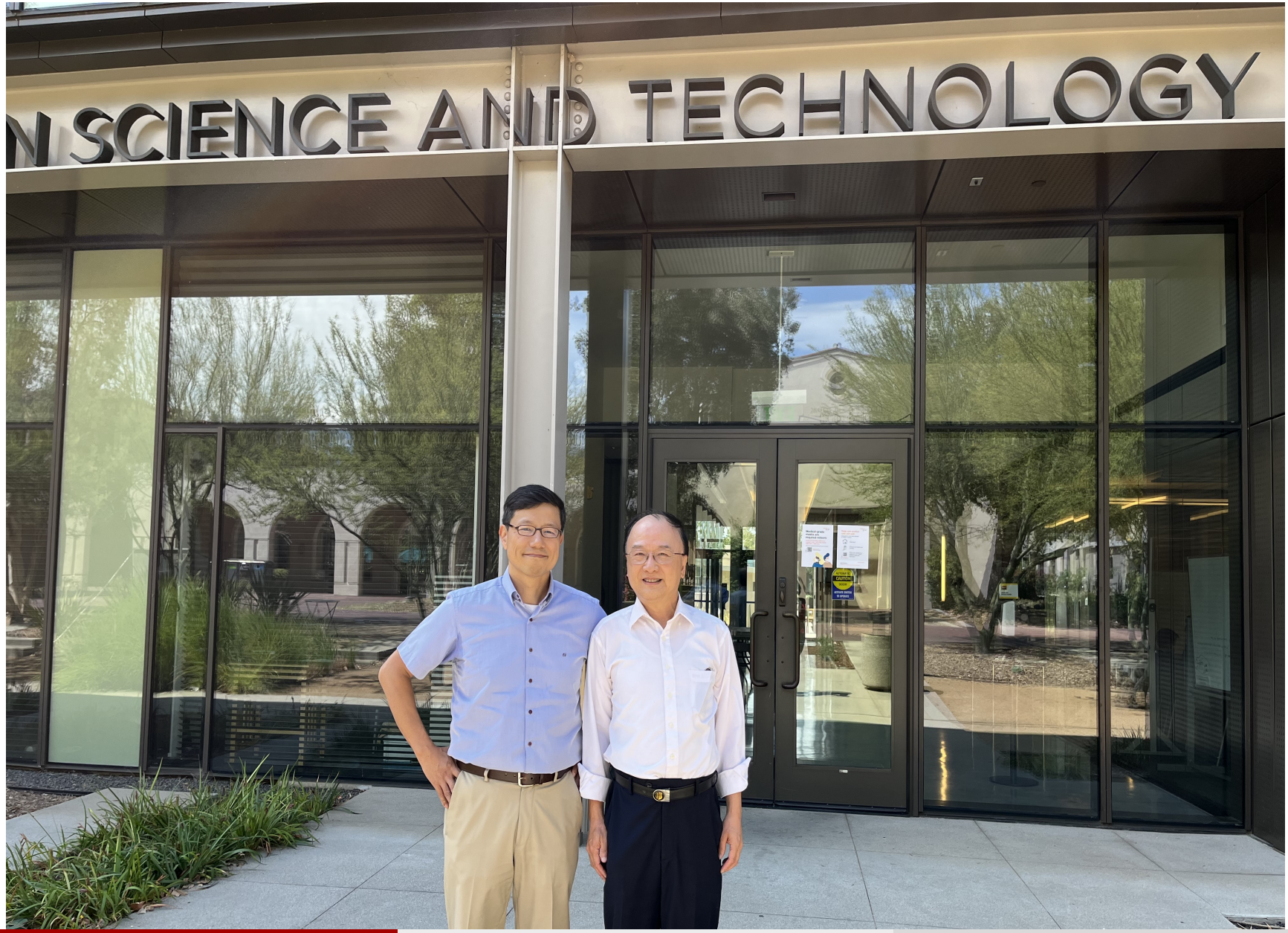
Gang Hu (Ph.D. 2000, Hou, Hedge Fund),

Mayya Tokman (Ph.D. 2001, Meiron and Bellman, UC Merced).

Valentin Gabriel Stredie (Ph.D. 2005, Hou and Ted Wu, Oracle).

L. Berlyand, Y.Efendiev and H. Owhadi, 5/1/2023

Peter Park, Harvard Medical School, 8/1/2022



Gang Hu, Managing Partner–WinShore Capital Management

Some of the students from AMa/ACM

More recently, we have

Laurent Demanet (Ph.D. 2006, Candes)

Wuan Luo (Ph.D. 2006, Hou, Citadel)

Lei Zhang (Ph.D. 2007, Owhadi, SJTU)

Catherine Beni (Ph.D. 2011 at age of 20, Bruno, MD, UW Medicine)

Peyman Tavallali (Ph.D. 2014, Hou, Ph.D. in ME, JPL/JP Morgan)

Albert Chern (Ph.D. 2017, Schroeder, UCSD)

Pengfei Liu (Ph.D. 2017, Hou, Citadel)

Pengchuan Zhang (Ph.D. 2017, Hou, Meta AI Lab),

De Huang (Ph.D. 2020, Hou, PKU)

Florian Scaheffer (Ph.D. 2021, Owhadi, GaTech)

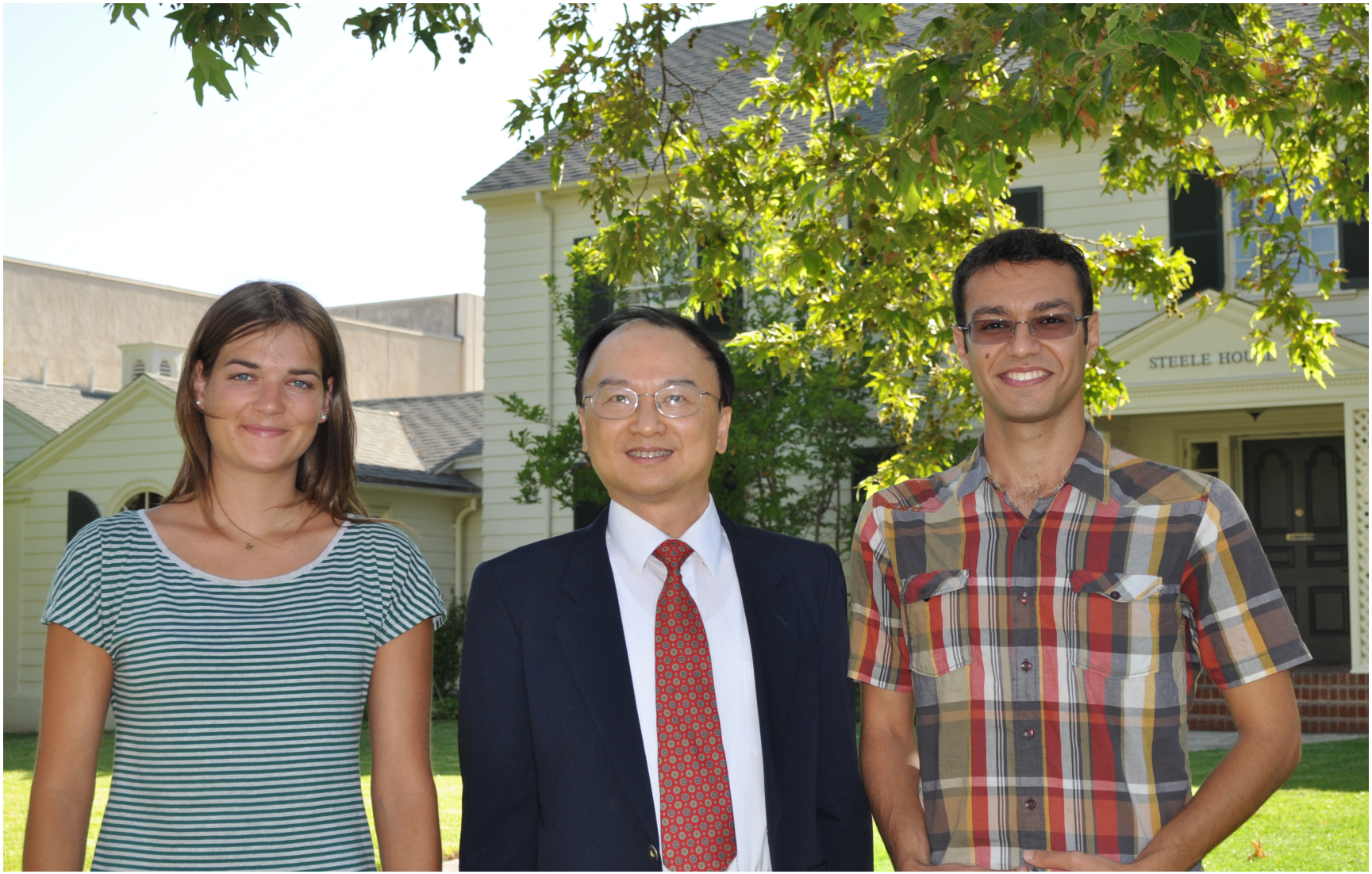
Jiajie Chen (Ph.D. 2022, Hou, Courant Institute)

Yifan Chen (Ph.D. 2023, Hou, Owhadi and Stuart, Courant Institute)

Wuan Luo and his wife Lixiu Tian, Caltech, 6/2006

Catherine Beni, Ph.D. at age of 20, 6/2011, Stephen Wolfram got his Ph.D. in 1980 one week younger

Diane Guignard and Peyman Tavallai, 6/7/2012



Mr. K.C. Choi, Larry Lao, my research group, 5/28/19

Some of the postdocs from AMa/ACM

Tony F. Chan (1978-1979, postdoc of Keller, President of KAUST)

Eitan Tadmor (1980-1982, Bateman Instructor, Kreiss, Maryland)

Liliana Borcea (1996-1997, von karman Instructor, UMich)

Anne Gelb (1996-1998, postdoc of Keller, Dartmouth)

Michael Holst (1993-1997, von Karman Instructor, Keller, UCSD)

Lexing Ying (2004-2006, postdoc of Candes, Stanford)

Benjamin Recht (2010-2012, psotdoc of Candes, UC Berkeley)

Bamdad Hosseini (2017-2021, von Karman Instructor, Stuart, UW)

Elizabeth Qian (2020-2022, von Karman Instructor, Stuart, GaTech)

Franca Hoffmann (2017-2020, von Karman Instructor, Stuart, Caltech)

Tony Chan and Eitan Tadmor at Tony's 70th birthday

Tony Chan, Achi Brandt, Alfio Quarteroni, Raymond Chan, Chris Anderson and Randy LeVeque, HK, 1991

Photo with Franca Hoffmann, 12/20/2022

Some of my postdocs and visitors

Xiao-Hui Wu (1995-1997, Senior Principal Computational Scientist, ExxonMobile)

Pingwen Zhang (1995, 1997, 1998, President of Wuhan University)

Zhiming Chen (1997-1998, Academician, Chinese Academy of Sciences)

Hector Ceniceros (1998-2000, UCSB)

Ruo Li (2005-2006, Peking University)

Zhen Lei (2007-2008, Dean of School of Math, Fudan Univ)

Mike Yan (2008-2011, Principal, SLCG Economic Consulting, LLC)

Zuoqiang Shi (2008-2011, Tsinghua University)

Guo Luo (2009-2014, HSUHK)

Hayden Schaeffer (2013-2015, von Karman Instructor, UCLA)

Qin Li (2013-2015, von Karman Instructor, UW Madison)

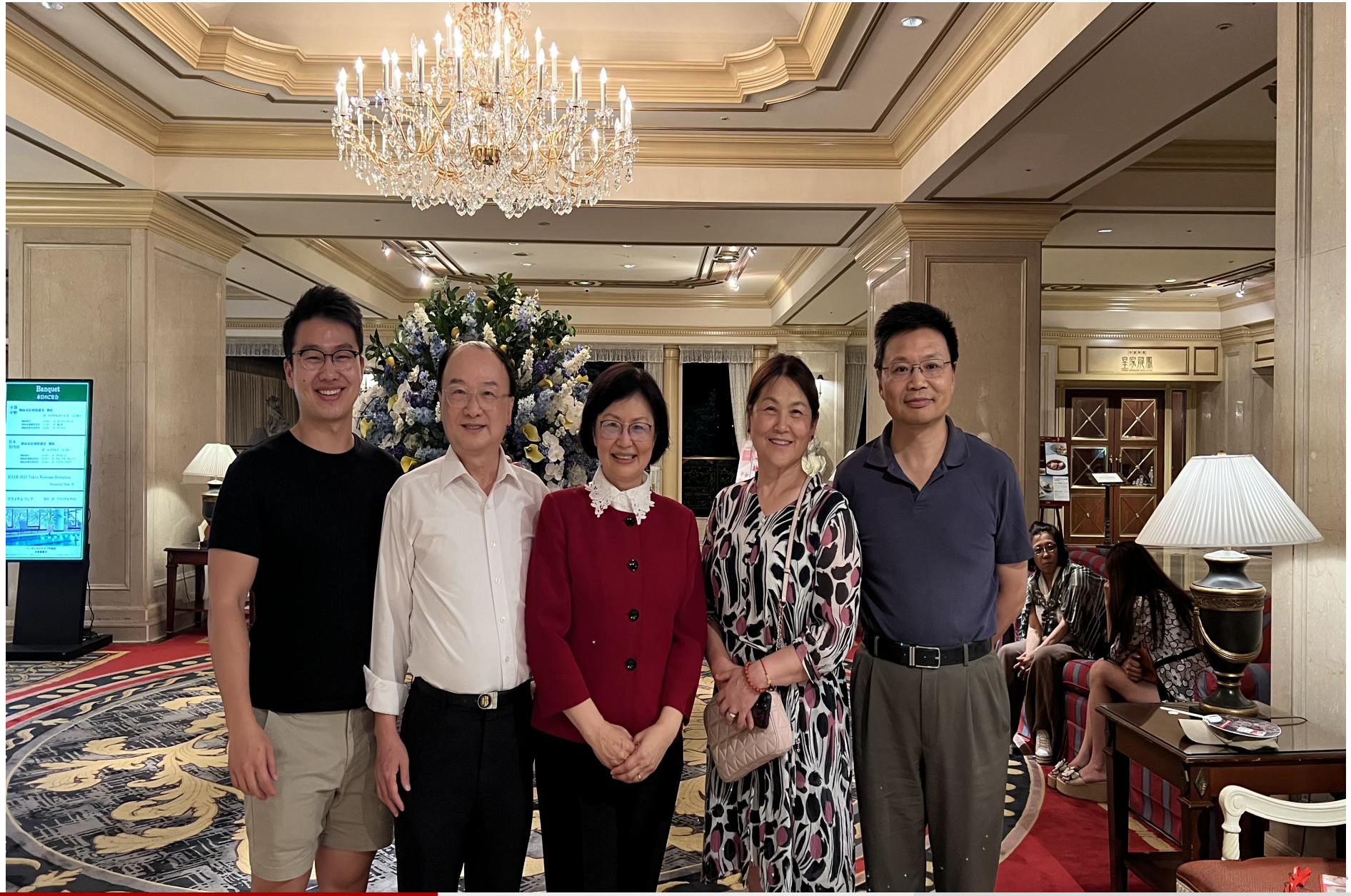
Zhiwen Zhang (2010-2014, Hong Kong University)

Photo with Xiao-Hui Wu in front of Guggenheim, 1995

Xiao-Hui Wu delivered a SPE Distinguished Lecture on goal-driven vs. data-driven reservoir modeling, 2/2016

Photo with Pingwen Zhang (President of Wuhan University) and his wife, ICIAM, 8/20/2023

Photo with Weinan E and his wife, ICIAM, 8/20/2023



Some of our distinguished visitors

Some of our distinguished visitorss include

John Chu (Columbia), Sherman Fairchild Distinguished Scholar, 1984.

Derek Moore (Imperial College), a regular visitor in late 80s and 90s.

Russ Caflisch (UCLA), on sabbatical to Caltech for one quarter, 1995.

George Papanicolaou (Stanford) , Gordon Moore Distinguished Scholar, 3/2003-5/2004.

S. T. Yau (Harvard), Gordon Moore Distinguished Scholar, Math Department, Fall of 2003.

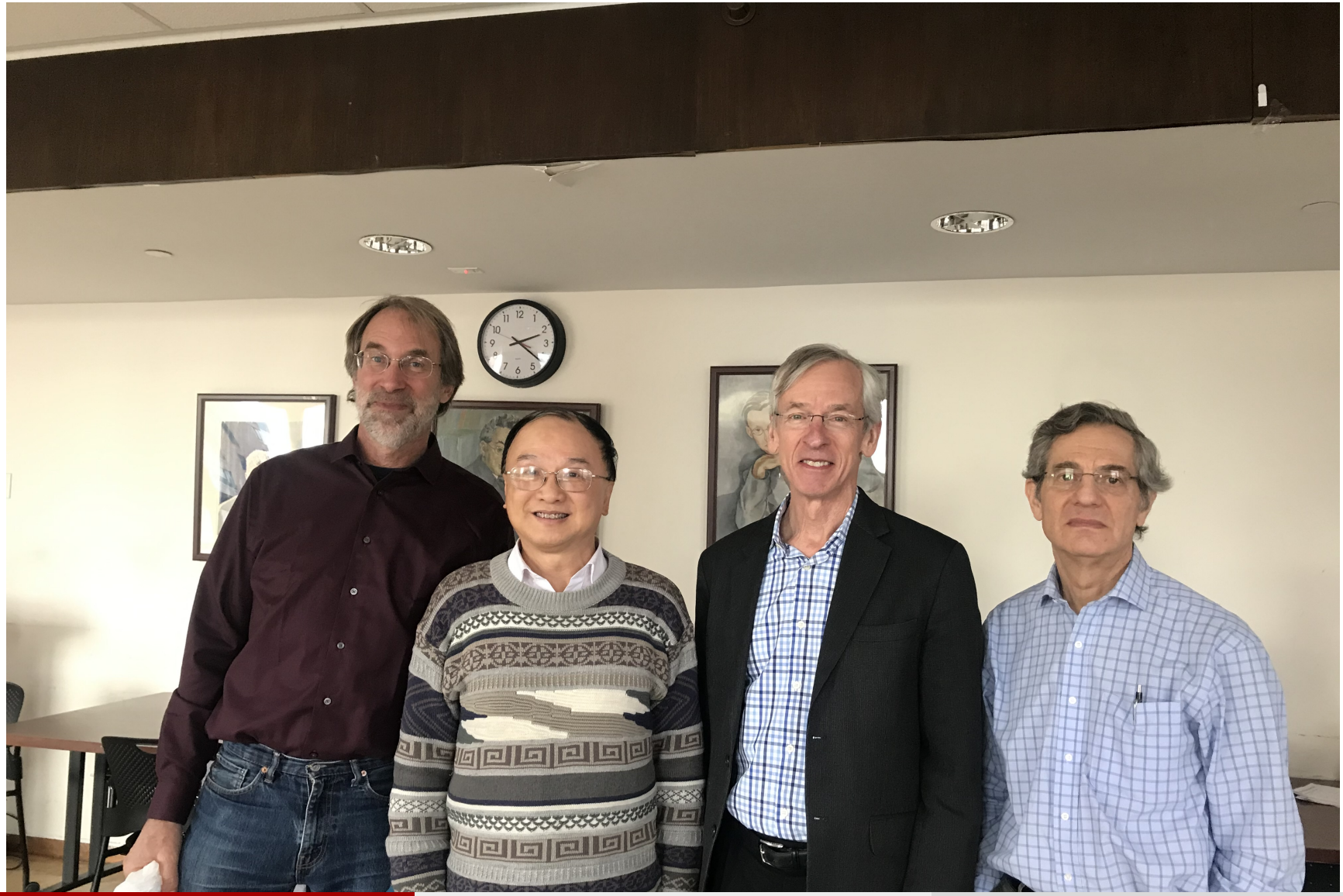
Peter Lax (Courant), Distinguished Visitor, Math Department, 2010.

HYP2002: E. Tadmor, T. Hou, P. Lax, G. Papanicolaou

Photo with Peter Lax at his home, 12/7/2019

George Papnicolaou, Tai-Ping Liu and Hou family, HKUST, 12/12/2007

with Jonathan Goodman, Russ Caflisch, and Bob Kohn, Courant Institute, 12/5/2019



Russ Caflisch and Alfio Quarteroni in ICIAM, 8/2023

Photo with Professor S. T. Yau at Caltech on 1/15/2011

My research – Multiscale Analysis and Computation

- My research on multiscale problems started at UCLA during my Ph.D. thesis under supervision of Bjorn Engquist.
- After I joined Caltech, I worked with my first postdoc, Xiao-Hui Wu, to develop MsFEM. Subsequently, MsFEM and GMsFEM were further developed jointly with Yalchin Efendiev.
- Other students who contributed to multiscale research include: Yu Zhang, Zhiming Chen, Jay Chu, Ivan Graham, Andrew Westhead, Peter Park, Shaoqiang Tang, Maolin Ci, Theo Strinopoulos, Hayden Schaeffer, Pengfei Liu, Pengchuan Zhang, and De Huang.
- The most recent work on Exponentially Convergent MsFEM for high frequency Helmholtz equation was developed jointly with Yifan Chen and Yixuan Wang (2021).

With Bjorn Engquist, Beijing, 8/15/2015, 70th birthday

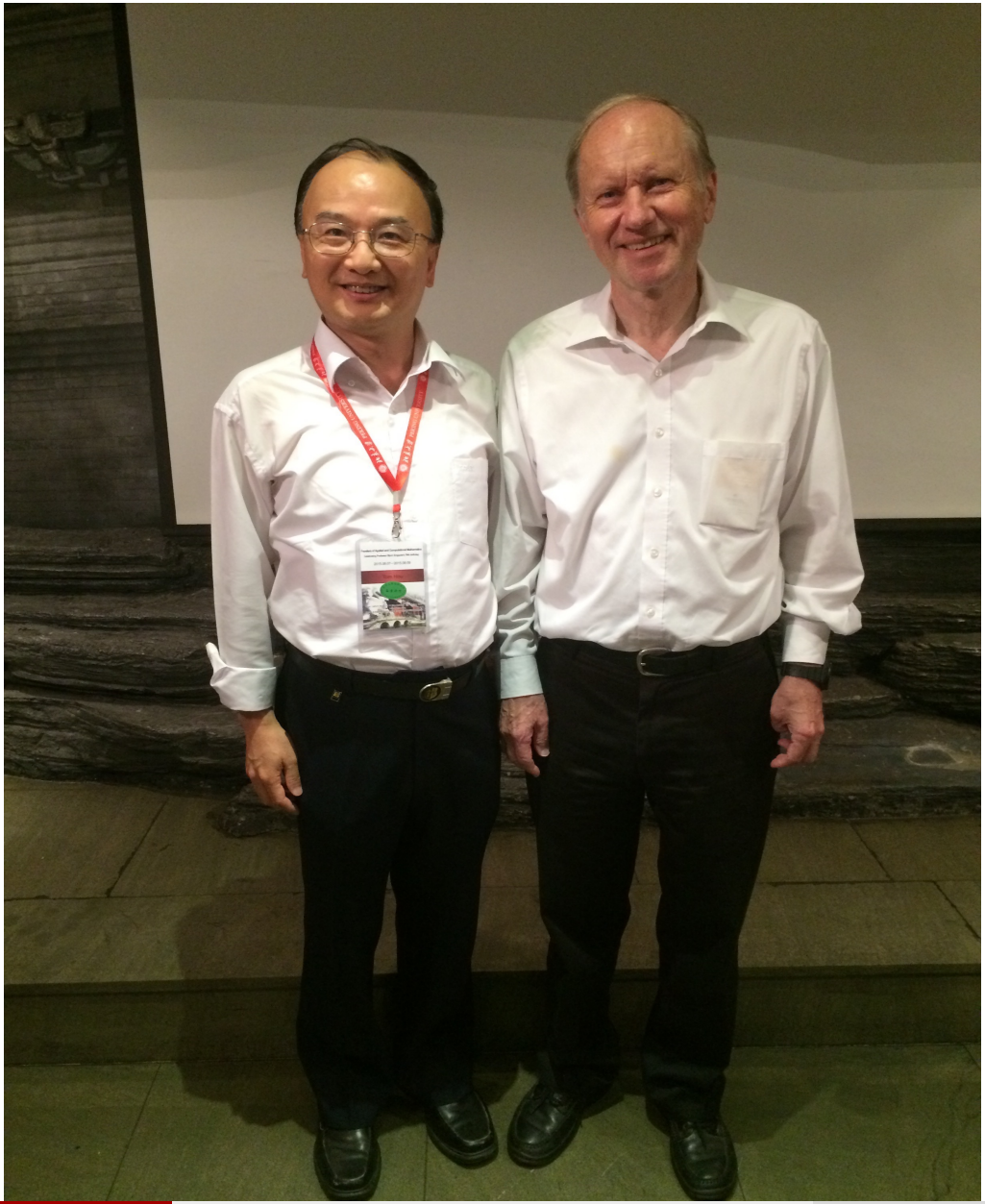
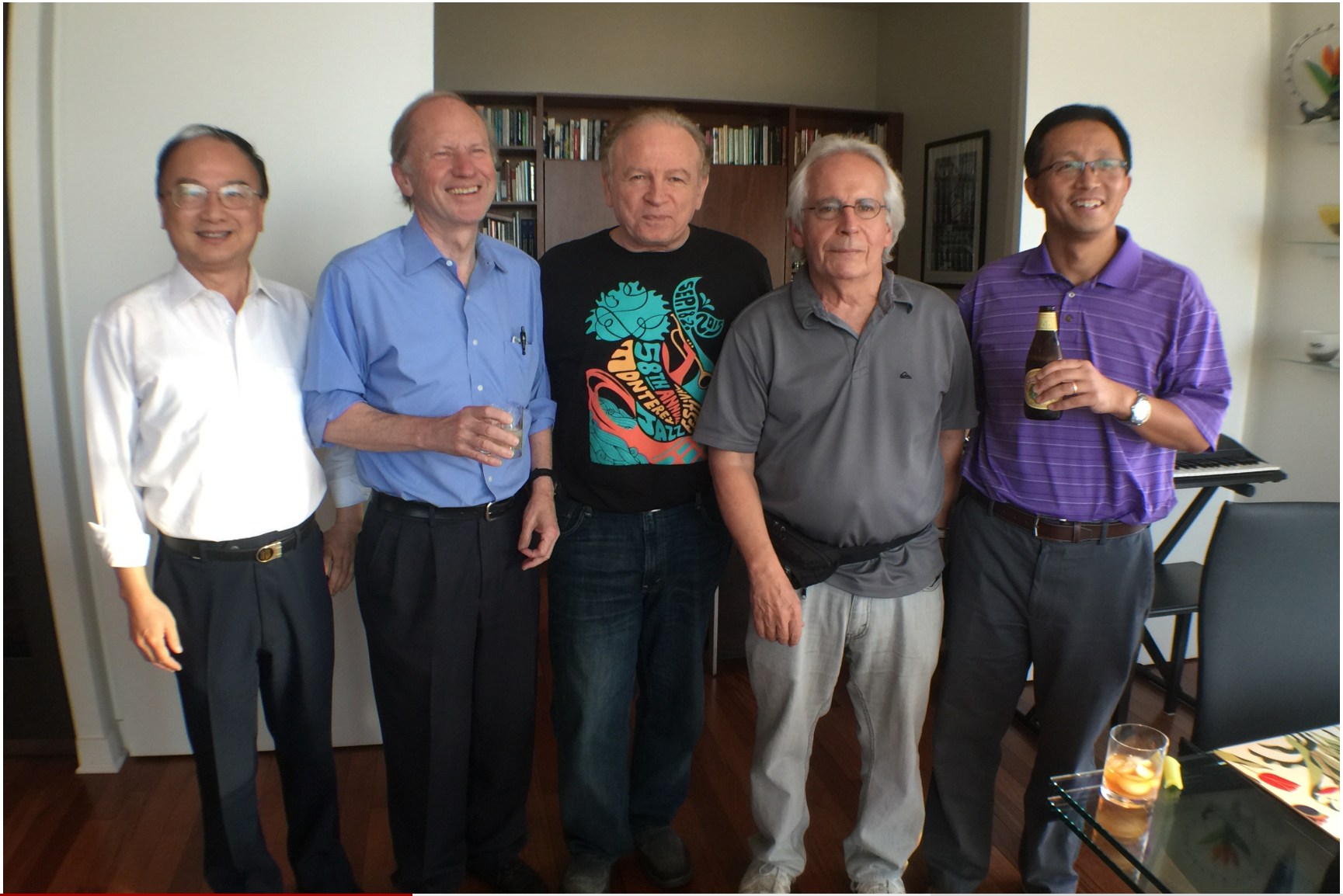


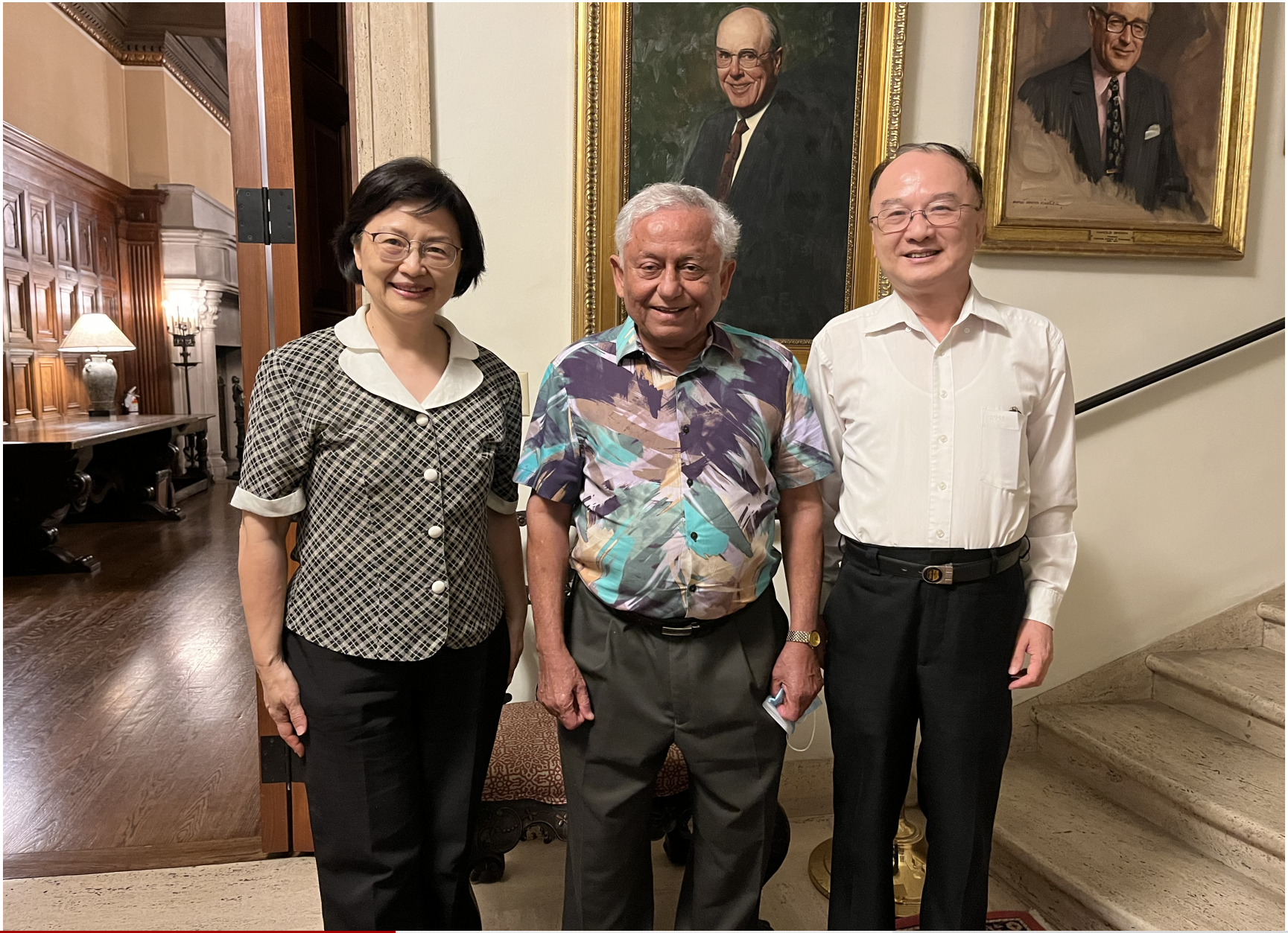
Photo with Bjorn Engquist, Eitan Tadmor, Stan Osher and Hongkai Zhao, 10/16/2015, 70th birthday



My research – Multiscale Analysis and Computation

- Multiscale analysis for fluid flows was conducted with Danping Yang, Hongyu Ran, Xin Hu, and Fazle Hussain.
- Solving Navier-Stokes equations with Browning motion forcing was conducted with Haomin Zhou, Wuan Luo, and Boris Rozovsky.
- Stochastic multiscale model reduction was conducted with Mulin Cheng, Zhiwen Zhang, Qin Li, Pengchuan Zhang and Pengfei Liu.
- Multiscale Invertible Generative Networks for High-Dimensional Bayesian Inference: with Pengchuan Zhang and Shumao Zhang.
- Low dimensional matrix recovery and convergence of Riemannian gradient descent: Zhenzhen Li and Ziyun Zhang.

Photo with Fazle Hussain, Athenaeum, 9/13/2022

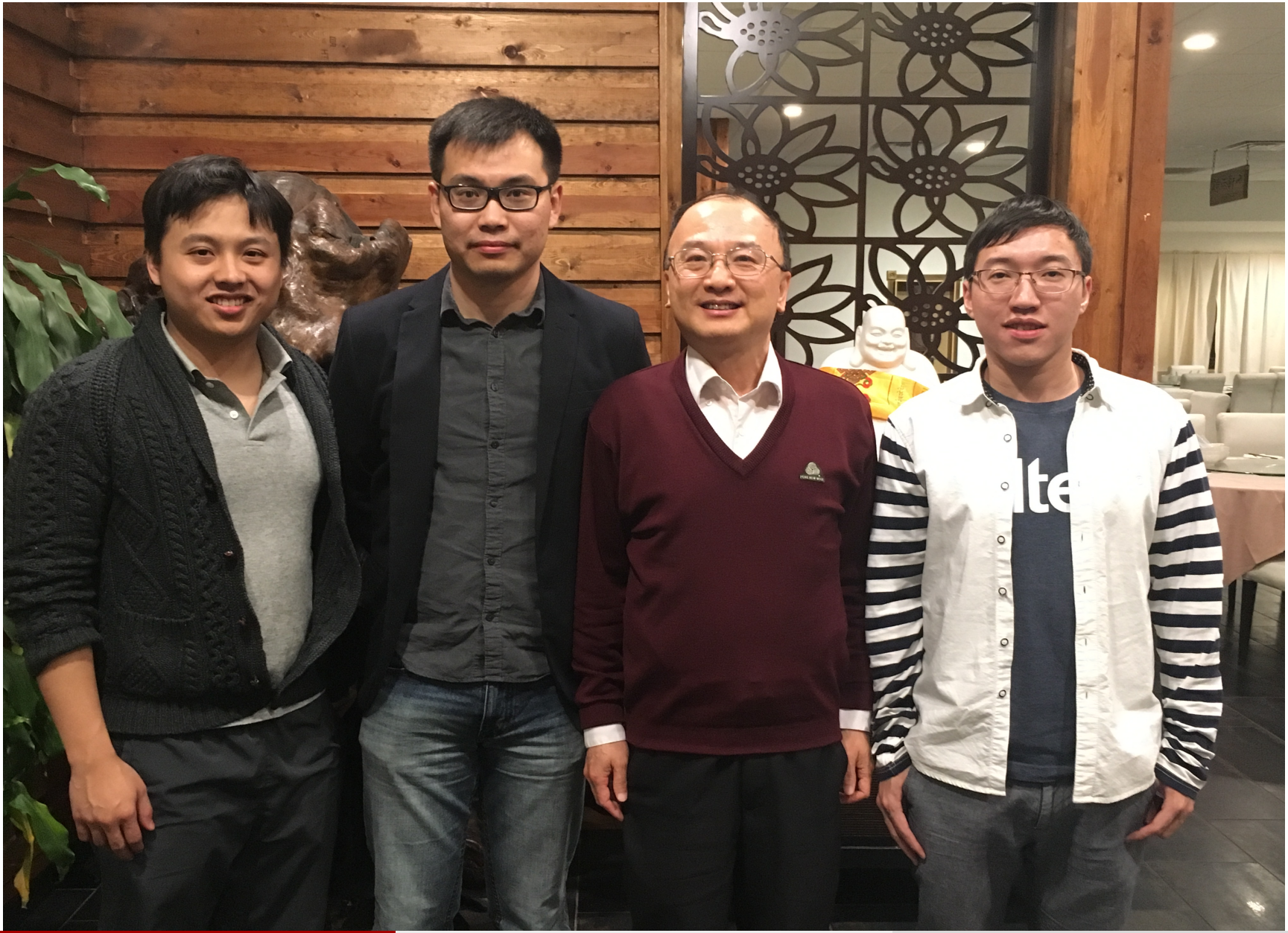


My research team with some speakers in a machine learning workshop at Harvard, 3/29/2019

My research – 3D Euler singularity

- My research on 3D Euler singularity started with Gang Hu's Ph.D. thesis on 3D vortex sheet singularity.
- In 2005, Jian Deng, Xinwei Yu and I developed a sharp non-blowup criterion inspired by Constantin-Fefferman-Majda.
- In 2008, 2009 (CPAM), I worked with Congming Li and Zhen Lei on the stabilizing effect of convection for 3D Navier-Stokes.
- In 2014, Guo Luo and I produced the first convincing evidence of 3D Euler singularity with smooth data and boundary.
- Building on Pengfei Liu's thesis and his crucial observation, Jiajie Chen and De Huang made great progress, leading to the final computer-assisted proof of 3D Euler singularity (Chen-Hou, 2022).

De Huang, Pengfei Liu, and Jiajie Chen, 12/14/2017



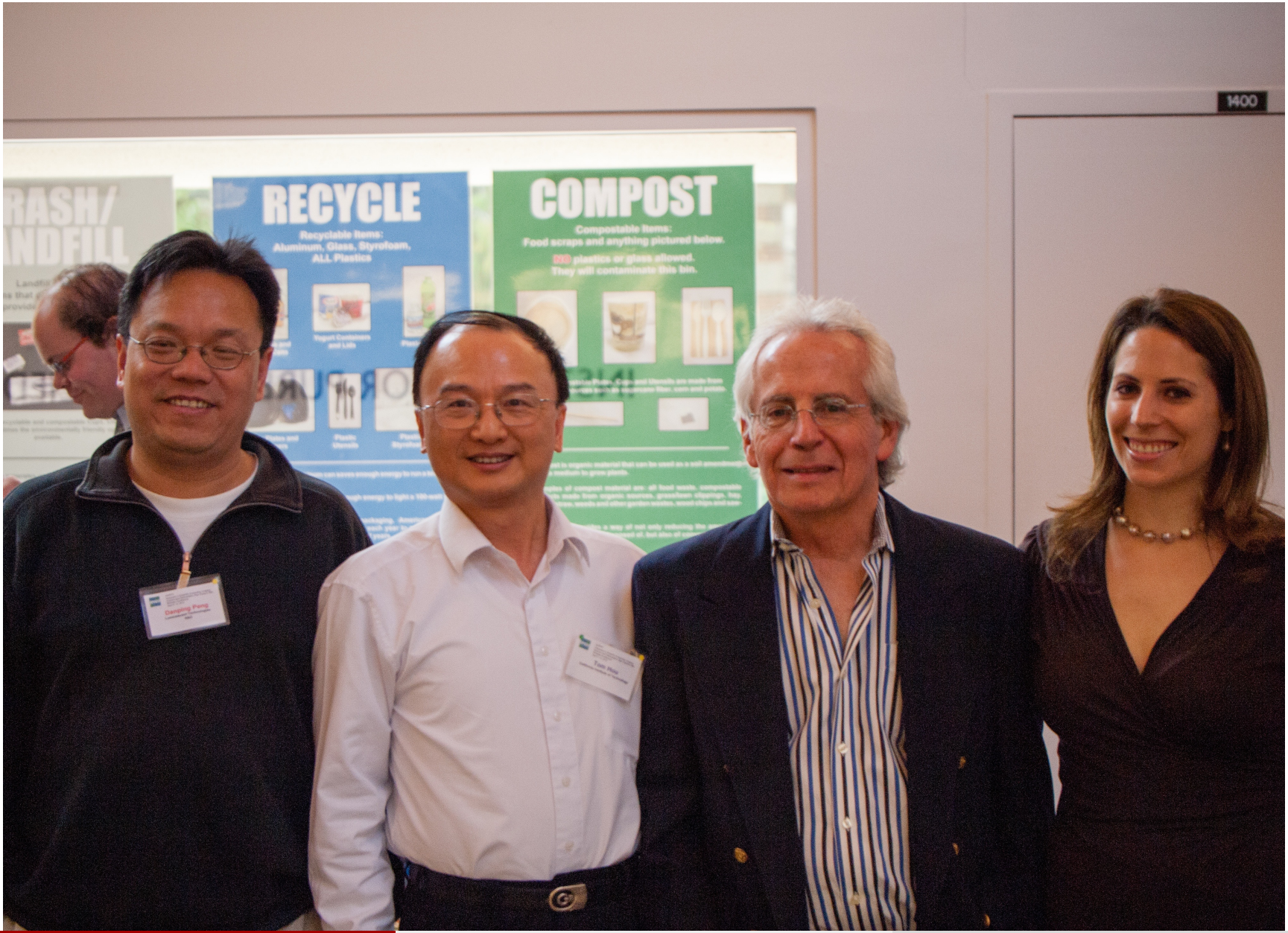
Some CMS faculty with EAS Division Chair Ravi Ravichandran and Mr. K. C. Choi, 4/20/2016

K. C. Choi and President Tom Rosenbaum, 5/28/2019

My Research – Interface problems

- My research on interface problems started with my joint work with Tom Beale, John Lowengrub, Mike Shelley at Courant in early 90s.
- In 1996, I collaborated with Yu-Chung Chang, Barry Merriman, and Stan Osher to develop the first level set method for incompressible interfacial flows with surface tension.
- I continued to work on 3D water problems with Pingwen Zhang after I moved to Caltech.
- I also collaborated with Hector Ceniceros and Helen Si on Hele-Shaw flow with surface tension and capillary waves.
- Gaby Stredie worked under Ted Wu to study aquatic and aerial animal locomotion and vortex formation behind a moving plate.

Stan Osher and his daughter, 4/5/2012, 70th birthday



With Stanley Osher, IPAM, 4/20/2022, 80th birthday

Chris Brennen and Ted Wu, 9/26/2014, 90th birthday

My Research – Adaptive data analysis

- My research on adaptive data analysis was inspired by the Empirical Mode Decomposition method of Norden Huang.
- My postdoc Zuoqiang Shi and I developed a data-driven time-frequency analysis based on nonlinear matching pursuit.
- We have had a close and friendly interaction with Ingrid Daubechies and Hau-Tieng Wu who used the Synchrosqueezed wavelets transform.
- My student, Peyman Tavallali, further developed this framework, and came up with a simplified intrinsic frequency concept.
- This led to several US Patents and a new start-up company to transfer this into a health care monitoring technology.

Ingrid Daubechies, Wolf Prize in Mathematics, 2023

Concluding Remarks

- I feel extremely grateful to my teachers and mentors (Bjorn Engquist, Stan Osher, Russ Caflisch, George Papanicolaou and Peter Lax) for their mentorship, support and lifetime friendship.
- I am equally grateful to my students/postdocs. Without them I could not have made progress on these challenging problems.
- I very much appreciate the generous support from my college alum Mr. K.C. Choi. I have learned so much from him and his wisdom.
- I am very inspired by Ingrid Daubechies' ideal of building a community for the next generations of applied mathematicians.
- We have benefited from the mentorship and support from our teachers. We should pass this tradition to our next generations.